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Central Stationers

Report presented to
Central Stationers by
Energy for Sustainable
Development Limited
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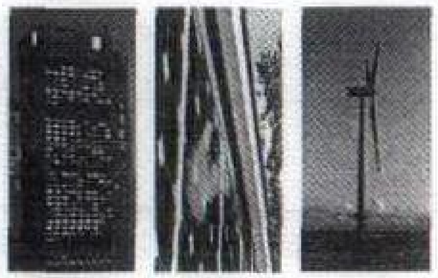
159-165 Camden High Street, Camden, NW1

Sustainable Energy Strategy



Final report

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Acronyms

GLA – Greater London Authority
GSHP – Ground Source Heat Pumps
NPV – Net Present Value
PV – Photovoltaic
SHW – Solar Hot Water
UDP – Unitary Development Plan

EXECUTIVE SUMMARY

Central Stationers are planning to build a six storey development on the site which stretches from 159-165 Camden High Street, NW1. The development will consist of a ground floor and lower ground floor area designated as commercial space and 14 flats on the 1st to the 4th floors of the development.

In response to the Camden UDP and the requirements of the London Plan, the proposed scheme is designed with regard to the principles of energy efficiency. The development is also designed so that 10% *of the total predicted energy consumption or 10% of the CO_2 emissions are reduced with on-site* renewable energy sources, whichever is the greater. The total predicted energy consumption for the site is shown in the table below.

Table 1: Energy demand assessment summary

	kWh/yr	Energy (%)	Carbon Dioxide (%)
Baseline energy and emissions	217,649	100%	100%
Savings from energy efficiency	44,378	20%	20%
Savings from renewable energy	17,027	10%	10%

The Energy Strategy has been developed following the Mayor's energy hierarchy of using a) less energy, b) using renewable energy and c) supplying energy efficiently. The main elements of the Strategy are as follows:

Use less energy – 'Be Lean':

- Appropriate glazing ratios to balance between passive solar gain, daylighting, heat loss and summer overheating.
- Exceed typical building regulation insulation standards to reduce heat loss from the building fabric.
- High efficiency lighting, both interior and exterior.
- Reduce energy consumption from lights and appliances through low energy lighting and A-rated appliances where provided.

Use renewable energy – 'Be Green':

The proposed option to meet the 10% renewables target is:

- Solar hot water collectors to supply domestic hot water to all the flats.

Supply energy efficiently – 'Be Clean':

- Air-sourced heat pumps are used for space heating, cooling and air conditioning in the flats. These units are air to air and have low CO_2 emissions because they run at relatively low temperatures.
- CHP is not recommended for this scheme due to the small scheme size and the lay out of the blocks. There are also concerns about the human resources required to maintain and operate a CHP unit at this location.

These measures provide an integrated approach to the energy efficiency and renewable energy objectives of the London Borough of Camden and the GLA.

1 INTRODUCTION

1.1 SCHEME SUMMARY

The development at 159-165 Camden High Street will be a mixed use development consisting of a ground floor and lower ground floor area designated as commercial space and 14 flats which stretch from the 1st to the 4th floors of the development.

The development is in a single six storey block facing approximately East with other buildings directly to the North and South and a garden/courtyard area to the West.

Table 2: Schedule of areas

Unit	Average unit area (m^2)	Total no. of units	Total NIFA (m^2)
Lower Ground Floor Commercial	*	*	*
Ground Floor Commercial	212	2.0	423
First Floor Flats	67	4.0	266
Second Floor Flats	69	4.0	276
Third Floor Flats	49	3.5	172
Fourth Floor Flats	85	2.5	213
Total		**16**	**1,350**

* Lower Ground Floor is unheated storage space so is not relevant for energy calculations.

1.2 RELEVANT POLICY

1.2.1 London Plan

Policy 4A.7 (Energy efficiency and renewable energy) states:

The Mayor will and boroughs should support the Mayor's Energy Strategy and its objectives of reducing carbon dioxide emissions, improving energy efficiency and increasing the proportion of energy used generated from renewable sources by:

- *improving the integration of land use & transport policy and reducing the need to travel by car*
- *requiring the inclusion of energy efficient and renewable energy technology and design, including passive solar design, natural ventilation, borehole cooling, combined heat and power, community heating, photovoltaics, solar water heating, wind, fuel cells, biomass fuelled electricity and heat generating plant in new developments wherever feasible*
- *facilitating and encouraging the use of all forms of renewable energy where appropriate including giving consideration to the impact of new development on existing renewable energy schemes*
- *minimising light lost to the sky, particularly from street lights*

The Mayor will work with strategic partners to ensure that the spatial, transport and design policies of this plan support the Mayor's Energy Strategy and contribute towards achieving CO_2 and renewable energy targets.

Policy 4A.8 (energy assessment) states:

The Mayor will and boroughs should request an assessment of the energy demand of proposed major developments, which should also demonstrate the steps taken to apply the Mayor's energy hierarchy. The Mayor will expect all strategic referrals of commercial and residential schemes to demonstrate that the proposed heating and cooling systems have been selected in accordance with the following order of preference: passive design; solar water heating; combined heat and power, for heating and cooling, preferably fuelled by renewables; community heating for heating and cooling; heat pumps: gas condensing boilers and gas central heating. Boroughs should apply the same criteria to major developments.

Policy 4A.9 states:

The Mayor will and boroughs should require major developments to show how the development would generate a proportion of the site's electricity or heat needs from renewables, wherever feasible.

The Mayor has defined an Energy hierarchy to help guide decisions about which energy measures are appropriate for a new development:

1. *Use less energy*
2. *Use renewable energy*
3. *Supply energy efficiently*

1.3 London Borough of Camden

With the Planning and Compulsory Purchase Act 2004, the government revised the system of planning documents in order to speed up the preparation of plans and to make the planning process simpler and more flexible. The new system of planning documents is called the Local Development Framework (LDF) and will replace 'old-style' Unitary Development Plans. The Camden LDF is in development and is due for adoption by the Council in March 2010.

The current (2006) London Borough of Camden UDP states the following:

C – Use of energy and resources:
The Council will seek developments that conserve energy and resources through:

a) *designs for energy efficiency*
b) *renewable energy use;*
c) *optimising energy supply; and*
d) *the use of recycled and renewable building materials.*

The Council require major developments to demonstrate the energy demand of their proposals and how they would generate a proportion of the site's electricity and heating needs from renewables wherever feasible.

1.62 Government policy on energy and planning is set out in Planning Policy Guidance 22 – Renewable Energy. The Government has accepted the recommendation of the Royal Commission on Environmental Pollution that greenhouse gases should be reduced by 60% by 2050. Buildings account for 46% of UK carbon dioxide emissions. If the principles of energy efficiency design are adopted for new and rehabilitated buildings, this will make a substantial contribution to reducing carbon dioxide emissions.

1.63 The Council particularly welcomes developments that have low or zero emissions. There are many ways of influencing the extent to which developments are energy efficiency and reduce carbon dioxide emissions. These include orientation, passive solar gain, density, location, choice of energy supply, use of renewable energy, choice of heating and ventilation systems, control systems and choice of materials.

Developers should give details of how they have addressed these issues in any design statement that is submitted under policy B1.

The Government's Climate Change Programme has set a target that 10% of the United Kingdom's electrical requirements are to be met from renewable resources by 2010, and 20% by 2020. Therefore, the Council expects major developments of 1000m² or 10 housing units or more to incorporate renewable energy production equipment to provide at least 10% of predicted energy requirements. The most likely sources of renewable energy for developments in Camden are solar water heating, photovoltaic cells, small scale wind turbines, passive solar energy, natural ventilation and borehole cooling. Developers should give details of how they have addressed these issues in any design statement that is to be submitted under policy B1. Although not strictly renewable, combined heat and power through its far greater energy efficiency, also has enormous potential for reducing carbon dioxide emissions. It can be used at both large and small scale. Special regard should also be paid to the Greater London Authority's "The Mayor's Draft Energy Strategy", (2002). Further guidance on energy matters and sustainable buildings is contained in supplementary guidance and the Camden Green Buildings Guide.

1.4 PLANNING CONSTRAINTS AND GUIDELINES

As mentioned above, the following policy and guidance has been referred to in the preparation of this sustainable energy strategy. The approach to energy issues set out in this strategy for the site responds to the policy objectives of current national, regional and local planning policy.

- Planning Policy Statement 22: Renewable Energy (ODPM, August 2004)
- The London Plan: Spatial Development Strategy for London (Mayor of London, February 2004)
- Green light to clean power: The Mayor's Energy Strategy (Mayor of London, February 2004)
- Integrating renewable energy into new development: Toolkit for planners, developers and consultants (London Energy Partnership, September 2004)
- The London Plan: Sustainable Design and Construction Supplementary Planning Guidance (Major of London, May 2006)
- London Borough of Camden UDP

2 ENERGY DEMAND ASSESSMENT

The following tables show the impact of the proposed measures on the energy demand for the site. A Baseline energy demand was produced for the development using Benchmark data. Subsequently building regulation (Part L) calculations have been produced for each of the types of flat based on the actual U values for the fabric of the flats. The resulting energy use requirement for the development has been used to determine what the 10% carbon dioxide reduction target from renewable energy should be. The subsequent energy demand after renewable energy has been implemented is reported below as the proposed energy and carbon dioxide for the scheme.

Table 3: Total energy efficiency and renewable energy savings vs. baseline scheme (annual figures)

Total energy efficiency savings vs. baseline scheme (annual figures)	Baseline scheme		Proposed scheme		[illegible]	
	kWh	kg/CO_2	kWh	kg/CO_2	kWh	kg/CO_2
Lighting and Appliances	167,646	70,747	127,634	53,882	40,012	16,885
Heating+Hot Water	50,003	21,101	20,463	8,636	29,540	12,466
Cooling	11,076	4,674	7,823	3,301	3,253	1,373
Total	228,725	96,522	155,921	65,799	72,804	30,723

Table 4: Energy efficiency savings summary (annual figures)

Energy efficiency savings summary	Amount	
Reduction in energy demand (kWh)	55,454	20%
Reduction in CO2 emissions	23,402	20%

Table 5: Renewable energy savings (annual figures)

Renewable energy savings	Amount (kWh)	
Required energy generation from Renewables	17,350	10%*
Proposed energy generation from Renewables:	17,350	10%*

* this is as a percentage of the net energy use after energy efficiency

Table 6: Renewable energy carbon savings (annual figures)

Carbon dioxide emissions reductions	Amount (kg CO2/year)	%
Required CO_2 reductions from renewable*	7,495	10%*
Proposed CO_2 reductions from renewables:	7,495	10%*

* this is as a percentage of the net energy use after energy efficiency

Table 7: Energy demand breakdown

Development type	GIFA (m^2)	BAU CO_2 emissions ($kgCO_2/m^2$)	Target CO_2 emissions ($kgCO_2/m^2$)	% reduction	BAU Total CO_2 emissions (tCO_2)	Target Total CO_2 emissions (tCO_2)
area averaged		68	54	20%		
Lower Ground Floor Commercial	0	0	0	0%	0	0
Ground Floor Commercial	423	137	114	17%	58	48
First Floor Flats	266	35	26	24%	9	7
Second Floor Flats	276	35	26	26%	10	7
Third Floor Flats	172	39	28	27%	7	5
Fourth Floor Flats	213	40	28	29%	8	6
Total						

Table notes:
1. Net internal floor area based on actual floor areas marked on drawings
2. This table excludes the contribution from renewable energy.

The following assumptions/benchmarks used to calculate the baseline figures:

- The development is all electric, therefore the baseline scheme numbers have been estimated from the TER from building regulations.
- For commercial space emissions are estimated at $137kgCO_2/m^2$ (baseline scheme) and $114kgCO_2/m^2$ (proposed scheme), based on typical and best practice benchmarks from CIBSE Guide F.
- Cooling loads have been estimated at $1.66kWh/m^2$ for the flats in the proposed scheme. This is based on an assumption of 4 hours per day cooling for 8 weekends per year and based on the actual unit sizes which will be installed (data from Daikin).The baseline cooling loads have been estimated assuming the same cooling duty supplied by a cooling fan.
- The target CO_2 emissions after energy efficiency are calculated using the building regulations (part L) calculations based on the actual U values used in the development.
- The energy consumption from appliances (not accounted in Part L) is taken from the calculation tool in Ecohomes 2006 (Building Research Establishment).

3 ENERGY EFFICIENT DESIGN MEASURES

Achieving low energy consumption in use requires action on four main fronts:

1. Promote and encourage sustainable lifestyles
2. Design and construction of building fabric and building services
3. Use, operation and management of buildings and building services
4. Selection and use of other energy consuming equipment

The developer and project design team have primary responsibility for item (2) design and construction, and the ultimate owners and occupiers of the buildings will have primary responsibility for items (1), (3) and (4). However the developer and design team can influence the ultimate owners and occupiers by:

- Designing buildings that are easy to operate and control with systems that 'default to off'
- Pre-installing low energy equipment as far as possible and/or advising on such
- Providing guidance on efficient use and operation of the buildings and building services

The following sections review the proposed energy efficiency measures. All measures set out in this report are recommendations for meeting the agreed energy saving measures. The client is responsible for the adoption of these recommendations by the design team in the detailed design of the scheme.

3.1 Building Orientation

The orientation of the blocks on this site is dictated by the setting. The block is oriented towards the East. Appropriate glazing ratios have been considered for the various facades to maintain a balance between passive solar gain, daylighting, heat loss and summer overheating.

3.2 Building Fabric Performance

Improving the insulation of the building fabric is one of the lowest cost methods of reducing life cycle carbon emissions and energy cost.

It is proposed to enhance insulation levels beyond that of 2006 Part L. This is for two reasons:

- To facilitate the use of solar thermal in meeting the 10% renewable energy requirement.
- To demonstrate enhanced insulation in the block and reduce the site baseline energy consumption.

Table 8 Target building fabric performance the block

Element	Benchmark U-values W/m^2K	Proposed U-values W/m^2K
External Walls	0.25	0.19
Internal Walls		0.35
Roof	0.13	0.12
Floor	0.20	0.16
Exposed Windows	1.80	1.60
Air-Permeability (m^3/hm^2 @50Pa)	3	5
Boiler type	Condensing boiler	Air conditioning unit

** The Benchmark U-values are indicative values required to meet building regulations 2006 standards. The proposed U values are those that have been used in SAP calculations to determine the DERs for the dwellings*

3.3 Domestic Hot Water

Domestic hot water (DHW) is usually at a lower temperature than water used for space heating, and it usually becomes waste wider after being used. Typical uses are not only the traditional showers, baths and taps, but also the hot water load of dishwashers and washing machines.

Water use will be minimised by using low flow taps such as that illustrated in the figure below. Besides saving water, this will save energy by reducing the consumption of hot water.

Figure 3-1 Example of water saving tap

3.4 Daylighting/ Low Energy Lighting

It is proposed that high efficiency lighting will be installed in the development, with fittings that only allow replacement with other high efficiency lamps (usually compact fluorescent lamps – CFL – or fluorescent strip lights). The range of fittings and lamps now available and improvements in colour rendering and warm-up times make this an increasingly practical proposition. This will not bar the householder from installing less efficient, decorative lighting but the desire for this will be limited by the use of attractive fixed fittings that are capable of providing different ambiences in the main habitable rooms.

Lighting for common areas will be installed with time-clock control and PIR occupancy sensors.

External space lighting will be specified with low energy fittings e.g. CFL, luminaires or strip lights, daylight cut-off devices or timers, and designed to reduce light pollution.

3.5 ENERGY EFFICIENT APPLIANCES

It is proposed that energy efficient white goods with a rating of A will be provided to reduce residents' cost in use or information provided recommending their use.

3.6 ENERGY EFFICIENT VENTILATION, HEATING AND COOLING

The lowest energy ventilation method is passive natural ventilation. However the site is located close to Camden High Street, a busy, noisy and polluted main road. Therefore because of noise and air quality issues the expectation is that the residents will not normally want to open their windows to the street. For this reason an air conditioning system will be fitted which will be used for both heating and cooling of the flats. The system is effectively a communal air source reversible heat pump which can give a cooling COP[1] of over 3.11 and a heating COP of over 3.38[2]. The system is less carbon intensive than a conventional system which would use gas boilers for heating in the heating system and electric fans for cooling in the summer.

3.7 HEATING SYSTEMS COMPARISON

Electrical heating

Direct electrical heating is not considered since it is the most carbon intensive way of heating, and it is not listed in the Major's hierarchy of options for heating. As mentioned above, indirect electrical heating, cooling and air conditioning is being used in the development. Each flat will also have a hot water tank heated through an electric emersion element. However only 40% of the hot water requirements will be provided by electricity as a solar hot water system will be installed to provide the other 60%.

CHP

CHP has been considered for integration into a communal heating system. This option is not recommended for the follow reasons:

- Limited heat load. Due to the small size of the scheme, there is only a modest heat load to serve and little diversity of load profile, meaning that there is not an appreciable baseload of heat for the CHP to supply. This means that only the smallest of CHP units would be technically suitable, which would yield little or no economic or environmental benefit. The heat load for the site will also be much lower once renewable energy options are implemented (see recommendations of this report)
- The difficulty of obtaining value for electricity produced. The value of exported power to the grid is low. There is very little landlord demand (high efficiency communal lighting only), thus electricity would have to be sold to tenants to obtain good economic value to the power produced. The administrative effort to charge tenants for their electricity is infeasible for a scheme of this size. The operation and maintenance requirements of a CHP unit are also a concern at this site.

[1] Coefficient of Performance – a measure of how many units of heat or coolth a heat pump will produce per unit of electricity used to run it.
[2] These are the minimum COPs quoted by Daikin for the entire system design.

Communal heating

In accordance with the London Plan, community heating has been considered for this development. A community heating scheme will be installed to service the flats. This community heating system will be in entirely heated using air-sourced heat pumps.

Individual gas boilers

Individual gas condensing boilers have not been chosen for this scheme

4 RENEWABLE ENERGY TECHNOLOGIES

This section reviews the options for meeting the London Energy Strategy requirement for 10% of the total predicted energy consumption to be from renewable energy sources through on-site generation. The London Energy Partnership's *Integrating Renewable Energy into New Developments* Toolkit[3] states that the appropriate renewable energy technologies to be considered are photovoltaics, solar hot water, biomass, ground source heating/cooling and small scale wind technologies. Each of these technologies are considered in the sections below.

4.1 Solar Hot Water (SHW) Heating

Solar Hot Water in the UK is designed to provide pre-heating for domestic hot water use. Solar hot water collectors have basically the same solar access constraints as PV panels, except that they are not so critically affected by shading. A particular type of collector, evacuated tube collectors, can have their fins rotated in the factory to the optimum solar angle and can therefore be fitted vertically or horizontally without losing any efficiency. This allows further opportunities for architectural integration.

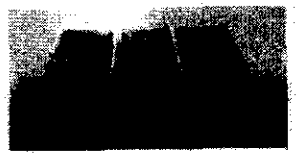


Figure 2: Evacuated tubes

In domestic applications, systems can serve either individual apartments or a communal hot water storage cylinder with a landlord's pumped hot water service. Communal systems require a large volume of hot water storage, which is often prohibitively expensive. Individual systems need to be in proximity to the apartments served, therefore are generally suitable for units on the top floor of blocks of flats only. The optimum panel area is a function of the anticipated domestic hot water demand. The panels themselves come in a variety of shapes and sizes. Some panels have now been produced which are specifically designed for large communal hot water systems.

To meet the 10% carbon dioxide reduction target would require just over 17.3MWh of heat to be provided through a solar hot water system. In order to achieve the high solar throughputs evacuated tube solar collectors would need to be used. There are a number of evacuated tube suppliers in the market. Examples include Veissmann, Thermomax, Schott and Riomay. A quote has been obtained for the installation of seven 20 tube and seven 30 tube Thermomax DF100 vacuum solar collectors to meet the solar hot water requirement. A schematic of how these systems are integrated into the roof is shown in Figure 4-2.

[3] Integrating Renewable Energy into New Developments: Toolkit for planners, developers and consultants (GLA, September 2004)

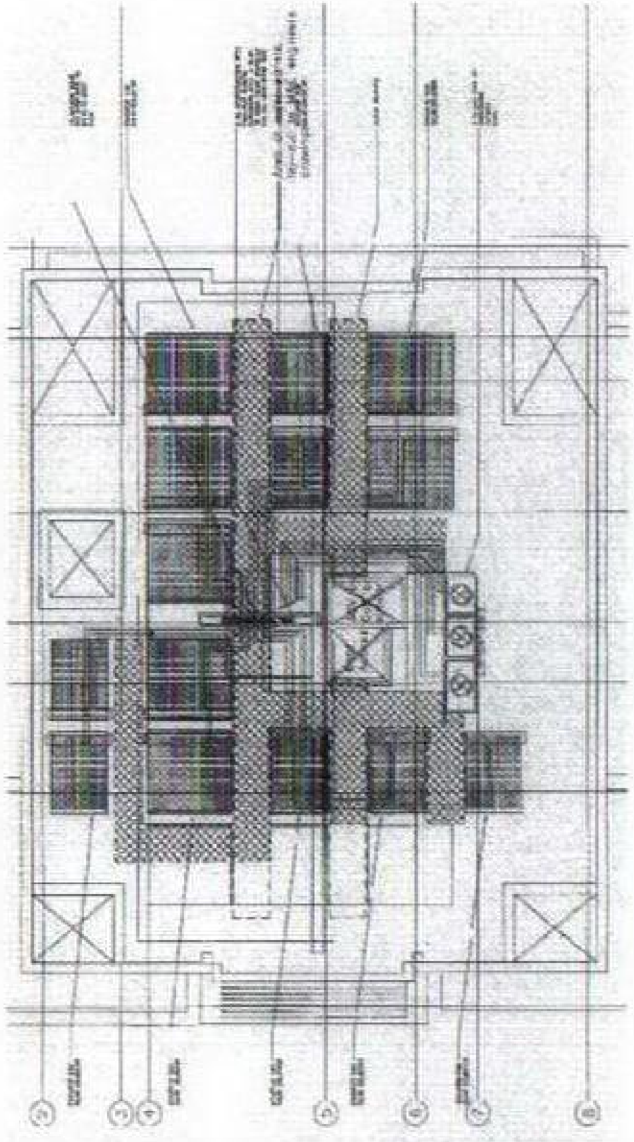


Figure 4-2 Schematic of proposed solar hot water panels integration to the roof.

4.2 Photovoltaics

Photovoltaic panels (PV) are solar panels that produce electricity. They can be easily integrated in roof spaces or façades. While roof integration is more discrete, it can still be designed to make an architectural statement.

Figure 4-4

In order to maximise the output of the PV installation the modules would ideally be roof-mounted and sloped toward the south at an angle of 30 degrees.

To meet the 10% CO_2 reduction requirement would require approximately 16kWp of PVs to be installed. This would require a roof area of approximately 120m^2 and would cost an estimated £90k to install.

The simple payback would be around 70 years assuming the current value of domestic electricity and including the value of Renewable Obligation Certificates, although there is some uncertainty over the future value of the certificates which are only guaranteed until 2015. This would require the managing agent to provide electricity to the apartments as a landlord's service in order to realise a higher value for the electricity than if it was exported to the grid. Even with the inclusion of revenue from the ROCs, the simple payback exceeds the 25 year expected life of the system.

4.3 Wind

Wind turbines provide the opportunity to generate renewable electricity more cheaply than equivalent PV systems. Urban Wind Turbines are still considered innovative, despite the widespread use of large scale wind turbines in wind farms. The cost effectiveness of wind turbines increases with scale. Thus from an economic perspective larger turbines are most economic, but are also more likely to be unacceptable from a technical and planning or architectural perspective in this instance.

Urban wind is associated with high levels of turbulence and it is difficult to estimate wind speeds. Performance is very site specific, depending on the local wind resource, topography and the characteristics of a particular turbine. It is however a technology that is evolving and some products are being developed explicitly to cope with the technical and planning constraints of urban wind turbines, resulting in a great variety of wind turbine types. The conventional 'windmill-type' horizontal axis turbines are the most cost effective in energy terms. In view of the number of new turbines being launched onto the market, it is important to check that credible performance data is available (ideally independently verified), that the products are BS type tested and that they have a sufficient warrantee.

Figure 4-4: Images of various small scale wind turbines

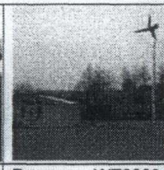
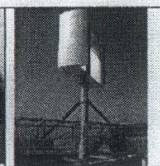
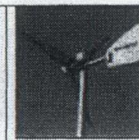
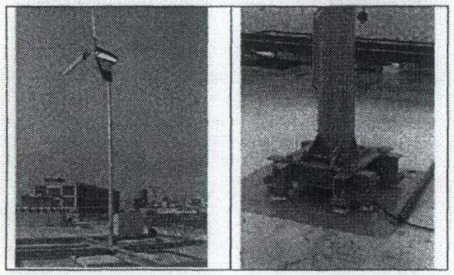
				
Proven WT600 (0.6kW)	Proven WT6000 (6kW)	Ropatec (3kW) – vertical axis	Windsave (~1kW)	Renewable devices Swift (~1kW)

Figure 4-5: A building mounted Proven 2.5kW turbine, plus detail of a mounting



There are no locations for ground mounted wind turbines for the site. Installation of two 1.5kW roof mounted wind turbines could be considered at the back of the property. The total installed capacity would be 3kW. With an assumption of a 10% load factor the wind turbines would pay back in 43 years. The total cost of this option would be £10k. However this level of wind turbine installation would only reduce CO_2 emissions by 2%. Low and uncertain wind speeds, perceived visual impacts and building integration risks mean that building integrated wind turbines have not be recommended for this development.

4.4 Ground Source Heating and Cooling

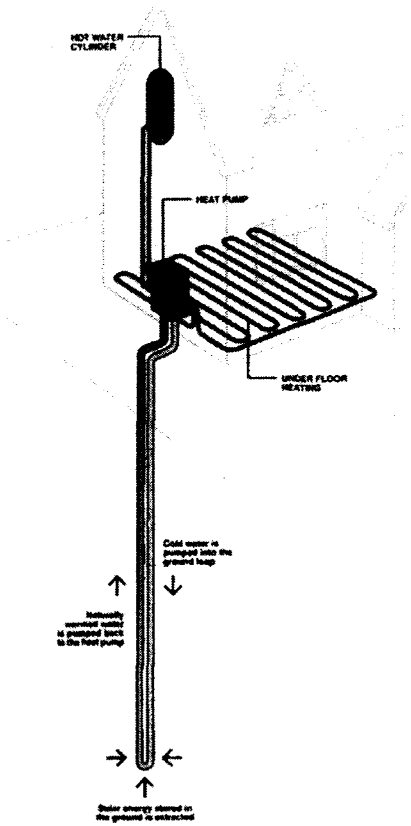
Ground Source Heat Pumps (GSHP) are often considered to be a renewable energy technology. They are typically installed with a closed water loop either in a horizontal trench or a vertical borehole. Electrical energy is required to drive the heat pump, using the stability of the earth's temperature to achieve high seasonal efficiencies.

GSHPs can supply all of the space heating and domestic hot water requirements of a dwelling. However, low temperature heat emitters are required due to their relatively low temperature output (up to 65°C, but the best efficiency is achieved at slightly lower temperatures). This requires either under floor heating or oversized radiators (by approx 30%). For individual systems GSHPs are best suited to ground floor dwellings, to minimise the distance from the borehole to the dwelling. The heat pump itself is about the size of a conventional boiler and does not require a flue. Typical ground conditions allow 50W/m of heat to be absorbed through a vertical ground probe.

Although the Toolkit recommends considering GSHP as a renewable energy, as a CO_2 reducing measure it is less easy to justify. This is because GSHPs typically use a high CO_2 emitting fuel (electricity) to displace lower CO_2 emitting fuel (gas). The CO_2 saving ability of GSHP depend on them running with high coefficients of performance (COP). High COPs are achieved if the outlet temperature for the heat pump is low.

For this development this can be achieved if the heat pump is operating in heating mode. However if operating in hot water mode where the temperatures need to be much higher the COPs tend to be much lower and this means that in carbon terms the heat pump is not the best option. Because of the high insulation and airtightness for this site heating requirements are relatively low. Therefore it would not be possible to meet the 10% CO_2 reduction target using GSHP.

Figure 7: Schematic of a GSHP system



4.5 Biomass

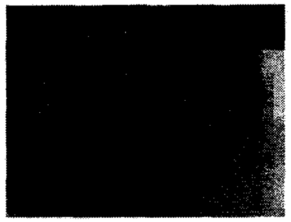


Figure 4-7: Wood pellets

Biomass is a generic name for either solid biomass such as woodchips and pellets, and liquid biofuels, such as bioethanol or biodiesel. In this section report, 'biomass' here refers only to woodchips and pellets, which are the main biomass fuels for heating applications. Biofuels are currently expensive when compared to natural gas, and therefore not a first choice for developments in London at present.

Biomass fuels have become more readily available and the technology is maturing. Biomass boilers are readily available in a range of sizes. Biomass CHP is still at an early stage of development, and there are currently only a handful of installations in the UK. Biomass CHP is not an option for this development, as the smallest available engine size would be too large.

Providing heat with biomass boilers is one of the cheapest capital cost solution to meet 10% of renewables, but the most onerous in terms of operation and maintenance. Pellets tend to be a more competitive solution at the small scale, since they have a higher calorific value than woodchips, meaning they are easier to transport and store.

The reversible air-sourced heat pump strategy for the site means that the biomass boiler would only serve an estimated hot water load of 26.9MWh/year. A 20kW pellet boiler would be sufficient to service this need. The boiler could be installed for around £20k. With an assumed pellet price of £150/tonne this system would payback in 19 years. This low payback is mainly due to the fact that the primary fuel for hot water heating is electricity which has a high cost. If the pellet boiler met all of the hot water load for the site it would reduce CO_2 emissions on the site by 14.2%.

The figures below show a typical fuel supply and storage system. A boiler of this size would consume approximately 1m^3 of wood pellets a week (~500kg). The total floor area required for both plant and fuel storage would be around 10m^2.

Figure 4-8: Biomass store

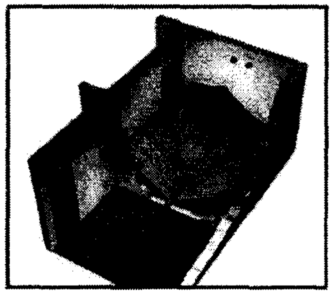
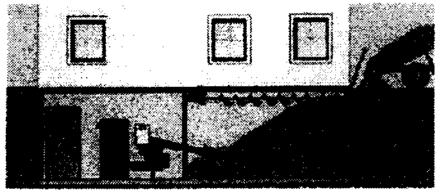


Figure 4-9: Biomass fuel delivery and store



The reversible heat pump strategy for the site means that the biomass boiler would only serve an estimated hot water load of 26.9MWh/year.

The cost of wood pellets and their distribution in London is subject to specific contract negotiations. As a result, the economic viability of the biomass scheme is dependant on the development of a competitive market for biomass in London. Paybacks of less that 20 years are possible, but this is only because the avoided cost of electrical hot water heating is high for the site. A particular issue for this scheme is the relatively low quantity of biomass required. It is likely to be difficult to procure such a small volume at a reasonable price. Road access to the site is also a big issue. For these reasons biomass has not be recommended as an option for this site.

4.6 Green Tariffs

It is recommended that all apartments on the development are initially signed up to a green electricity provider, even though this does not qualify for the 10% target. This helps build demand for renewable energy as part of the generation mix.

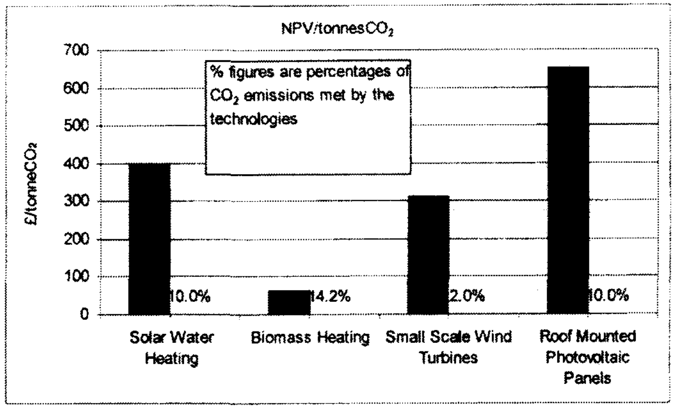
There are a wide variety of tariffs available depending on the proportion of renewably generated electricity included in the supplied power. Some suppliers will offer 100% renewably generated electricity but charge a premium of 0.5-1p/kWh. Others will match conventional suppliers offering 10% renewable make-up initially, increasing with each year of continued support.

4.7 Conclusions

None of the options achieve a positive Net Present Value at a 3.5% discount rate over 15 years against the competing all electric energy provision. All options are an additional cost.

Figure 4-10 below shows the renewable energy options which have been considered for the site in terms of life-cycle carbon saving Net Present Value over 15 years. This provides a convenient comparison of the relative total costs (capital and operating cost) of the different options. The percentage contribution towards site energy consumption for each option is shown as a percentage next to the associated bar.

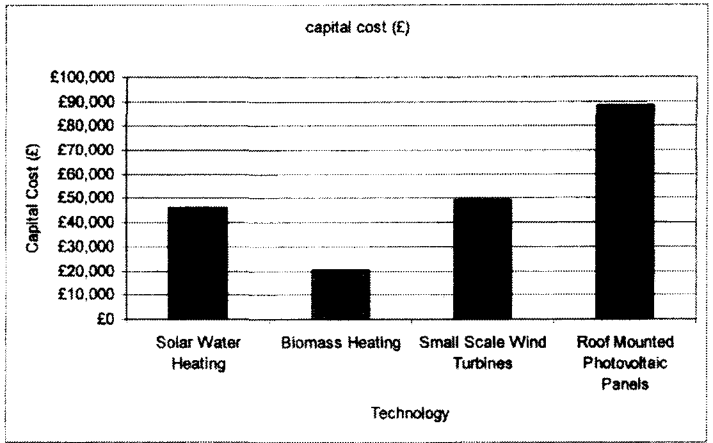
Figure 4-10: Life cycle cost comparison



Biomass heating has a relatively low life cycle costs per unit of carbon saved over 15 years. Wind power and solar water heating life cycle costs are broadly similar. Photovoltaics life cycle costs significantly more expensive. Ground Source Heat Pumps are not shown since they would not be able to technically meet a 10% target without becoming net CO_2 emitters.

Figure 4-11 compares the capital cost of each option. Capital costs have been scaled assuming a 10% CO_2 reduction target could be met, although in the case of small scale wind and photovoltaics this would not be possible in this instance. A communal biomass boiler for the block of flats is the cheapest option, however this option is discounted due to access issues. The next cheapest option is a solar hot water system.

Figure 4-11: Capital cost comparison



In view of the technical, commercial and practical constraints reviewed in this report, the recommended option is **a solar hot water system to feed hot water to each flat.**

The reasons for selecting this option are:

- Financial performance – low capital and life cycle cost compared to other options.
- Practicalities of implementation – relatively easy to implement within the roof area of the building.
- Technical performance – The SHW systems can meet the 10% renewables target and the CO_2 target.
- Low operational requirements. SHW systems have minimal operational requirements for building occupants and the landlord. This is a particular benefit for this relatively small development.
- The main implication of using SHW is:
  - The need for individual hot water storage tanks for each flat and associated pipe work to deliver hot water to each flat.
  - Careful attention to be paid to roof integration of the system to ensure there is adequate area for the chosen system.

  - **Biomass Heating** *is not recommended for this scheme for the following reasons:*
    - Access to the site for fuel deliveries is off a main road. It is unlikely that the appropriate access consents would be obtainable from the local authority.
    - The modest size of this development. There is no obvious management structure on site that could successfully maintain and operate a biomass boiler. A larger plant room and fuel store would have to be constructed using valuable site area.
    - Immature fuel supply chain in London at present. The small volume of biomass required (~600kg/month on average) which will exacerbate the difficulty of finding an economic supply.

  - **Wind Power.** The wind resource at this site is poor, due to its geographic location and urban setting. *The capacity of wind power is technical unfeasible to achieve on this site with acceptable* visual and noise impact. The cost of renewable energy production from wind would be significantly greater than the renewable heat options. There are concerns over integration of the system into the buildings structure.

  - **Photovoltaic panels (PV).** Integration of a large number of PVs into the roof area is likely to be problematic due to the shape and size of the roof, therefore meeting the 10% target would be difficult. This option is also the most expensive option by a wide margin. The capital cost would be in the region of £90k.

  - **Ground source heat pumps (GSHP).** It is not possible to implement a ground source heat pump solution at this site to meet the 10% CO_2 target. This is because in order to meet hot water and space heat requirements the system would need to run at high temperatures which would reduce the COP drastically *and therefore make this solution a net CO_2 generator.*

Conclusions and commitments

The following specific measures are either adopted or recommended at this stage (which may be subject to future modification as the project develops):

Use less energy – 'Be Lean':

- Appropriate glazing ratios to balance between passive solar gain, daylighting, heat loss and summer overheating.
- Exceed typical building regulation insulation standards to reduce heat loss from the building fabric.
- High efficiency lighting, both interior and exterior.
- Reduce energy consumption from lights and appliances through low energy lighting and A-rated appliances where provided.

Use renewable energy – 'Be Green':

The proposed option to meet the 10% renewables target and the 10% equivalent carbon dioxide target is:

- Solar Hot Water to deliver solar hot water to all the flats.

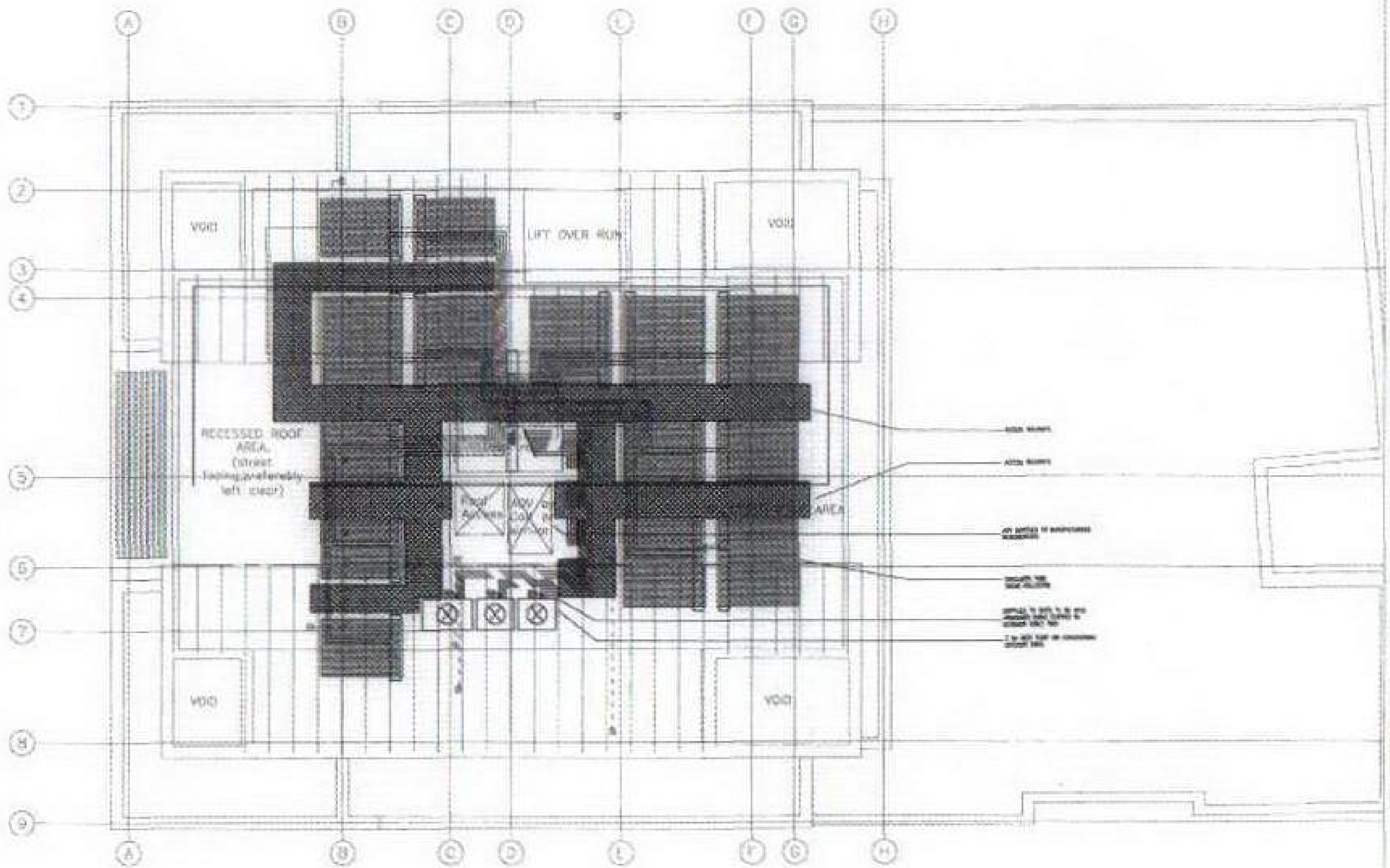
Supply energy efficiently – 'Be Clean':

- Reversible Air-sourced heat pumps to deliver heating, cooling and air conditioning to the development.
- CHP is not recommended for this scheme due to the small scheme size and the fact that all of the space heat provision will be from an air sourced heat pump. There are also concerns about the human resources required to maintain and operate a CHP unit at this location.

These measures provide an integrated approach to the energy efficiency and renewable energy objectives of the London Borough of Camden and the GLA.

APPENDIX A IMAGE SOURCES

Solar Century
Viessman
Riomay
Proven Wind Turbines
Ropatec
Windsave
Renewable Devices
Okofen
Alwitra/Evalon Solar
Powergen/Earth Energy Engineering
Neale and Norden Architects



NOTES

AJD DESIGN PARTNERSHIP

S PATEL

CAMDEN HIGH STREET
LONDON NW1 7JY

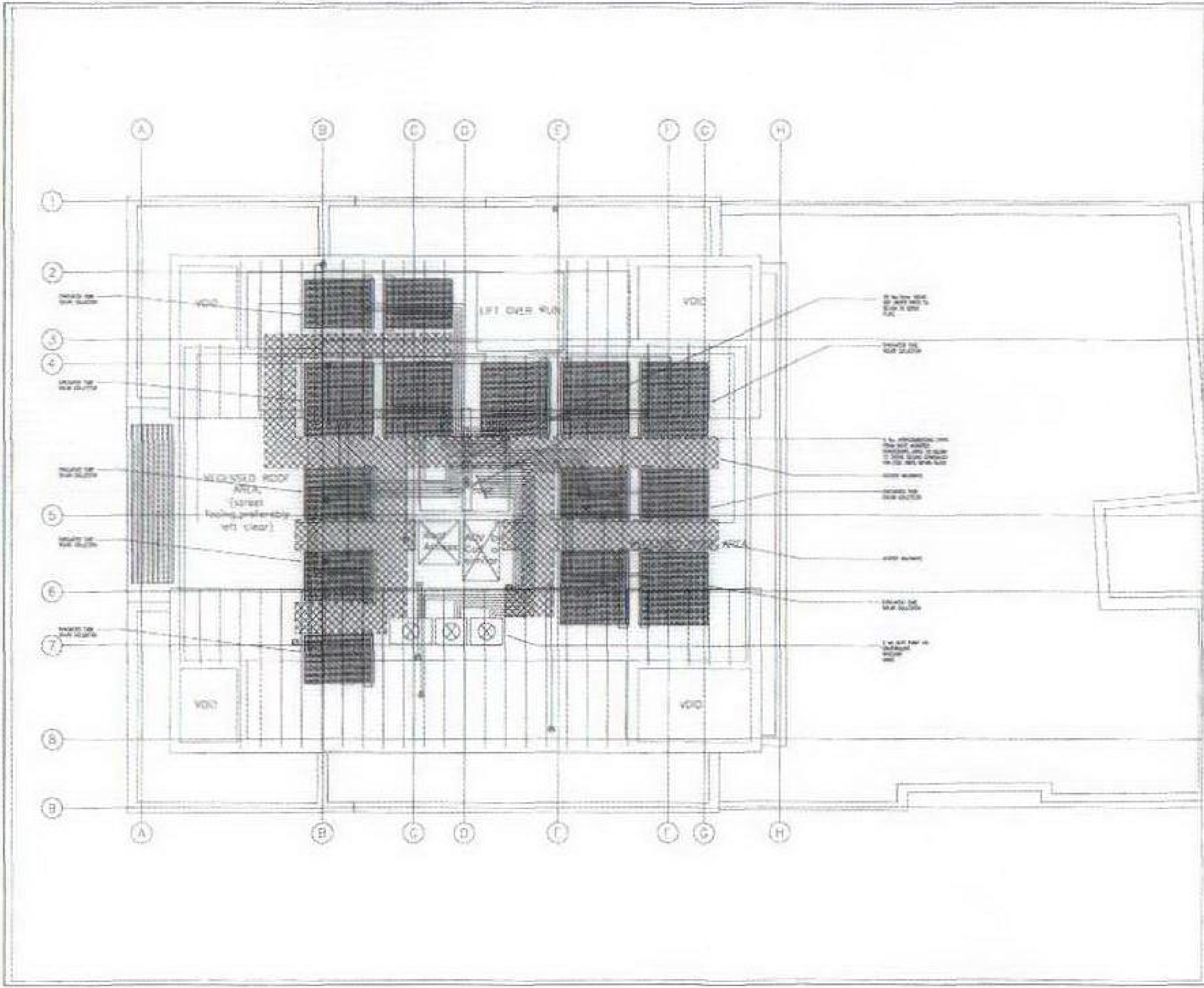
ELECTRICAL SERVICES
ROOF LAYOUT

PRELIMINARY

P2606-E-113 P1

JUNE 08 1:50@A1

ATM



NOTES

AJD DESIGN PARTNERSHIP

S PATEL

CAMDEN HIGH STREET
LONDON NW1 7JY

MECHANICAL SERVICES
ROOF LAYOUT

PRELIMINARY

P2606-M-106 P3

NOVEMBER '07 1:50@A1

S.K

Cole Jarman

159-165 Camden High Street

Plant Noise Assessment

08/3380/R2

Cole Jarman

159-165 Camden High Street

Plant Noise Assessment

08/3380/R2

Christo & Co

148 Kentish Town Road
London
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Issue	Date
1st Issue	23/07/2009

Prepared by	Checked by
Lee Montague	Philip Hankin

Table of Contents

Attachments

1 Introduction

1.1 Planning permission has been granted for the development of 159-165 Camden High Street. A number of residential apartments will be built above commercial premises on the busy road through Camden. As part of the development, mechanical services plant items will be installed. Planning permission for these items is now being sought.

1.2 Cole Jarman have been commissioned to assess the potential noise impact of the new plant items, against criteria set by the London Borough of Camden.

1.3 This report describes an environmental noise survey conducted at the site and an assessment of noise from the proposed mechanical services plant installation.

2 Site Layout

2.1 The site is located on Camden High Street (A400). The front of the site faces Camden High Street, which is a busy one-way route through the area. The rear of the site is screened from the road and faces the rear of buildings located on Arlington Road, including a parking area.

2.2 Road traffic is the dominant noise source affecting the site, especially at the front façade. At the rear, noise from some existing mechanical services plant items is audible, a small car park was in constant use, but is screened to at least second floor level. It was therefore distant road traffic which was the main source of noise at the rear of the site.

2.3 The existing buildings at 159-165 Camden High Street are commercial in nature. The proposed development will consist of 4 storeys of residential flats above commercial premises at ground level.

2.4 The new mechanical services will be installed on the roof of the development. The plant proposed consists of 3 condenser units which will potentially operate 24 hours a day. There will be 2 No. of Daikin REYQ8M units and a single REYQ12M unit. These will be located towards the north side of the roof, at least 8m back from the building frontage with the road. All of the units will be fully screened from nearby residential windows on the neighbouring properties and are at least 28m from the buildings on the opposite side of Camden High Street.

2.5 The nearest noise sensitive dwellings are found at second floor level of neighbouring property to the north. This building is lower than the site and the windows are located in the façade fronting the road. Therefore the windows are well screened from the roof plant. To the other side, the windows are at 3rd floor level in the façade facing the site but are still screened as the windows are also lower than the roof level of the new development.

2.6 There are also some residential flats above shops on the opposite side of Camden High Street. These are approximately 28m from the proposed plant location and are slightly lower than the roof level of the site.

3 Noise Survey Methodology and Instrumentation

3.1 An unattended noise survey was undertaken to quantify the existing background noise levels in the area to the front and rear of the site.

3.2 The survey was completed over a 24 hour period starting at 1300 on 11th November 2008. Measurement position MP1 was 1m from the front façade at first floor level of 161 Camden High Street, overlooking the High Street. MP2 was 1m from the rear façade of the same property, at second floor level.

3.3 The noise climate at the front façade of the building was dominated by road traffic. To the rear of the site noise levels were much lower, but also consisted primarily of background traffic noise.

3.4 Measurements were made in terms of the L_{Aeq}, $L_{Amax(fast)}$ and L_{A90} noise levels every 15 minutes during the measurement period with a continuously logging sound level analyser (see Glossary of Acoustic Terms for an explanation of noise units used). Spectral data was also recorded.

3.5 Measurements were made using the following equipment:

Item	Manufacturer	Type
Sound Level Analyser	Norsonic	118
Acoustic Calibrator	Norsonic	1251
Weatherproof windshield	Norsonic	1212
Sound Level Analyser	Brüel & Kjær	2260
Acoustic Calibrator	Brüel & Kjær	4231
Weatherproof windshield	Brüel & Kjær	UA 1404

T1 Equipment used during noise survey

3.6 The measurement microphones were fitted with weatherproof windshields and were calibrated before and after the surveys and were found not to have drifted significantly.

3.7 Throughout the survey, weather conditions were dry and mild with very little wind.

4 Noise Survey Results

4.1 The results of the noise measurements are shown in the attached time history graph figures 08/3381/F2 and F3.

4.2 Noise levels at the front of the site are much higher than the rear as it is exposed to the road traffic.

4.3 It can be seen that the minimum measured background noise level over any 15 minute period at MP1 was 53dB L_{A90}, occurring at 0330 hours. At MP2 the minimum recorded level was 46dB L_{A90}, occurring at 0345 and 0500 hours.

5 Plant Noise Limits

5.1 In order to minimise the risk of creating a community noise disturbance, it is recommended that any proposed plant be designed such that it does not elevate the existing noise climate by more than 1dBA at any nearby noise sensitive residential locations.

5.2 This means that any new mechanical plant items must be designed to a combined level that is at least 5dB(A) below the existing L_{A90} background noise level as measured during the relevant time period. In addition there should be no audible tonality or intermittent nature to noise emissions from the proposed plant.

5.3 Plant items found to be having either a tonal characteristic or intermittent nature will need to be designed to a level 5dB below the proposed plant noise limits to compensate for the increased likelihood of disturbance caused by this type of noise.

5.4 This is in line with the planning policy defined in Camden's UDP (June 2006). Policy SD8 (part A) – *'Disturbance from plant and machinery'* states:

The Council will only grant planning permission for plant or machinery, including ventilation or air handling equipment, if it can be operated without causing a loss to local amenity and does not exceed the thresholds set out in Appendix 1 - Noise and Vibration (Table E).

5.5 Table E states the requirement of 5dB(A) below the background L_{A90} at 1m from the external façade of noise sensitive premises. It further mentions that noise that has a distinguishable discrete continuous note (whine, hiss, screech, hum) should be assessed to 10dBA below the L_{A90}.

5.6 Plant noise limits at nearby noise sensitive locations are shown in table T2 below. They are based on the criteria of 10dB below the lowest measured background levels, taking into account the nature of the plant. These noise limits are to apply to the combined effect of all plant items running during the appropriate period as measured 1m from the appropriate window.

Position	Noise Emission Limit, dB(A)	
	Up to 2300 hours operation only	24 hour operation
MP1 – To the front of the site on Camden High Street	50	43
MP2 – To the rear of the site	40	36

T2 Plant noise emission limits at the nearest noise sensitive properties.

6 Plant Noise Assessment

6.1 Our assessment is based upon information and drawings provided by AJD Design Partnership and Neale + Norden limited. The proposed plant installation is described in section 2.4 above.

6.2 The manufacturers' noise data for the condensers are presented in table T3 below. The figures are sound power levels.

Unit	Sound Power Level L_w (dB) @ Octave Band Centre Frequency (Hz)						
	125	250	500	1k	2k	4k	8k
Daikin REYQ8M	83	79	77	71	67	62	57
Daikin REYQ12M	86	84	80	74	70	64	64

T3 Noise Levels for Condenser Units * calculated from sound pressure levels

6.3 In order to meet the noise emission criteria, it will be necessary to partially screen the units. This screen will need be to around three sides of the installation (facing the opposite side of the road and to the sides) no more than 500mm away from the units. The screen must be erected to a height of at least 100mm above the installed height of the units, be of imperforate construction, and extend down to roof level with no gaps at the base.

6.4 The screen must also have a surface mass of at least 10kg/m^2 and the internal face of the enclosure must be acoustically absorbent.

6.5 The attached specification 08/3380/SPC1 details acoustic panels which would be suitable for use in the construction of the screen. The attached figure 08/3380/F3 indicates the extent and location of the screen around three sides of the condensing units.

6.6 We have calculated the predicted noise levels at the windows of the closest noise sensitive premises.

6.7 With the screen in place, the units have been assessed as compliant with the noise limits set at all locations. The calculations have been included for reference in attached Appendix A.

7 Conclusions

7.1 An unattended noise survey has been conducted at 159-165 Camden High Street. The minimum background noise levels over a complete 24 hour period have been quantified.

7.2 The measured levels have enabled us to set plant noise limits to which the new mechanical services plant items will need to adhere to, in order to comply with the requirements of Camden Council.

7.3 A screen has been specified which must be installed around three sides of the installation to a height at least 100mm above the installed height of the condenser units.

7.4 The predicted noise levels at the nearest noise sensitive locations due to the proposed plant installation have been calculated. The installation has been assessed to be compliant with the plant noise limits set.

■ End of Section

Noise Level Time History at Position MP1, 11-12 November 2008

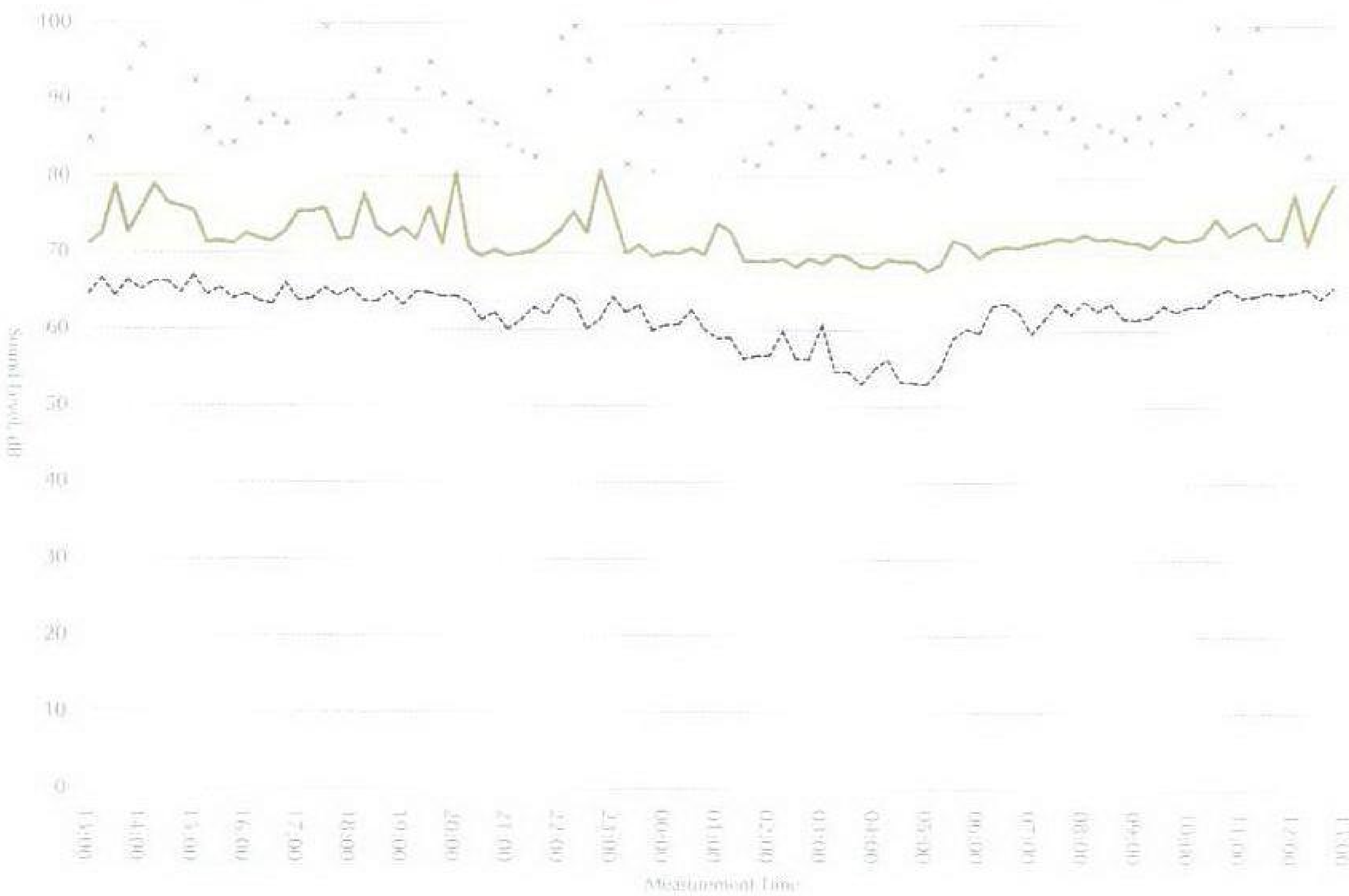


Figure 08/3380/F1

Noise Level Time History at Position MP2, 11-12 November 2008

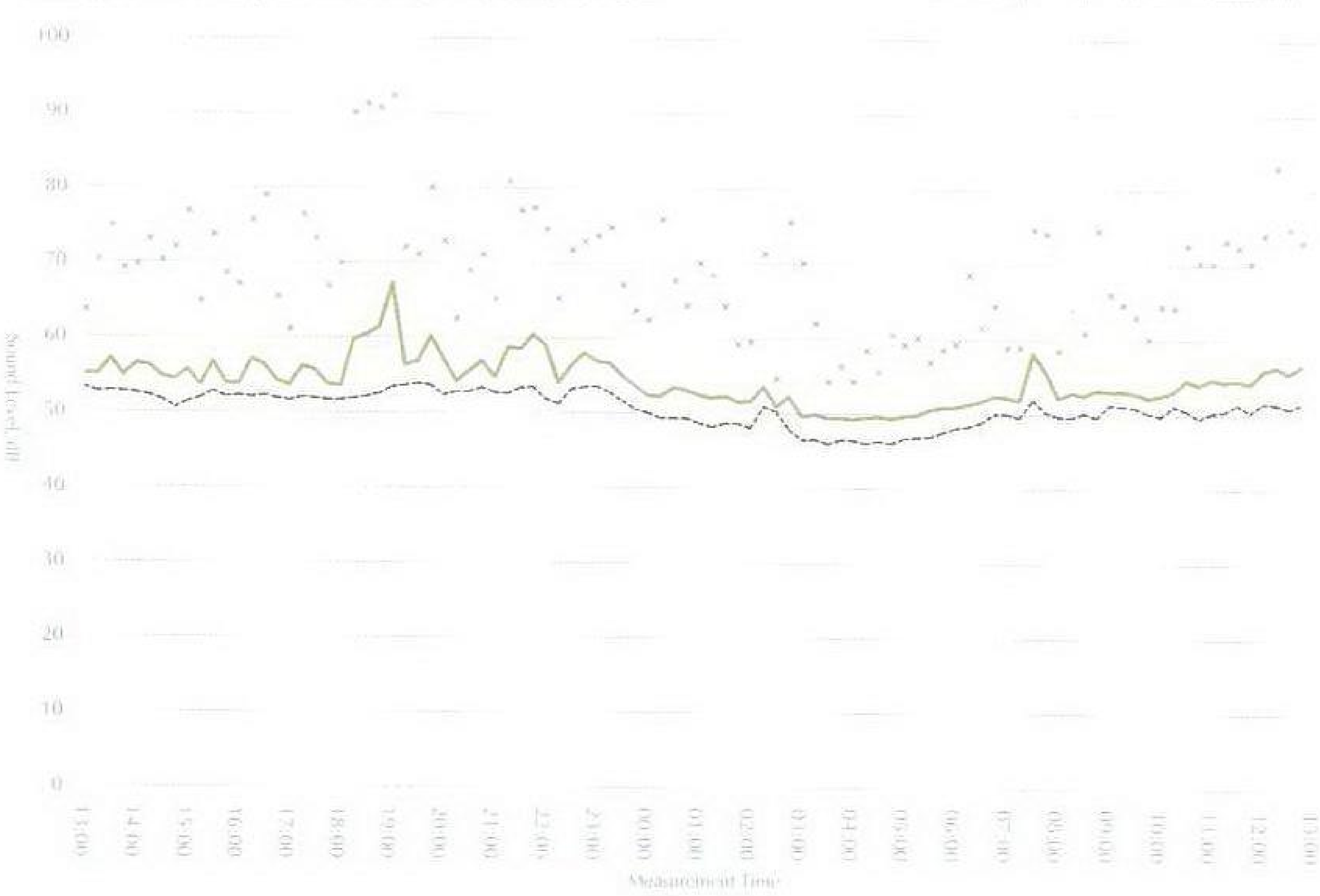


Figure 08/3380/F2

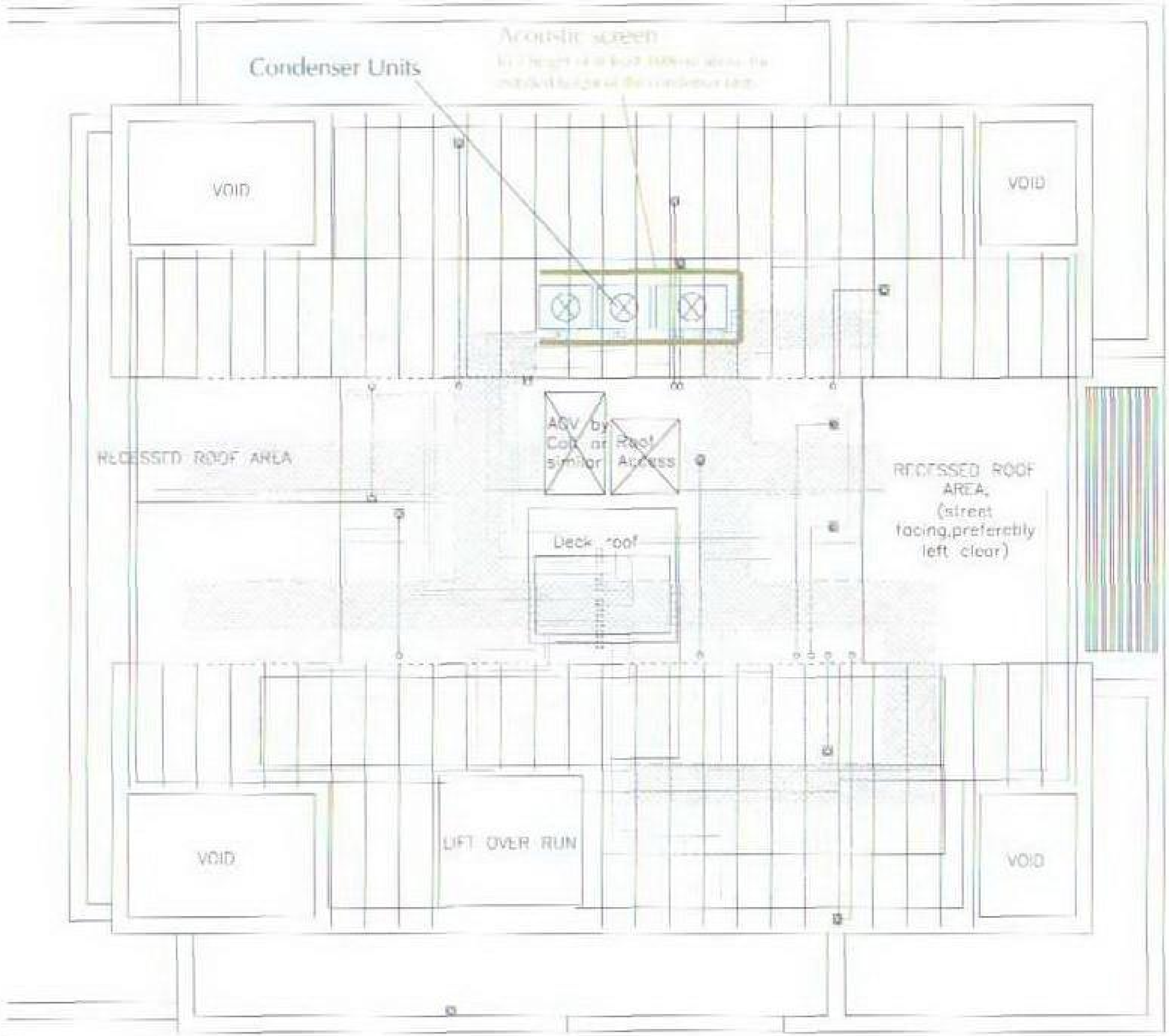
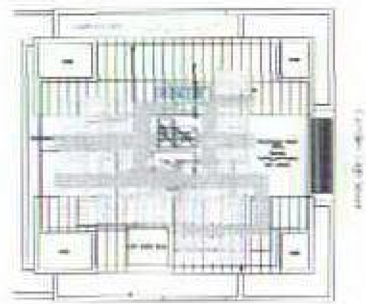


Figure 08/3380/F3

Title:

Roof plan showing location and extent of acoustic screen required around plant items



Project:

159-165 Camden High Street

Date:

23 July 2009

Scale:

Not to scale

Cole
Jarman

Specification 08/3380/SPC1

Project: **159-165 Camden High Street**
Subject: **Acoustic panels to form screened enclosure around rooftop plant area**
Date: **23 July 2009**

1 General

The panels shall be constructed to form a solid enclosure to the extent shown in our drawing 08/3380/F3, to a height of at least 100mm above the installed height of the condenser units.

2 Performance

The internal surfaces of the screen panels shall be designed to give the following minimum average absorption coefficients when tested in accordance with BS 3638:1987:

	Absorption Coefficient (α) @ Octave Band Centre Frequency (Hz)					
	125	**250**	**500**	**1k**	**2k**	**4k**
Minimum absorption coefficient	0.20	0.50	0.70	0.80	0.80	0.70

3 Construction

The screen panels shall be constructed from galvanised mild steel sheet at least 1.2mm thick (18swg) or as otherwise specified. The absorbent internal lining shall be faced with glass fibre cloth or other infill protection membrane and retained by perforated galvanised mild steel sheet having an open area preferably in excess of 20%, and the whole panel should not be less than 50mm thick.

Provision shall be made inside the panel to prevent settling of the acoustic medium. The panels shall be suitably weather protected. In particular panels shall have drain holes as required to avoid soaking of the acoustic medium.

Demountable sections shall be designed to allow easy disassembly and reassembly by unskilled personnel without affecting the acoustic performance.

The supplier shall ensure that the assembled screen is designed and constructed to withstand site operating conditions.

The acoustic media shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure that fibre migration is prevented.

4 Suppliers

The following suppliers would typically be able to design, supply and install a suitable acoustic panel enclosure to screen the plant. Other manufacturers may also be able to provide suitable panels and the following examples are provided for information only.

TEK Limited Seeleys Road Greet Birmingham B11 2LQ	Contact: Paul Virgo Tel: 0121 766 5005 Fax: 0121 766 5010
IAC IAC House Moorside Road Winchester Hampshire SO23 7US	Contact: Mike Jackson Tel: 01962 873 000 Fax: 01962 873 102
Caice Acoustic Air Movement Ltd Riverside House 3 The Pastures Gazelle Close Winnersh Berkshire RG41 5HH	Contact: Andy Smith Tel: 0844 847 5370 Fax: 0844 847 5371
Noico Ltd Patrick House Station Road Hook RG27 9HU	Tel: 01256 766207 Fax: 01256 768413

End of Section

Glossary of Acoustic Terms

L_{eq}:

The notional steady sound level (in dB) which over a stated period of time, would have the same A-weighted acoustic energy as the A-weighted fluctuating noise measurement over that period. Values are sometimes written using the alternative expression dB(A) L_{eq}.

L_{max}:

The maximum A-weighted sound pressure level recorded over the period stated. L_{Amax} is sometimes used in assessing environmental noise when occasional loud noises occur, which may have little effect on the L_{Aeq} noise level. Unless described otherwise, measured using the "fast" sound level meter response.

L_{10} & L_{90}:

If non-steady noise is to be described, it is necessary to know both its level and degree of fluctuation. The LAn indices are used for this purpose. The term refers to the A-weighted level (in dB) exceeded for n% of the time specified. L_{A10} is the level exceeded for 10% of the time and as such gives an indication of the upper limit of fluctuating noise. Similarly L_{A90} gives an indication of the lower levels of fluctuating noise. It is often used to define the background noise.

L_{A10} is commonly used to describe traffic noise. Values of dBL_{An} are sometimes written using the alternative expression dB(A)Ln.

Cole Jarman

Appendix A

Subject: **Noise assessment calculations**
Project: **159-165 Camden High Street**
Date: **23 July 2009**

A1 Assessment Position AP1 – Opposite side of Camden High Street

Unit 1	**Octave Band Centred Frequency (Hz)**							
	125	**250**	**500**	**1k**	**2k**	**4k**	**8k**	**dBA**
Sound Power Level (L_w)	86	84	80	74	70	64	64	81
No of units (1)	0	0	0	0	0	0	0	
Radiation (Hemispherical)	-8	-8	-8	-8	-8	-8	-8	
Distance correction (28m)	-29	-29	-29	-29	-29	-29	-29	
Façade correction (façade incident)	+3	+3	+3	+3	+3	+3	+3	
Screening (0.04m path difference)	-5	-6	-7	-9	-11	-13	-16	
Total (L_p)	47	44	39	32	26	17	15	40

T1 Noise assessment calculation: Unit 1 to AP1

Units 2&3	Octave Band Centred Frequency (Hz)							
	125	250	500	1k	2k	4k	8k	dBA
Sound Power Level (L_w)	83	79	77	71	67	62	57	78
No of units (2)	+3	+3	+3	+3	+3	+3	+3	
Radiation (Hemispherical)	-8	-8	-8	-8	-8	-8	-8	
Distance correction (29m)	-29	-29	-29	-29	-29	-29	-29	
Façade correction (façade incident)	+3	+3	+3	+3	+3	+3	+3	
Screening (0.04m path difference)	-5	-6	-7	-9	-11	-13	-16	
Total (L_p)	46	42	39	31	25	18	10	36

T2 Noise assessment calculation: Units 2&3 to AP1

	Octave Band Centred Frequency (Hz)							
	125	250	500	1k	2k	4k	8k	dBA
Unit 1	47	44	39	32	26	17	15	40
Units 2 & 3	46	42	39	31	25	18	10	39
Total	50	46	42	34	28	21	16	43

T3 Noise assessment calculation: Total at AP1

A2 Assessment Position AP2 – Neighbouring property to south

Unit 1	**Octave Band Centred Frequency (Hz)**							
	125	**250**	**500**	**1k**	**2k**	**4k**	**8k**	**dBA**
Sound Power Level (L_w)	86	84	80	74	70	64	64	81
No of units (1)	0	0	0	0	0	0	0	
Radiation (Hemispherical)	-8	-8	-8	-8	-8	-8	-8	
Distance correction (16m)	-24	-24	-24	-24	-24	-24	-24	
Façade correction (façade incident)	+3	+3	+3	+3	+3	+3	+3	
Screening (0.25m path difference)	-7	-8	-10	-13	-15	-18	-21	
Total (L_p)	49	45	38	30	23	14	11	40

T4 Noise assessment calculation. Unit 1 to AP2

Units 2&3	**Octave Band Centred Frequency (Hz)**							
	125	**250**	**500**	**1k**	**2k**	**4k**	**8k**	**dBA**
Sound Power Level (L_w)	83	79	77	71	67	62	57	78
No of units (2)	+3	+3	+3	+3	+3	+3	+3	
Radiation (Hemispherical)	-8	-8	-8	-8	-8	-8	-8	
Distance correction (16m)	-24	-24	-24	-24	-24	-24	-24	
Façade correction (façade incident)	+3	+3	+3	+3	+3	+3	+3	
Screening (0.25m path difference)	-7	-8	-10	-13	-15	-18	-21	
Total (L_p)	49	43	38	30	23	15	7	40

T5 Noise assessment calculation: Units 2&3 to AP2

	125	250	500	1k	2k	4k	8k	dBA
	Octave Band Centred Frequency (Hz)							
Unit 1	49	45	38	30	23	14	11	40
Units 2 & 3	49	43	38	30	23	15	7	40
Total	52	47	41	33	26	18	13	43

16 Noise assessment calculation: Total at AP2

A3 Assessment Position AP3 – Neighbouring property to north

Unit 1	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	**dBA**
	Octave Band Centred Frequency (Hz)							
Sound Power Level (L_w)	86	84	80	74	70	64	64	81
No of units (1)	0	0	0	0	0	0	0	
Radiation (Hemispherical)	-8	-8	-8	-8	-8	-8	-8	
Distance correction (13m)	-22	-22	-22	-22	-22	-22	-22	
Façade correction (not façade incident)	0	0	0	0	0	0	0	
Screening (3.74m path difference)	-18	-20	-23	-26	-29	-32	-35	
Total (L_p)	38	33	26	17	10	1	0	29

17 Noise assessment calculation: Unit 1 to AP3

Units 2&3	Octave Band Centred Frequency (Hz)							
	125	250	500	1k	2k	4k	8k	dBA
Sound Power Level (L_w)	83	79	77	71	67	62	57	78
No of units (2)	+3	+3	+3	+3	+3	+3	+3	
Radiation (Hemispherical)	-8	-8	-8	-8	-8	-8	-8	
Distance correction (13m)	-22	-22	-22	-22	-22	-22	-22	
Façade correction (not façade incident)	0	0	0	0	0	0	0	
Screening (3.74m path difference)	-18	-20	-23	-26	-29	-32	-35	
Total (L_p)	38	31	26	17	10	3	3	28

18 Noise assessment calculation: Units 2&3 to AP3

Item	Octave Band Centred Frequency (Hz)							
	125	250	500	1k	2k	4k	8k	dBA
Unit 1	38	33	26	17	10	1	0	29
Units 2 & 3	38	31	26	17	10	3	3	28
Total	41	35	29	20	13	1	0	31

19 Noise assessment calculation: Total at AP3

End of Section