Network Rail

Kings Cross Station Enhancement

Energy Statement

ISSUE B

Network Rail

Kings Cross Station Enhancement

Energy Statement

Rep 205

December 2006

This report takes into account the particular instructions and requirements of our client.
It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party

Ove Arup & Partners Ltd
13 Fitzroy Street, London W1T 4BQ
Tel +44 (0)20 7636 1531 Fax +44 (0)20 7755 3743
www.arup.com

Job number

ARUP

Job title	Kings Cross Station E	Job number	54200-61
Document title	Energy Statement Report 205	File reference	
Document ref			

Revision	Date	Filename	Kings Cross Energy Statement.doc		
Draft 1	13/08/06	Description	First draft		
			Prepared by	Checked by	Approved by
		Name	James Thonger	James Thonger	Peter Williams
		Signature			
Issue	14/08/06	Filename	0003Kings Cross Station Enhancement Energy Strategy Issue 1.doc		
		Description	Second draft		
			Prepared by	Checked by	Approved by
		Name	James Thonger	Peter Williams	Peter Williams
		Signature			
Issue A	29/11/06	Filename	0003Kings Cross Station Enhancement Energy Strategy - Rev A.doc		
		Description	Revised following discussions with Camden Council Planners.		
			Prepared by	Checked by	Approved by
		Name	James Thonger	Peter Williams	Peter Williams
		Signature			
Issue B	13/12/06	Filename	0003Kings Cross Station Enhancement Energy Strategy - Rev B.doc		
		Description	Revised following further discussions with Camden Council Planners by Network Rail.		
			Prepared by	Checked by	Approved by
		Name	James Thonger	Peter Williams	Peter Williams
		Signature			

Issue Document Verification with Document ✓

Contents

1 Executive summary

This document describes how the proposed development at Kings Cross Station Enhancement (KXSE) addresses the energy efficiency and renewable energy requirements of the London Plan as defined in the London Plan Policy 4A.7, 8 and 9 and Camden Planning Policy SD9C.

In accordance with the London Plan, the development incorporates design features that significantly reduce energy consumption by more than 26% compared with other developments of its kind.

An evaluation of renewable energy sources using the guidelines of the London Renewables toolkit shows that photovoltaic cells and,subject to further assessment, biomass boilers are renewable technologies that could be used in this development.

Using this report as the basis of energy consumption it is proposed that, subject to the necessary approval of local and national bodies, Network Rail will commit to providing 10% of the energy consumption of the development by a combination of wood pellet boilers and Photovoltaic arrays. The exact ratio of wood pellet to Photovoltaic Cells will be determined at a later date.

2 Introduction

The design team has followed an holistic approach to sustainability and a series of measures has been incorporated in the design to reduce the carbon emissions of the development. This is achieved by reducing the energy demand from the office development and the retail accommodation spaces as well as ensuring an efficient delivery of the energy required. At this stage, the measures considered to achieve this goal include:

- Passive solar shading devices and natural ventilation of the concourse
- Improvement of the office façade thermal performance
- Reuse of heat from the retail units to heat the concourse
- Low energy lighting and enhanced lighting control
- Wood-pellet-fired boilers

Preliminary estimates show that the carbon emissions of the proposed scheme are more than 20% lower than those given as a benchmark in the London Renewables Toolkit. This level of energy usage will be comparable to the latest Building Regulations Part L. These measures are inline with the approach taken by the GLA and defined in the 'Energy Hierarchy' of the Energy Strategy in the London Plan.

This document addresses the requirements of the London Plan and considers the feasibility of a number of renewable technologies and evaluates their impact in terms of cost and carbon emissions following the guidelines proposed in the London Renewables Toolkit.

3 Baseline carbon emissions

The energy demand of the development has been calculated following the method proposed by the London Renewables Energy Toolkit (section 4.3.2 of the Toolkit), taking into account the following end uses:

- Space heating and hot water, fans, pumps and controls
- Gas catering
- Refrigeration/cooling
- Lights and appliances
- Centralised IT
- Other miscellaneous electricity

The figures below show the 'Benchmark carbon emissions' and are taken from Table 6 in section 4.3.3 of the London Energy Partnership document entitled 'Integrating renewable energy into new developments: Toolkit for planners, developers and consultants' dated September 2004 which will be referred to as 'The Toolkit' in this report.

	Gross Internal floor area	Benchmark predicted annual delivered energy requirements		Benchmark carbon emissions arising from		Benchmark total carbon emissions
		Electricity	Gas	Electricity	Gas	
Carbon emission factor (kgC/kWh) *	-	-	-	0.115	0.053	
	m²	kWh/year	kWh/year	kgC/year	kgC/year	kgC/year
Office **	3,827	489,856	371,219	56,333	19,675	76,008
Retail ***	2,271	619,983	0	71,298	0	71,298
Restaurant ****	471	386,220	226,080	44,415	11,982	56,397
Concourse *****	5525	1,215,500	0	139,783	0	139,783
Pub ******	415	269,750	456,500	31,021	24,195	55,216
Total						**398,702**

Note: * Carbon emission factors are given by the Building Regulations Part L 2006.

**The Office figure is based on a good practice Type 3 Standard Office with a gas load of 97 and an electrical load of 128 kWh/m²/year – this is because the offices are refurbished offices with standard air conditioning.

*** The retail figure is based on the benchmark of 273 kWh/m²/year which is the figure advised by Camden for retail spaces when the occupier is not known.

**** The Restaurant figure is assumed to be fast food with a gas load of 480 and an electrical load of 820 kWh/m²/year

***** This figure is based on the estimate of 220 kWh/m²/year electrical load on a space with 24 hour access which includes external lighting to the façade.

****** This figure (Bar) is based on a Restaurant with Bar and has a gas load of 1100 and an electrical load of 650 kWh/m²/year

4 Proposed energy efficiency design measures

4.1 Office building energy efficient design

4.1.1 Façade

The office building is an existing structure that is Grade 1 listed, and as a result the amount of refurbishment that can be achieved is limited. However, it is proposed to add secondary glazing to the windows, which will improve the performance of the façade in terms of both heat transfer and air leakage.

4.1.2 Building location

The building benefits from existing windows that are not excessively large and that there is a very good degree of external shading afforded by the existing concourse to the east and the new concourse to the west.

Both concourses will serve to moderate the environment immediately external to the offices, thereby reducing the heating and cooling demands over the year.

4.1.3 Roof

It is intended that during the refurbishment, the roof covering and insulation will be renovated and replaced where necessary to improve the insulation levels to comply with new Part L Building Regulations requirements. This will serve to reduce heat loss in winter and heat gain in summer.

4.1.4 Combined heat and power

Initial assessments have been undertaken that suggest that a gas-fired CHP installation will not be feasible because there is very little hot water heating requirement for the development. Without a significant heating demand the installation would not be energy efficient and would not be commercially viable.

It has been suggested by Camden that it may be possible to connect to a CHP installation being proposed by the adjacent development (King's Cross Central). Whilst this may be true, the combination of relatively low heat demand and the fact that the heat demand is only in the Winter months means that the requirement for heating in this development does not fit the energy profile required for a CHP installation. In addition, it is proposed that one of the most effective ways to provide heating to this development is by using wood pellet boilers which have a lower carbon footprint than any CHP installation.

4.1.5 Combined Cooling and Power

Calculations show that using waste heat from a gas or oil fired generator installation to drive an absorption chiller for chilled water production is at least 7% more carbon intensive than using a conventional chiller installation using mains supplied electricity. This is particularly the case when the primary fuel source is natural gas which has low carbon intensity and can be converted to electricity with efficiencies of up to 57% in combined-cycle gas-fired power stations. As a result, there is no carbon benefit in using an absorption chiller in this situation.

The use of Absorption chillers should only be considered in situations where (as the result of a particular process) there is waste heat available. The use of small scale inefficient generators installed in buildings is not energy efficient, even if the waste heat is used in absorption chillers. This is true of all Combined Cooling and Power plants using fossil fuel as the primary fuel source and as a result should not be installed in any building in the UK unless conversion efficiencies increase significantly.

In addition, the Mayor of London has stated that he is concerned about the high temperatures experienced in London in summer and that these temperatures need to be reduced. These high temperatures will further increase if widespread use of Combined Cooling and Power is employed in London.

4.1.6 Building Systems Controls

A full Building Management System (BMS) will be installed to minimise the building plant hours of operation, vary the water flow rate for heating and cooling, prevent simultaneous heating and cooling in the same zone, and control plant capacity to ensure good part-load efficiencies.

4.1.7 Lighting Control

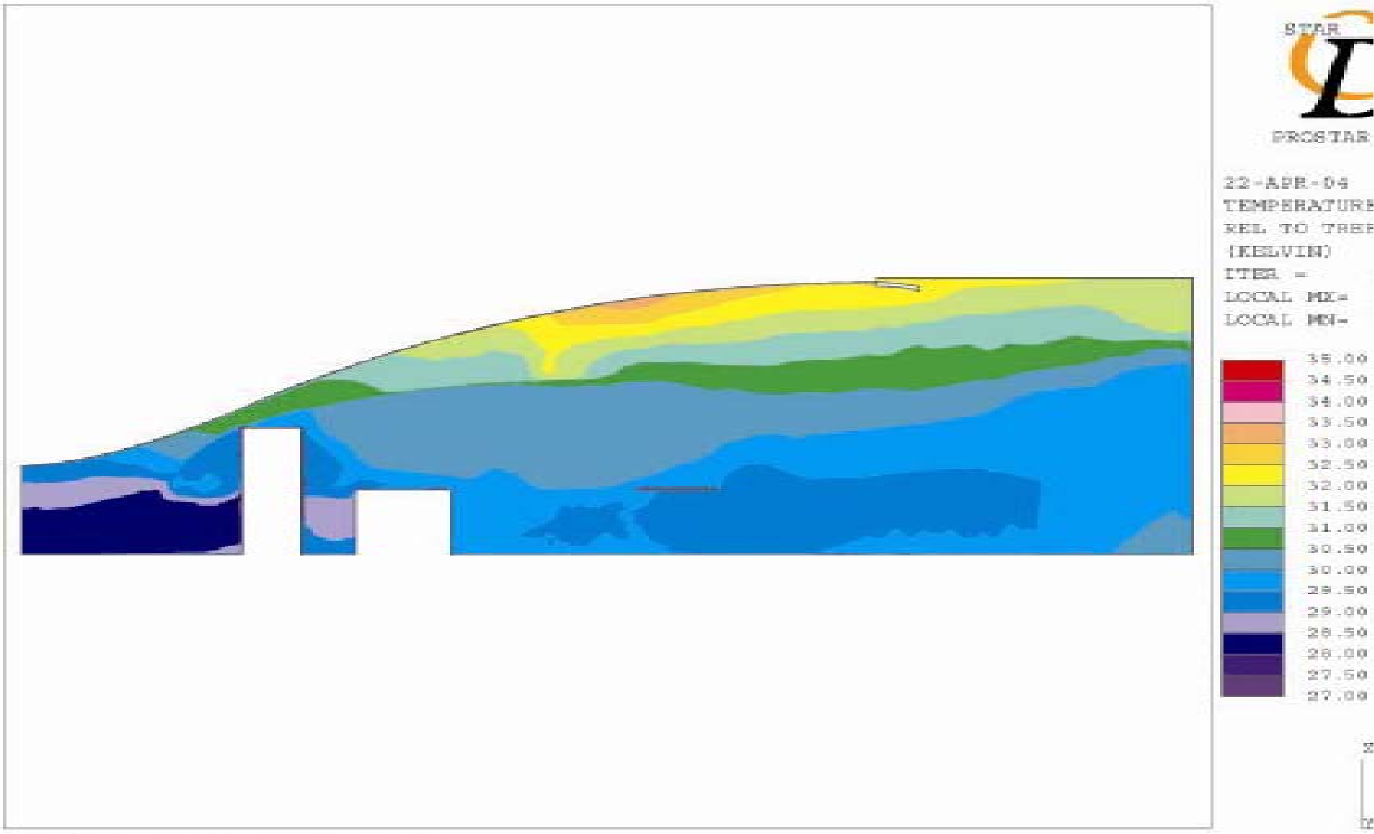
A lighting control system will be installed to allow zonal switching based on occupancy detectors. Lighting will be switched off after a fixed time when people are no longer detected in the zone.

Daylight controlled lighting will be installed adjacent to the building perimeter. This will automatically dim the artificial lighting when the daylighting conditions inside the office allow.

4.2 Retail Units and Concourse Energy Efficient Design

The retail units and concourse benefit from the following energy saving features:

- The retail units are located within the concourse, which is a naturally ventilated space within an insulated building envelope. As a result the occupants are shielded from the extremes of the external atmospheric conditions. This means that the temperature range experienced by the building occupants will be less than the existing concourse, meaning greater levels of comfort for the occupants than current concourses in London. Computational Fluid Dynamic simulations of the Concourse show that the space is considerably more comfortable for occupants and users than existing buildings of this type.
- The concourse has an insulated roof, which means that the internal temperatures are moderated.
- The concourse benefits from warm air transfer from the retail units extract in Winter, thereby reusing the heat generated within the retail units.
- Low energy lighting will be installed throughout the concourse
- An intelligent lighting control system will be installed to control the lighting within the Concourse. The lighting will be controlled with time clocks, light sensors and presence detectors where suitable to reduce the amount of electrical demand.
- It should be noted that the fitting-out of all retail units is not part of this submission, as a result, it is not possible to state whether the retail tenants will install energy efficiency devices within their tenancies. Energy saving devices such as using heat recovery of the kitchen extract ventilation may be investigated when a Tenant leases the retail units.



Kings Cross Western Concourse
Case 2: Summer analysis (15:00 hours) - Section perpendicular to rooflights
ARD - 54200/52 - DK

5 Baseline carbon emissions and predicted energy demand

As a result of the energy efficiency designs described above, the following approximate energy consumption improvements have been calculated in comparison with the benchmark figures:

Office Accommodation - 30% improvement

Retail - 20 % improvement

Restaurant - 20% improvement

Concourse - 33% improvement

Pub - 20 % improvement

As a result, baseline energy demand for the KXSE development is calculated as:

Breakdown of site predicted baseline carbon emissions

	Gross Internal floor area	**Benchmark predicted annual delivered energy requirements**		**Benchmark carbon emissions arising from**		**Benchmark total carbon emissions**
		Electricity	**Gas**	**Electricity**	**Gas**	
Carbon emission factor (kgC/kWh)	-	-	-	0.115	0.053	
	M²	**kWh/year**	**kWh/year**	**kgC/year**	**kgC/year**	**kgC/year**
Office	3,827	342,899	259,853	39,433	13,772	53,205
Retail	2,271	495,986	0	57,038	0	57,038
Restaurant	471	308,976	180,864	35,532	9,586	45,118
Concourse	5525	814,385	0	93,654	0	93,654
Pub	415	215,800	365,200	24,817	19,356	44,173
Total						**293,188**

The above analysis shows that the predicted reduction of carbon is 104,884 kg of Carbon which is a total reduction of 26% less than the baseline carbon emissions.

In order to achieve a 10 % carbon source from renewables the target energy produced is 29,319 Kg.C/year.

6 Renewables

The following evaluation of renewable technologies, estimates of energy demand, carbon emissions and costs constitute a planning stage assessment and should not be relied on as a detailed design assessment.

6.1 Renewable technologies shortlist

The Mayor's Energy Strategy sets a target of 10% of the base energy demand to be generated from renewable sources where feasible, and proposes a list of renewable energy technologies to be considered for new London residential developments:

- Wind generators
- Photovoltaic cells
- Solar water heating
- Biomass heating
- Biomass CHP
- Ground source heat pumps

The feasibility of each technology has been evaluated following the guidance provided in the London Renewables Toolkit (paragraphs 4.1.1 to 4.1.10), taking into account the particular constraints of this development.

6.1.1 Wind generators

Wind power is best captured by large wind turbines, and their output is a function of the square of the wind speed. The strongest winds are found at height, in coastal regions away from any features that break up the flow of wind. This development is in a city centre, surrounded by taller buildings and away from the coast. Any wind turbines would be best located on the roof of the Western Range buildings. This is a Grade I listed structure and any roof-mounted generators would need approval from English Heritage. The size of any generators would be limited by the structural capacity of the existing building to carry the load from the generators. Whilst the load will generally be low due to the low wind speeds, the connections would have to be able to withstand the maximum possible wind speeds in the area. The building is of 1850's masonry construction which was not designed for these additional loads.

For these reasons the use of wind generators is discounted.

6.1.2 Photovoltaic cells

The energy output of photovoltaic (PV) cells depends greatly on their orientation and is a maximum for south facing arrays not subject to overshadowing from nearby buildings. Consequently, a study has been undertaken to install PV cells on the roof of the main train shed roof, offices and the taxi canopies to the West of the development.

6.1.3 Solar water heating

The development does not present a year round domestic hot water demand. Therefore, solar water heating systems are not suitable for this development.

6.1.4 Biomass Heating

The development will consider the installation of a wood pellet fired boiler to serve the office building. The system would be sized to supply approximately 66% of the theoretical maximum peak heating load in the buildings. The wood pellets are manufactured using a combination of sawdust (from saw mills) and ground wood chips and are almost carbon neutral in their production.

Fuel pellets would be delivered using 10 tonne blower delivery trucks, which would discharge the pellets into a fuel silo. The total amount of fuel required for the development is expected to be approximately 30 tonnes of fuel per annum. This would require approximately 3 deliveries of fuel between the months of October to March.

Currently there are difficulties in locating both the boilers and the wood pellet fuel store on site. The only currently identified potential suitable location for the plant is in the existing basement of the office building. During the next stage of design the designers will assess the impact of installing these boilers within the existing building and the impact of the fuel delivery trucks which will need to cross the open area to the front of the station. It is anticipated that the inclusion of wood pellet boilers will have knock-on effects to the basement layouts, possibly requiring a lowering of the basement floor slab and may affect the Tenancy spaces currently identified. These effects will be assessed in the next stage of design.

6.1.5 Ground source heat pumps for heating and cooling

Ground source heat pumps need to be used for both heating and cooling as a year-on-year excess of either heat absorption or rejection into the ground will make it colder or warmer, eventually reaching the point where the system ceases to function efficiently.

Vertical pipe loops in bore holes present the highest potential output and the installation considered in this analysis consists of vertical pipes in bore holes distributed over the whole site.

The site is directly over the numerous underground railway lines and utilities distribution that serve Kings Cross and as a result, ground source heat pumps are not considered feasible for this development.

6.2 Contribution of photovoltaics to renewable energy

6.2.1 Areas for PV Arrays

The feasibility of using photovoltaics has been evaluated in more detail. The energy output of the photovoltaic array has been estimated using the benchmark figures proposed by the London Renewables Toolkit and supplemented with more detailed analysis of the proposed PV locations taking into account the PV orientation and the effects of surrounding buildings, in particular St Pancras Station.

There are several areas of roof that could be considered for installation of PV:

- **The Exit Canopy** to the south of the train sheds (shown in green in Figure 2) giving an area of 725 m².

- **Main train shed roofs**: these are 'listed' and any work is subject to English Heritage approval; however, the area of roof that is potentially suitable for the installation of PV is very significant. It is believed that it will be possible to install PV at the apex of the two train shed roofs (shown in red in Figure 1 and in yellow in Figure 2 below), provided that the orientation follows the line of the existing roof. These roofs provide a surface area of approximately 2,927 m². Despite the building's listed status it is believed that the Train Shed Roofs offer the most likely acceptable location of PV as far as English Heritage are concerned due to the fact that the chosen location is the least visually intrusive of the roofs available and that they are already fitted with maintenance walkways.

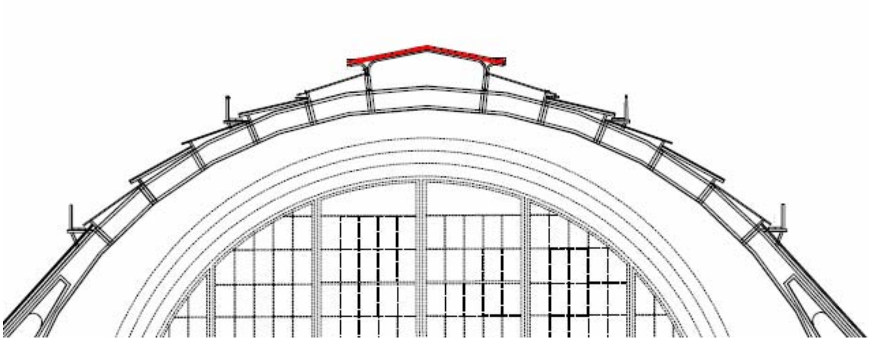


Figure 1: Train shed roof orientation

- **Concourse:** much of the concourse is tilted away from the sun and so reduces the efficiency of collection of solar energy by PV. In addition the concourse is shaded by the surrounding buildings and being a curved surface will mean that the cost of installing PV's on this surface will be considerable more expensive than the other surfaces identified in this report. Given the visual nature of this new roof and the complexities that the curved form will give to the installation of PV's it is preferred not to install PV on this roof. If it were insisted that PV's are to be installed on this roof then the design of the roof will need to be significantly changed to install the PV panels and the associated permanent walkways (required for regular cleaning access and maintenance as part of the CDM regulations). It is unlikely that these revisions will retain the visual integrity of the roof. As a result of the above, the Concourse Roof is not considered suitable for the installation of PV cells.

- **Taxi Drop-Off Canopy**: located to the west of the concourse provides a surface of approximately 560 m² (shown in orange in Figure 2).

- **Taxi Pick-Up Canopy:** located to the south-west of the concourse, this canopy provides a surface of approximately 510 m² (shown in orange in Figure 2).

- **Western Range Roof:** this relates to the existing roof over the Western Range offices which have a listed building status. These roofs are generally a pitched construction inclined towards the East and West. The roofs are punctured with a number of large chimney stacks (see Figure 2) which will significantly affect the PV output. It would only be 51% efficient. In addition to the installation of the PV cells, the roofs will need to be fitted with permanent access walkways for regular cleaning and maintenance access in accordance with CDM regulations. These walkways and access points will be permanently installed structures which are likely to be highly visible. An area of 958 square meters of PV suitable roof has been identified in an initial study, however, due to the difficulties stated above; these areas are not as suitable as the other areas identified in this report for the installation of PV. As a result, the following analysis does not consider this location.

- **Eastern Range Offices:** this relates to the existing roof over the Eastern Range offices which already have a Listed Building Consent and which do not form part of this submission. These roofs are generally a pitched construction inclined towards the East and West. The roofs are punctured with a number of large chimney stacks which have listed status (see Figure 2) which will significantly affect the PV output. It would only be 60% effective. In addition to the installation of the PV cells, the roofs will need to be fitted with permanent access walkways for regular cleaning and maintenance access in accordance with CDM regulations. These walkways and access points will be permanently installed structures which are likely to be highly visible. An area of 2196 square meters of PV suitable roof has been identified in an initial study, however, due to the difficulties stated above; these areas are not as suitable or efficient as the other areas identified in this report for the installation of PV. As a result, the following analysis does not consider this location.

Note that the canopy areas specified are indicative only and based on the size and design of the canopies originally submitted as part of the Planning and Listed Building Consent Applications. It has been agreed with LB Camden that the exact dimensions of the taxi canopies are to be agreed post-determination of the applications through condition. The exact size and design of the Exit Canopy is currently being finalised through discussions with LB Camden and other key stakeholders

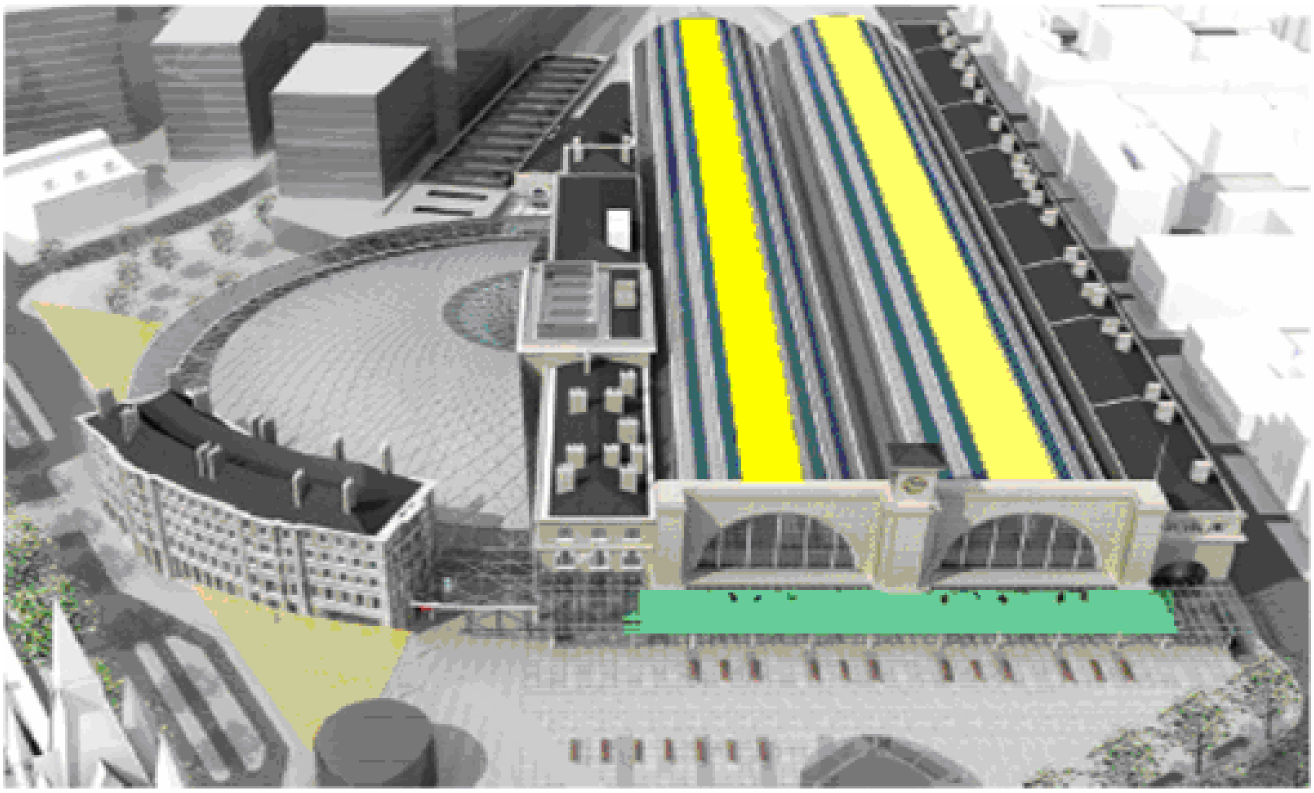


Figure 2: Potential PV module locations.

The total area of roof suitable for installation of PV is approximately 4722m². However, due to its inclination and orientation, the PV annual energy production will under-perform from the optimum by between 9% and 26% relative to optimum conditions as follows :-

Exit Canopy	**725 m²**	**91% effective**
Train Shed Roof	**2927 m²**	**82% effective**
Taxi Drop-Off Canopy	**560 m²**	**78% effective**
Taxi Pick-up Canopy	**510 m²**	**74% effective**

It should be noted that the canopies are subject of further discussion and the exact areas allocated may change.

6.2.2 Photovoltaic Cell Types

Photovoltaic (PV) cells utilise semiconductor technology to convert solar irradiance (sunlight) into electrical energy. Currently all of the main photovoltaic technologies are silicon based, and are classified as either:

• **crystalline** (sliced from ingots or castings or grown ribbons),

• or **thin film** (deposited in thin layers on a low cost backing).

6.2.2.1 Mono crystalline PV

Single crystal silicon cells are usually manufactured from a single crystal ingot, most commonly grown by the Czochralski method. The ingot is cut into thin slices which are processed to make solar cells. The basic design of a crystalline silicon cell is shown in F**igure 3**. The thickness of the substrate is 200-400 μm while the thickness of the front surface doping (emitter) layer is less than 1 μm. On the front side, a metallisation grid consists of fingers to conduct the generated current to central collectors (busbars). The selected metallization pattern is a compromise between shadow losses and resistance losses. To increase the amount of light absorbed into the cell, which will result in higher currents, an anti-reflection coating (thin layer that results in the typical blue colour) is used. To improve the light absorption, the front surface can be textured.

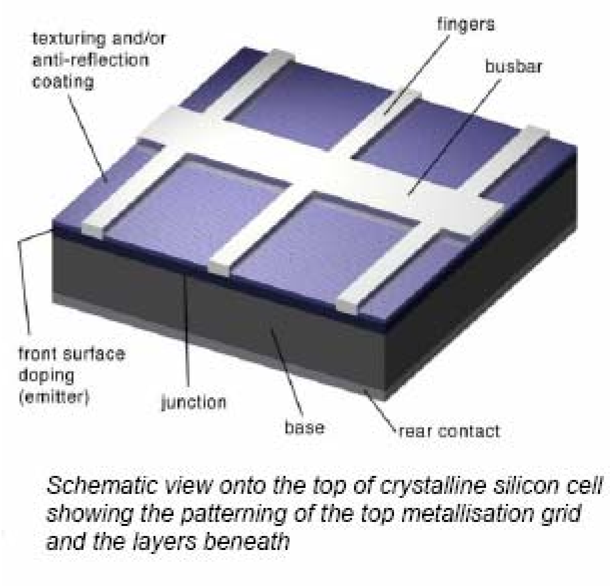


Figure 3: Mono-Crystaline Silicon PV Cell

6.2.2.2 Polycrystalline PV

PV cells made from Polycrystalline silicon have now become popular as they are less expensive to produce, although slightly less efficient. Polycrystalline cell manufacture usually begins with a thermal process in which silicon is melted and solidified in such a way that crystals are oriented in a predetermined direction. This produces a rectangular ingot of Polycrystalline silicon that is then cut into blocks or bricks. These are finally sliced into thin wafers that are used to make the cells, similar to the completion of single crystal cells.

6.2.2.3 Thin Film PV

Thin film modules are constructed by depositing extremely thin layers of photovoltaic materials on a low cost support, such as glass, stainless steel or plastic. Individual 'cells' are formed by then scribing through the layers with a laser. Thin film cells offer the potential for cost reductions. Initial material costs are lower because much less semiconductor material is required. Labour costs are reduced because the films are produced as large, complete modules and not as individual cells that have to be mounted in frames and wired together. The most fully developed thin film technology is hydrogenated **amorphous** silicon. This is the material normally used in consumer applications, although it is used, but less frequently, in power modules. The efficiency of commercial amorphous silicon modules has improved from around 3.5 % in the early 1980's to over 7 % currently.

6.2.2.4 Hybrid PV

Hybrid modules incorporate a combination of amorphous thin film and single-crystalline technologies. This results in a higher efficiency than either of the cell types individually with a marginal increase in cost.

6.2.3 PV Maximum Power Output

Table 1 gives relative efficiencies for each PV technology.

Type	**Typ. Module efficiency**	**Energy payback of Embodied energy**
Mono Crystalline	12-15%	4-5 years
Polycrystalline	11-14%	~4 years
Hybrid	17-18.5%	~4 years
Thin Film	5-7%	0.5 - 2 years

Table 1: PV technology efficiency

6.2.4 Photovoltaic Cell Energy Analysis

Initially a product example was obtained for each of the four main PV technologies for comparative purposes. The Mono-crystalline PV option was immediately abandoned as the Hybrid PV system offered superior efficiency for a minor increase in capital cost. The relative efficiencies and capital costs for the selected options in their optimum configurations are shown below:-

PV Type	**Cost** **£ / m²**	**PV Output (annual)** **kW.hr per m²**	**Comparison** **£ / kW.hr (annual)**
Polycrystalline	763	97kW.hr	7.87
Hybrid	1060	132 kW.hr	8.03
Thin Film	427	46 kW.hr	9.36

Table 2: Optimum PV output

From this analysis, it can be seen that the most cost effective PV installation is poly-crystalline, whereas the highest output per m² is the Hybrid variety. The thin film PV is the least efficient and the most expensive option.

From Section 5 we are given that in order to achieve a 10 % carbon source from renewable energy sources the target energy produced is 29,319 Kg.C/year. If this target was to be produced using PV technology alone, the development will need to produce a total of (29,319 / 0.115) = **254,950 kW.hr** per year. Given that the installation would be likely to install PV in it's most cost effective locations the three types of PV would use the entrance canopy first (725 m²), then the train shed roof (2,927 m²), then the Taxi Drop-Off Canopy (560 m²) and finally the Taxi Pick-Up Canopy (510 m²).

The resulting installations required to provide 254,950 kW.hr/annum are as follows :-

Polycrystalline – 97 kW.hr/m² @ 763 £/m²				
	Efficiency	**Area**	**Output/ kW.hr**	**Cost / £**
Exit Canopy	91%	725	63,995	553,175
Train Shed Roof	82%	2400	190,955	1,831,200
Taxi Drop-Off Canopy	78%	0	0	0
Taxi Pick-up Canopy	74%	0	0	0
Total for Polycrystalline			**254,950**	**2,384,375**

Hybrid – 132 kW.hr/m² @ 1060 £/m²				
	Efficiency	**Area**	**Output/ kW.hr**	**Cost / £**
Exit Canopy	91%	725	87,087	768,500
Train Shed Roof	82%	1550	167,863	1,643,000
Taxi Drop-Off Canopy	78%	0	0	0
Taxi Pick-up Canopy	74%	0	0	0
Total for Hybrid			**254,950**	**2,411,500**

Thin Film – 132 kW.hr/m² @ 427 £/m²				
	Efficiency	**Area**	**Output/ kW.hr**	**Cost / £**
Exit Canopy	91%	725	30,350	309,575
Train Shed Roof	82%	2,927	110,410	1,249,829
Taxi Drop-Off Canopy	78%	560	20,090	239,120
Taxi Pick-up Canopy	74%	510	17,360	217,770
Total for Thin Film			**178,210***	**2,016,294**

*** Note:** *Thin film fails to provide the renewable energy target of 10% of the annual energy consumption. With a maximum coverage the thin film PV only provides 7.0% of the annual energy consumption.*

From the above it can be seen that both the Polycrystalline and the Hybrid PV's can provide the required power output, with the Polycrystalline PV being the most cost effective.

The Thin Film PV does not provide sufficient power and is the least cost effective.

Space for the PV electrical inverters and switch panels will need to be located during the next design stage of the project.

6.2.5 Cost of PV installation

The above studies indicate that PV would contribute to the reduction of carbon emissions and that polycrystalline PV will give the best payback. With regard to costs, this planning application does not take into account any possible grant assistance since there is no guarantee that it will be available in the future.

Based on the costs given above based on the poly-crystalline, the following table details the cost efficiency of the PV installation:

Technology	Reduction of base carbon emissions	Estimated cost of installation	Reduction in carbon emissions	Cost efficiency
	%	£	kgC / annum	£ / kgC saved
Polycrystalline cells	10 %	**2,384,375**	**29,319**	**81.33**

At a cost of 7p per kW/hr of electricity the overall energy saving would be £17,850 per annum which would mean that the initial cost of the photovoltaic array would be paid back in 134 years. This does not take into account any annual maintenance costs, replacement costs or finance costs, which would further increase the payback time.

6.3 Contribution of wood pellet boilers to renewable energy

Using the London Toolkit, the development is expected to generate carbon emissions of 293188 kgC/year. The carbon emissions arising from heating the offices are calculated to be 13,772 kgC/year, which is 4.7% of the total carbon emissions of the development. It is proposed that at least 80% of this heating load will be supplied using wood pellets.

Using Table 2 of the Building Regulations, Part L2 the carbon emission factor given for Natural Gas is 0.194 $kgCO_2/kWh$ and the carbon emissions factor given by biomass is 0.025 $kgCO_2/kWh$. As a result the biomass fuel source emits (0.025 / 0.194) 12.9% of the carbon of the natural gas fuel source.

The saving in carbon by using biomass instead of natural gas is therefore calculated as follows:-

Baseline carbon emissions for the whole development is			**293188** kgC/annum
Baseline carbon emissions for the offices gas heating is			13,772 kgC/annum
Carbon from natural gas (proposed 20%)	= 13,772 x 0.20	=	2,754 kgC/annum
Carbon from wood pellets (80%)	= 13,772 x 0.80 x 0.129	=	1,421 kgC/annum
Total carbon using proposed boiler combination		=	**4,175** kgC/annum
Giving a saving of (13,772 – 4,175)		=	**9,597** kgC/annum

Which is a percentage saving of (9597 / 293188) x 100 = 3.3 %

The potential difficulties in installing a biomass facility are set out in paragraph 6.1.4 of this report.

7 Conclusion

An energy demand calculation for the building has been undertaken using figures given in the London Toolkit.

There is sufficient space to generate a maximum saving of at least 10 % in carbon using polycrystalline PV cells at a cost currently estimated as £2.4m.

Analysis shows that a wood pellet boiler installation would reduce the carbon emissions for the whole development by approximately 3.3%. There is currently a shortage of space for fuel storage and the installation of the wood pellet boilers. The next stage of detail design will investigate the potential difficulties posed by the location of the boiler installation and fuel store. In addition consideration will need to be given to how fuel is delivered to the bulk fuel store.

Using this report as the basis of energy consumption it is proposed that, subject to the necessary approval of local and national bodies, Network Rail will commit to providing 10% of the energy consumption of the development by a combination of wood pellet boilers and Photovoltaic arrays. The exact ratio of wood pellet to Photovoltaic Cells will be determined at a later date.