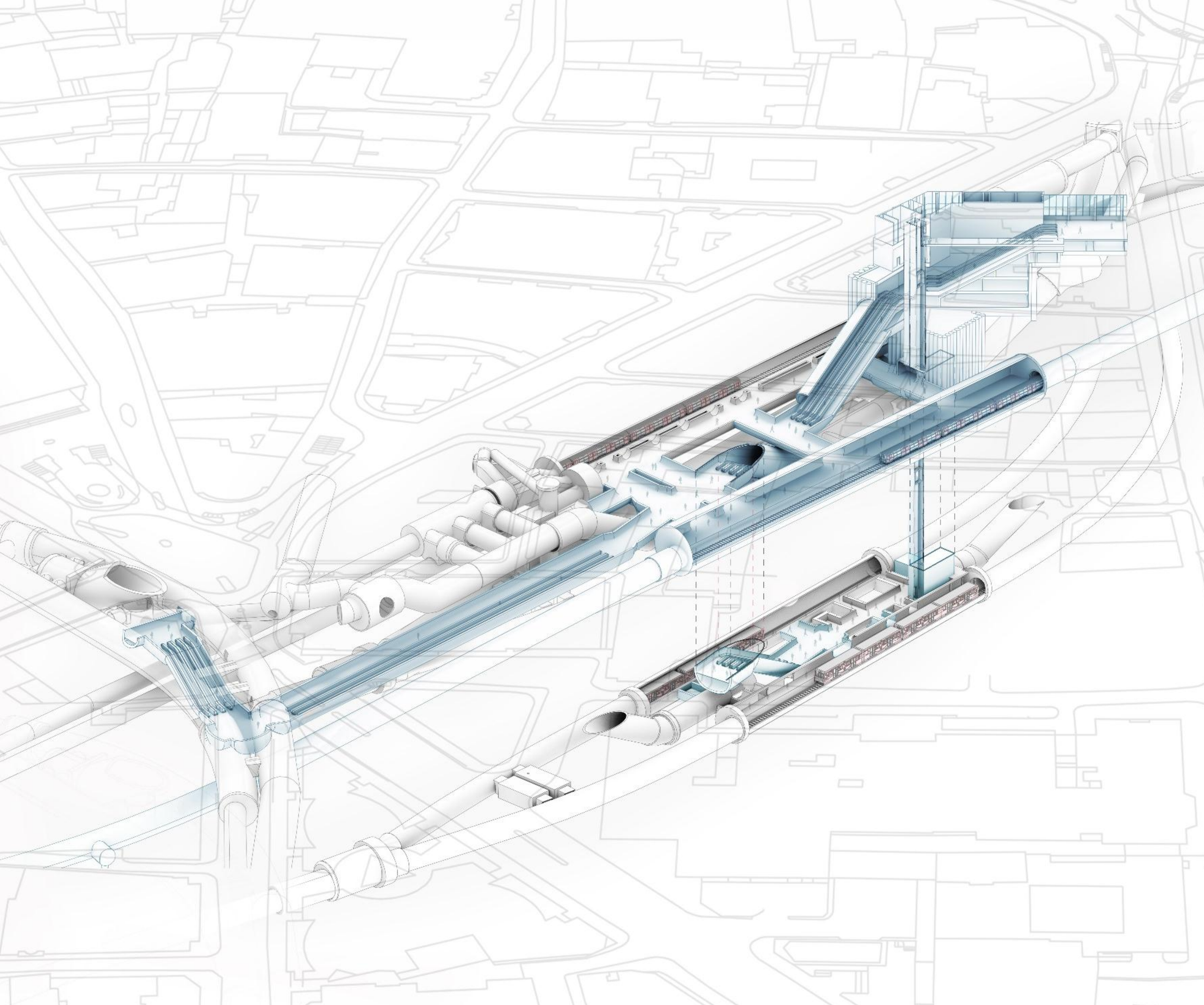
A6.3 – Energy Statement



Transport and Works Act 1992

London Underground (Bank Station Capacity Upgrade) Order

Energy Statement

September 2014

MAYOR OF LONDON

TRANSPORT FOR LONDON
EVERY JOURNEY MATTERS

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Bank Station Capacity Upgrade Project
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List of Abbreviations

Abbreviation	Definition
ADL	Approved Document L
AHU	Air Handling Unit
AQMA	Air Quality Management Area
ASHP	Air Source Heat Pumps
BMS	Building Management System
BSCU	Bank Station Capacity Upgrade
CCHP	Combined Cooling Heat and Power
CEEQUAL	Civil Engineering Environmental Quality and Assessment Scheme
CHP	Combined Heat and Power
CIBSE	Chartered Institution of Building Services Engineers
CLP	Construction Logistic Plan
CoCP	Code for Construction Practice
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalent
DEN	District Energy Network
DHW	Domestic Hot Water
DLR	Docklands Light Railway
DSM	Dynamic Simulation Model
EU	European Union
GLA	Greater London Authority
GSHP	Ground Source Heat Pump
H_2	Hydrogen
HSE	Health, Safety and Environment
ISO	International Standards Organization
LED	Light Emitting Diode
LUL	London Underground Limited
LZC	Low and Zero Carbon
M&E	Mechanical and Electrical
MVHR	Mechanical Ventilation Heat Recovery
NO_X	Nitrogen Oxide

Abbreviation	Definition
NPPF	National Planning Policy Framework
PIR	Passive Infra Red
PM_{10}	Particulate Matter (of 10 Microns in diameter or smaller)
PSD	Platform Screen Doors
PV	Photovoltaic
SHW	Solar Hot Water
SPG	Supplementary Planning Guidance
TfL	Transport for London
TWAO	Transport and Works Act Order
VRF	Variable Refrigerant Flow

Executive Summary

This Energy Statement has been prepared in support of a Transport and Works Act Order (TWAO) application by London Underground Limited (LUL) for the Bank Station Capacity Upgrade (BSCU). The BSCU will comprise a number of improvements and additions to the existing Bank Station facilities.

In compliance with the Greater London Authority (GLA) policies, this report outlines the energy strategy proposed for the BSCU and shows achievable energy and carbon dioxide (CO_2) emissions savings associated with the BSCU.

A significant portion of the BSCU's CO_2 footprint is expected to be associated with construction. A number of energy saving measures have been proposed to reduce the impact of construction in line with the best practice construction methods.

In line with the *London Plan 2011*, the main focus of this report is the operational energy consumption associated with the BSCU. This Energy Statement demonstrates how the designers have considered the aspirations set in the *London Plan 2011* by following the Mayor's Energy Hierarchy, i.e.:

- *Be lean: use less energy (via passive design and energy efficiency);*
- *Be clean: supply energy efficiently (e.g. by connecting to district heating networks); and*
- *Be green: use renewable energy (by incorporation of on-site renewable energy technologies).*

Baseline

For the purposes of this report, the baseline is represented by a notional 'non-building' infrastructure constructed to a typical industry standard complying with all relevant regulations and LUL standards.

Be Lean

Due to the nature of the BSCU, it was recognised that the highest potential for CO_2 emissions savings will be associated with energy efficiency. A number of options have been considered for the BSCU and the most appropriate measures have been proposed.

The measures currently considered feasible have been included in the calculations of this Energy Statement and will be refined at detailed design stages. As the design develops further opportunities for energy efficiency may be realised and implemented in the project. The design team and Transport for London (TfL) are committed to energy efficiency and will promote it through the design and construction process as far as practicable.

The currently proposed passive design and energy efficiency measures alone (i.e. *Be Lean* scheme) would allow the BSCU to achieve CO_2 emission savings of approximately **23 per cent over the baseline**.

Be Clean

The potential for connection to any existing neighbouring low carbon energy distribution networks including Combined Heat and Power (CHP) was investigated. Based on the estimated heat loads of the BSCU, it has been concluded that the loads are too low to enable a viable connection to a District Energy Network (DEN).

The potential for incorporation of an on-site Combined Heat and Power (CHP) plant, Combined Cooling Heat and Power (CCHP) plant or a system recovering waste heat from the tunnels have also been considered and found to not be appropriate for the BSCU.

Be Green

To further reduce CO_2 emissions, a feasibility analysis of renewable energy technologies has been undertaken. However, it was concluded that due to the site constraints and the nature of the BSCU, there are no viable renewable energy technologies that could be utilised.

Therefore, the final operational savings achieved by the BSCU will be associated solely with passive design and energy efficiency measures achieving **23 per cent reduction** in CO_2 emissions over the baseline. The total operational CO_2 emissions and the potential savings in CO_2 emissions are shown in Executive Summary Table 1.

Executive Summary Table 1: CO_2 Emissions for the Energy Stages

Carbon Dioxide Emissions (Tonnes CO_2 Annually)			
Assessment	Total BSCU	Savings	Percentage Improvement
Baseline	1,688	-	-
After energy demand reduction (Be Lean)	**1,301**	**387**	**23%**
After low carbon technology (Be Clean)	1,301	0	0%
After renewables (Be Green)	1,301	0	0%

This report will be revised through each design stage and will fulfil the role of the Carbon and Energy Efficiency Plan required by TfL's Pathway process.

1 Introduction

1.1.1 This Energy Statement has been prepared in support of a Transport and Works Act Order (TWAO) application by London Underground Limited (LUL) for the Bank Station Capacity Upgrade (BSCU) which seeks to deal with serious existing and anticipated shortfalls in passenger capacity.

1.1.2 Transport for London (TfL), which includes LUL, has strategic environmental priorities including reducing carbon dioxide (CO_2) emissions, minimising waste and enhancing the natural and built environments. As a transport provider LUL accepts its responsibility to operate a network that is as low-carbon as possible and resilient to the expected changes in the City of London's climate.

1.1.3 To limit climate change the Mayor of London has set a target to reduce London's CO_2 emissions by 60 per cent compared to 1990 levels by 2025 (Greater London Authority, 2011b). Transport for London is expected to assist by achieving CO_2 reductions across its public transport networks. It has therefore committed to setting its own carbon reduction goals to 2031, which are expected to be published as part of TfL's upcoming *Corporate Environment Framework.*

1.1.4 Although there are physical limitations when upgrading an existing station, there is a good opportunity to incorporate sustainability and energy efficiency measures as part of the BSCU. This report evaluates the opportunities for reducing the CO_2 emissions associated with the BSCU and following these evaluations outlines the energy strategy for the project.

1.1.5 In the context of this TWAO application, consideration has been given to the requirements of the following planning documentation:

- *The London Plan, Spatial Development Strategy for Greater London, Greater London Authority (*Greater London Authority, 2011b*);*
- *Sustainable Design and Construction – The London Plan Supplementary Planning Guidance (SPG) (*Greater London Authority, 2014b*);*
- *GLA Guidance on Preparing Energy Assessments (*Greater London Authority, 2014a*);*
- *Delivering London's Energy Future: The Mayor's Climate Change Mitigation Energy Strategy (*Greater London Authority, 2011a*);* and
- *Core Strategy (*City of London Corporation, 2011*).*

1.1.6 In line with the above documents, it is sought to reduce the BSCU's CO_2 emissions and to mitigate the impact on climate change following the principles set out in the Mayor's Energy Hierarchy described in *Policy 5.2 – Climate Change Mitigation of the London Plan* (Greater London Authority, 2011b).

1.1.7 The Energy Statement will take into account environmental and spatial constraints and will identify how to minimise the BSCU's operational energy consumption through the implementation of passive design measures, energy efficiency, and low and zero carbon (LZC) technologies.

1.1.8 In line with the project requirements the BSCU will be assessed under Civil Engineering Environmental Quality and Assessment Scheme (CEEQUAL) with a target rating of 'Excellent'.

1.1.9 This report will be revised through each design stage and will fulfil the role of the Carbon and Energy Efficiency Plan required by TfL's Pathway process.

2 Overview of the Bank Station Capacity Upgrade Project

2.1 Project Background and Context

2.1.1 The BSCU involves a major upgrade of the Bank Monument Station Complex to provide greatly improved passenger access, circulation and interchange. It will also improve emergency fire and evacuation protection measures. It includes provision of a new passenger entrance with lifts and escalator connections; a new Northern Line passenger concourse using the existing southbound platform tunnel; a new Northern Line southbound running and platform tunnel (and diversion of the Northern Line through this); and new internal passenger connections between the Northern Line, the Docklands Light Railway (DLR) and the Central Line.

2.1.2 The new Station Entrance will open on to Cannon Street at the junction with Nicholas Lane. An entrance hall will provide circulation space, as well as accommodating staff facilities, plant rooms and associated retail space. New passenger lifts will link the entrance hall directly with the Northern Line and DLR providing step free access from these lines. Escalators will also connect the entrance hall with the Northern Line.

2.1.3 The existing southbound platform for the Northern Line will be converted into a new passenger concourse. A new southbound running and platform tunnel will be located to the west of the existing platform. New cross passages will connect the Northern Line concourses and platforms. New walkways and escalators will better connect the Northern Line, the DLR and the Central Line. In particular, a tunnelled passageway fitted with moving walkways and new escalators will greatly improve interchange between the Northern Line and the Central Line.

2.1.4 Works to divert and protect utilities and to protect listed and other buildings from ground settlement, will also be undertaken, where monitoring and/or damage analysis indicates this is required. The compulsory purchase and temporary use of land, the temporary stopping up of streets, street works and ancillary works will also be required.

2.1.5 The BSCU is shown in three dimensions in Figure 4.2 (See ES Figures Volume). Figures 4.3-4.7 (ES Figures Volume) show the proposed changes at each level and the new Station Entrance. The BSCU will be constructed and operated within the limits of deviation applied for as part of the Transport and Works Act Order (TWAO) application. The TWAO application is accompanied by a request for a Planning Direction for deemed planning permission for all works that may be built for the BSCU Order. This is accompanied by proposed planning conditions which allows for some details of the BSCU such as materials and finishes of the Station Entrance to be approved by the City of London Corporation when discharging these conditions. The following sections describe the BSCU in more detail.

Construction of the BSCU

2.1.6 Construction will commence in 2016 with the diversion of utilities within Arthur Street prior to construction of the Arthur Street shaft. The tunnelling and below ground excavation will start towards the end of 2016 and will take approximately four years (completing late 2020) with peak tunnelling activity occurring in 2017. Construction of the new Station Entrance Hall is programmed for 2021. An indicative works programme including the phasing of construction activities is provided in the Outline Construction Logistics Plan (Appendix A8.2 of the ES).

2.1.7 Permission for an Over Site Development (OSD) located over and around the new station infrastructure was sought via an application to the City of London Corporation under the Town and Country Planning Act 1990. Permission was granted on 27 June 2014.

2.1.8 The BSCU will be constructed from two work sites. The first work site will be at the site bounded by King William Street, Nicholas Lane, Cannon Street and Abchurch Lane (the Whole Block Site - note that this is referred to as the Cannon Street Work Site in some consultation material) (see Figure 4.10 ES Figures Volume). The Whole Block Site will be used to construct the escalators, cross passages and new Northern Line passenger concourse. A second smaller work site will be located on Arthur Street (see Figure 4.11 ES Figures Volume). A shaft will be sunk at Arthur Street and used to excavate the new Northern Line southbound running tunnel. Approximately 80 per cent of the concrete required for construction will be prepared at the work sites. The remaining 20 per cent of the concrete will be delivered to the sites. The disused King William Street underground station located beneath the junction of King William Street and Arthur Street will be used for logistics purposes during construction.

Tunnelling

2.1.9 The construction of the new tunnel, cross passages, openings, walkways and escalator barrels will be primarily carried out a using sprayed concrete lining method. This involves excavating the ground (at a rate of between one metre and three metres per day) and spraying the excavated surfaces with steel fibre reinforced concrete.

Utilities Works

2.1.10 Works to divert and protect utilities potentially affected by construction are also proposed. These will comprise:

- protective works to the Low Level 2 Sewer (an west-east sewer between Cannon Street and King William Street) and to the London Bridge Sewer (a north-south sewer running beneath King William Street);
- diversion of utilities at Arthur Street to allow construction of the shaft; and
- other minor protective works to utilities to ensure there are no impacts from settlement.

2.1.11 Utilities work will be undertaken in accordance with relevant codes of practice, and with regular liaison with the City of London Corporation and Transport for London highway authority.

2.2 Permanent Components of the BSCU

A new station entrance

2.2.1 A new Station Entrance Hall will be constructed within the Whole Block Site. It will open on to Cannon Street at the junction with Nicholas Lane. A canopy extending over the pavement will provide weather protection and add to the street presence of the station in long views. Bollards at the pavement boundary will be provided for security and to protect passengers at the entrance. Nicholas Lane will feature a level surface for pedestrians and vehicles. The new Station Entrance Hall will include staff facilities, plant rooms and associated retail space. The Nicholas Lane façade will include louvres to ventilate the plant rooms.

2.2.2 In response to pedestrian and vehicle studies, a new pedestrian crossing on Cannon Street to the west of the new Station Entrance will be provided in the event that no alternative arrangement emerges as a result of area-wide initiatives by the City of London Corporation and/or Transport for London. While a light controlled crossing is included at this stage in the process, the type of crossing will be developed at a later stage in discussion with the City of London Corporation.

2.2.3 From the new Station Entrance Hall, two banks of triple escalators will take passengers to the Northern Line concourse. Two 17-person passenger lifts will be provided to access the Northern Line, with one also continuing down to the DLR level. An emergency intervention/escape staircase will be provided within the lift shaft. The existing passenger lift linking King William Street with the DLR will be upgraded to allow additional connection with the Northern Line. A walkway will be provided from this lift to the Northern Line concourse and platforms.

Northern Line Improvements

2.2.4 To improve circulation for Northern Line passengers, the existing southbound platform will be converted into a new concourse. This will require a new platform and running tunnel to accommodate the southbound Northern Line, which will be constructed west of the existing platform. The new tunnel will be approximately 700m long. It will diverge from the existing southbound track beneath a point approximately 14m north of the junction of Gresham Street with Lothbury and it will link into the existing Northern Line tunnel south of Lower Thames Street.

2.2.5 Four new cross-passages will be constructed which will link the platforms and concourse, with three also connecting with new interchange routes.

Central Line Improvements

2.2.6 A new tunnelled passageway (Central Line Link) from the Northern Line concourse, with moving walkways approximately 95m long, will provide access to a bank of triple escalators which will take passengers up to the Central Line platforms via an existing cross passage which will be reconstructed and enlarged. A second cross passage at the far (western) end will provide improved access between the eastbound and westbound platforms.

2.2.7 Supporting infrastructure will include a cable tunnel between the Central Line Link and the existing Bank Station ticket hall, and new electrical and communications rooms for the operation of the station.

Docklands Light Railway Improvements

2.2.8 A new bank of triple escalators connecting the new Northern Line concourse and the DLR will be provided and to facilitate their installation a number of existing plant rooms will be relocated. Two new cross passages will link the DLR arrival and departure platforms with the existing DLR passenger concourse, and a third will link the DLR arrival platform to the existing passenger concourse.

3 Planning Context

3.1.1 National planning policies and building control processes exist that contribute to the Government's long-term commitment to support sustainable development.

3.1.2 In addition, being aware of the scale of the impact transport has on the environment TfL and LUL have prepared a number of standards and guidance documents, which set out their sustainability targets and aims to mitigate the impacts.

3.1.3 The main policy drivers relating to the Energy Statement are included in the following section. Details on all policy documents and guidance that have been considered in the context of this report are included in Appendix A.

The London Plan (Greater London Authority, 2011b)

3.1.4 *The London Plan*, which establishes policy over the next 20 – 25 years, retains the fundamental objective of accommodating London's population and economic growth through sustainable development. This Energy Statement has been prepared following the guidance of the following policies of the *London Plan*.

3.1.5 *Policy 5.1* includes a strategic target to achieve an overall reduction in London's CO_2 emissions of 60 per cent by 2025.

3.1.6 *Policy 5.2: Minimising CO_2 emissions* sets out that the Mayor expects all new developments will fully contribute towards the reduction of CO_2 emissions. Specifically, *Policy 5.2 (A)* requires developments to make the fullest contribution to minimising emissions of CO_2 in accordance with the Mayor's Energy Hierarchy:

- *Be Lean: use less energy ;*
- *Be Clean: supply energy efficiently*; and
- *Be Green*: *use renewable energy*.

3.1.7 *Policy 5.2 (B)* sets targets for CO_2 emissions reduction, which all major developments are expected to meet. It should be noted that *The London Plan* CO_2 emissions targets are set against the *Building Regulations*. The BSCU will include only a very small proportion of areas falling under the remit of the *Building Regulations*. These areas would not qualify as a major development. Therefore the above targets are not directly applicable to the BSCU.

3.1.8 All major development proposals are expected to include a detailed energy assessment to demonstrate how these targets are to be met within the framework of the Mayor's Energy Hierarchy *(Policy 5.2 (C))*. Guidance is also given on the content of Energy Assessments *(Policy 5.2 (D))*.

3.1.9 *Policy 5.5 DEN*, prioritises the development of decentralised heating and cooling networks at the development and surrounding areas, while *Policy 5.6: Decentralised Energy in Development Proposals (A)* requires development proposals to evaluate the feasibility of CHP systems.

3.1.10 *Policy 5.7: Renewable Energy* expects that within the framework of the Mayor's Energy Hierarchy, major development proposals will provide a reduction in CO_2 emissions through the use of on-site renewable energy generation.

3.1.11 *Policy 5.8: Innovative Energy Technologies* supports the use of alternative energy technologies (e.g. the uptake of electric and hydrogen fuel cell vehicles, hydrogen supply and distribution infrastructure and the uptake of advanced conversion technologies such as anaerobic digestion, gasification and pyrolysis).

3.1.12 *Policy 5.9: Overheating and Cooling* expects major development proposals to reduce potential overheating and reliance on air conditioning systems and demonstrate this in accordance with the recommended cooling hierarchy.

Energy Planning – Greater London Authority Guidance on Preparing Energy Assessment (Greater London Authority, 2014a)

3.1.13 This guidance provides details on how to address the Mayor's Energy Hierarchy through the provision of an energy assessment to accompany strategic planning applications. This Energy Statement report follows the methodology outlined in this guidance.

Sustainable Design and Construction Supplementary Planning Guidance (Greater London Authority, 2014b)

3.1.14 In April 2014 the Mayor published the Sustainable Design and Construction Supplementary Planning Guidance (SPG) to provide guidance to developers. This SPG details the Mayor's standards, covering a wide range of sustainability measures that major developments are expected and encouraged to meet.

Delivering London's Energy Future: The Mayor's Climate Change Mitigation and Energy Strategy (Greater London Authority, 2011a)

3.1.15 The strategy sets out the Mayor's strategic approach to limiting further climate change and securing a low carbon energy supply for London.

3.1.16 To limit further climate change impacts the Mayor has set a target to reduce London's CO_2 emissions by 60 per cent on 1990 levels by 2025. The strategy details the programmes and activities that are on-going across London to achieve this.

3.1.17 This strategy also details policies and activities underway to reduce CO_2 emissions from new development and transport through *The London Plan* and the *Mayor's Transport Strategy*.

Local Development Framework – Core Strategy (City of London Corporation, 2011)

3.1.18 *The Core Strategy* was adopted in September 2011 and sets out the future vision and key policies for planning within the City of London.

3.1.19 *Policy CS15* promotes sustainable choices adapted to the changing climate by:

- requiring all redevelopment proposals to demonstrate the highest feasible and viable sustainability standards in the design, construction, operation and 'end of life' phases of development; and
- requiring development to minimise carbon emissions and contribute to a City of London wide reduction in emissions by:
  1. *Adopting energy-efficiency measures;*
  2. *Enabling the use of decentralised energy, including safeguarding the Citigen CHP network, CHP-ready designs in areas where Combined Cooling Heat and Power (CCHP) networks are not yet available, and localised renewable energy technologies;*
  3. *Adopting offsetting measures to achieve the Government's zero carbon targets for buildings saving millions of pounds every year.*

3.1.20 It should be noted that some of the requirements specified within *Policy CS15* are relevant to buildings and may not all be directly applicable to the BSCU.

4 Construction Energy

4.1 Background and Approach

4.1.1 In line with best practice, site-wide construction emissions for all large-scale projects should be minimised where possible.

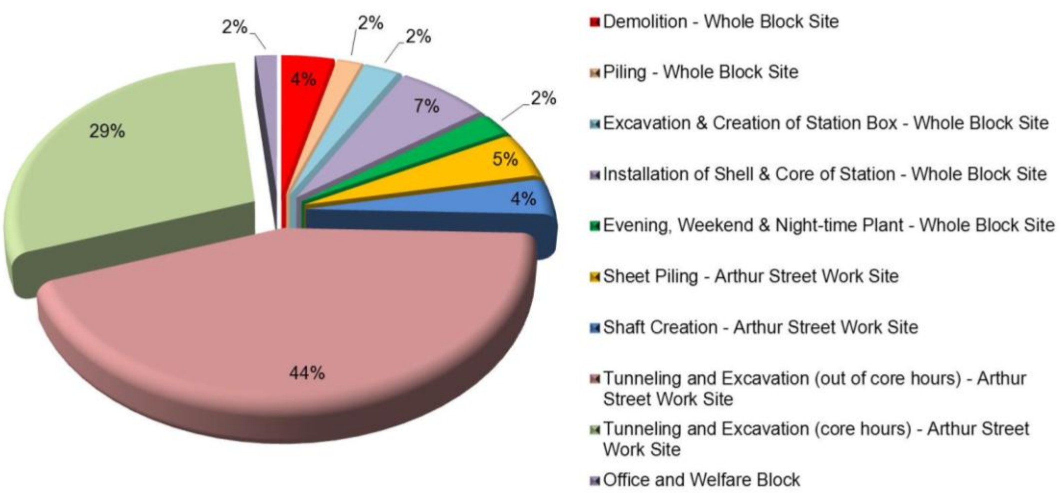
4.1.2 The objective of this section is to identify the areas with high energy consumption and with a high potential to reduce it. The assumptions and recommendations of this section will be considered in further detail prior to the start of the construction works. It should be noted that this section of the assessment focuses solely on the energy associated with the demolition and construction process (e.g. plant, welfare facilities and equipment).

4.1.3 Given the current stage of design, detailed information is not available on the exact specification or operation of construction equipment. The predicted energy consumption breakdown has been based on available data and reasonable assumptions of likely plant.

4.1.4 Information in the Construction Logistics Plan (CLP) (Appendix A8.2 of the Environmental Statement (ES)) and the draft Code of Construction Practice (CoCP) (Appendix A4.1 of the ES) for the BSCU Project has been used. Where appropriate, assumptions have been made to determine the approximate energy breakdown for the duration of the 6 year construction phase of the works.

4.1.5 A chart of the predicted relative energy consumptions of on-site activities for the duration of the construction phase can be seen on Figure 4.1.

Figure 4.1: Predicted Energy Consumption Breakdown by Categorisation of On-site Construction Activities



4.1.6 Figure 4.1 shows that the activities with the highest proportion of energy consumption are predicted to be tunnelling and excavation.

4.1.7 The tunnelling works also represent the longest site operational hours, running 24 hours a day, 7 days a week on shift rotations. This activity therefore requires additional welfare and amenity facilities for the reduced workforce during night hours and these excess hours have been taken into account within the overall energy consumption statistics.

4.1.8 Energy consumption will vary during the construction period, with the majority of the energy-intensive tunnelling and excavation activities occurring between the months of October 2016 and November 2020, a duration of approximately 50 months.

4.1.9 The amenity and welfare facilities have been assumed to be entirely electrically powered, with space heating, catering, auxiliary plant and hot water provided by electric supply.

4.2 Energy Saving Measures

4.2.1 Potential energy saving measures for the course of the BSCU, not solely dependent on plant use, are listed in Table 4.1. This includes those measures in the draft CoCP and considers their feasibility at this stage. A number of measures from the Considerate Contractors Scheme are also included as the BSCU will be registered under the scheme and the contractor will apply for the Considerate Contractors Scheme's Environmental Award. Furthermore, the Carbon Trust's recommendations listed within their *Action Plan to Reduce Carbon Emissions* (Carbon Trust, 2010) are included.

4.2.2 The contractor will commit to implement working methods that reduce energy consumption through the CoCP and will aim to continually improve energy efficiency on the BSCU Work Sites. The measures listed above support this task and have been selected to bring savings in energy consumption and consequently CO_2 emissions. Particular attention will be paid to those measures associated with high energy consuming activities such as tunnelling.

Table 4.1: Potential Energy Saving Measures

	Measures: Construction Energy	Feasibility	Potential for CO_2 savings	Note
1	Minimising the use of diesel or petrol powered generators and instead using mains electricity or battery powered equipment	High	Medium	A high capacity grid connection secured early within the project stage. The electricity substation currently below 20 Abchurch Lane to be retained for temporary power during the construction.
2	Power-down equipment/plant when not in use	Medium	Medium	Where not detrimental to the running or lifecycle of plant, switch off all engines/power when not in use.
3	Recommended vehicle and plant servicing	High	Low	Ensure all vehicles and machinery is serviced at recommended intervals to guarantee optimum engine efficiencies and reduce waste energy.
4	Select energy efficient plant	High	Medium	Fuel-efficient plant, machinery and vehicles used wherever possible.
5	Maximise vehicle utilisation	Medium	Medium	Ensuring all vehicles and plant are fully loaded before starting a cycle or trip to ensure minimum run-time and efficient use of capacity.
6	Keep spent fuel record	Medium	Low	Maintain records of all fuel used by site plant, machinery and vehicles to determine usage characteristics.
7	Use low carbon fuelling options	High	Medium	Biodiesel or ultra-low sulphur diesel alternatives used wherever possible.
8	Set energy targets	High	Low	Set SMART targets for site energy consumptions and make them clearly visible to the entire workforce.
9	Metering of energy usage	Medium	Low	Collect metered data on all non-plant related energy usage and monitor usage characteristics.
10	Specify smart controls for offices and welfare spaces	Medium	Low	Install smart controls for lighting and heating of non-plant related energy usage including timers and motion sensors.

	Measures: Construction Energy	**Feasibility**	**Potential for CO_2 savings**	**Note**
11	Correctly size generators	High	Medium	Deploy correctly sized generators for electrical provision on-site, where applicable.
12	Efficient lighting and small power	High	Medium	Use low-energy equivalents of common equipment, e.g. low-energy lighting and efficient air heaters.
13	Provide well insulated site accommodation.	Medium	Low	Provide appropriate levels of thermal insulation to the relevant areas of site accommodation to reduce energy consumption associated with heating.
Key:	*Green – measures to be incorporated*			

5 Assessment Methodology - Operational Energy

5.1 Background and Proposed Approach

5.1.1 The overall strategy and measures identified to reduce CO_2 emissions associated with the operational stages of the BSCU reflect the Mayor's Energy Hierarchy.

5.1.2 This hierarchy is generally applied to a development as follows:

- the baseline energy demand and CO_2 emissions of a scheme are calculated, which represent the development designed just to comply with *Building Regulations Approved Document L (ADL) 2010* (Her Majesty's Government, 2010) and/or a typical industry standard, as appropriate (Note that for the purposes of this report the baseline scheme does not represent the existing Sites' conditions);
- feasible energy efficiency and passive design measures are determined and applied to the energy calculations, representing an enhanced baseline (*be lean*) scheme;
- appropriate clean energy supply technology (CHP/DEN) is determined and applied to the energy calculations, representing a *be clean* scheme; and
- appropriate renewable energy technologies are identified and applied to the energy calculations, representing a *be green* performance.

5.1.3 This Energy Statement accounts for these four scenarios in detail.

5.1.4 For the purposes of this report the baseline energy consumption and associated CO_2 emissions of the development represent an estimate of the energy usage of the development where:

- 'buildings' (i.e. areas covered by the energy efficiency requirements of *Building Regulations ADL*) meet the minimum requirements of *Building Regulations ADL 2013* in relation to CO_2 emissions; and
- 'non-building' infrastructure (i.e. areas not covered by the *Building Regulations ADL*) is constructed to a typical industry standard complying with all other relevant regulations and standards (e.g. LUL standards).

5.1.5 The BSCU will include only a very small proportion of areas (<200m^2) falling under the remit of the energy efficiency requirements of the *Building Regulations ADL*. These areas would not qualify as a major development and therefore for the purposes of the TWAO application have not been modelled for

ADL compliance. Energy consumption and associated CO_2 emissions of the BSCU are estimated for each stage of the Mayor's Energy Hierarchy using:

- technical documentation and information provided by the Mechanical & Electrical (M&E) engineers (e.g. electrical outputs of the energy consuming uses such as lighting, auxiliary, heating and cooling systems, escalators, lifts, equipment etc.);
- industrial benchmarks such as *Energy Efficiency in Buildings* - *CIBSE Guide F* (The Chartered Institution of Building Services Engineers (CIBSE), 2012b) , *Transportation systems in buildings* - *CIBSE Guide D* (CIBSE, 2010), *Energy Benchmarks - TM46* (CIBSE, 2008), and *Energy Consumption Guide 19- Energy use in offices* (CIBSE, 2012a); and
- previous experience on similar developments modelled using approved software used for Dynamic Simulation Modelling (DSM).

5.1.6 The expected whole energy use of the BSCU is considered in these Energy Statement calculations. This includes energy uses such as heating, cooling, lighting and auxiliary energy and extra energy uses such as appliances, computers, lifts, escalators, etc.

5.1.7 The feasibility of connection to a DEN was undertaken following the *District Heating Manual for London* (Greater London Authority, 2013a).

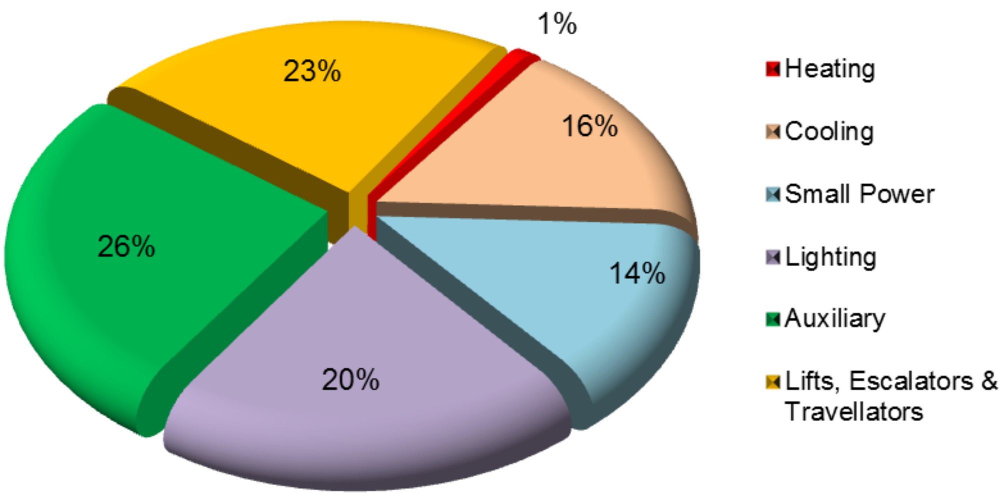
5.1.8 The assessment methodology of renewable energy sources is based on the publication *Integrating Renewable Energy into New Developments: Toolkit for Planners, Developers and Consultants*, (London Renewables, 2004) known as the Renewables Toolkit.

6 Baseline Assessment

6.1.1 This Energy Statement considers as the starting point an estimate of the energy usage of the BSCU in operation, where ‘non-building’ infrastructure is constructed to a typical industry standard complying with all other relevant regulations. Refer to Section 5 for details of the assessment methodology.

6.1.2 Figure 6.1 shows the breakdown by energy uses for the BSCU once operational.

Figure 6.1: Estimated Energy Consumption Breakdown by Energy Uses



6.1.3 The largest proportion of the energy consumption is estimated to be auxiliary energy such as fans and pumps, which is considered appropriate for a London Underground Station. The smallest proportion is represented by heating loads.

6.1.4 The BSCU’s estimated energy consumption and CO_2 emissions breakdown during operation is shown in Table 6.1.

Table 6.1: Estimated Baseline CO_2 Emissions by Energy Use

Estimated Baseline Scheme CO_2 Emissions (tonnes CO_2/year)							
Baseline Scheme	**Heating**	**Cooling (staff areas)**	**Small Power**	**Lighting**	**Auxiliary (Fans & pumps)**	**Escalators /Lifts/ other**	**Total**
BSCU	13	239	183	371	478	403	1,688

7 Be Lean – Passive Design and Energy Efficiency Measures

7.1.1 The design of the BSCU is fully integrated with the sustainability strategy to bring about savings in CO_2 emissions.

7.1.2 The following sections assess passive design and energy efficiency opportunities that could be incorporated into the design of the BSCU to reduce energy consumption and therefore enhance its environmental performance.

7.2 Passive Design

7.2.1 Based on the initial calculations and the project's characteristics, a number of passive design measures have been considered for the BSCU. These are listed in the following sub-sections. It should be noted that the London Underground Station is an unusual building type for which some passive measures typically applied to buildings (e.g. favourable orientation or shading systems) are not applicable.

Potential for Natural Ventilation

7.2.2 The energy consumption associated with mechanical ventilation has been identified as the highest amongst the energy uses. Although the nature of the BSCU does not allow sole dependence on natural ventilation, its potential will be maximised through the design.

7.2.3 The proposed design introduces an extra entrance and broader passenger routes and thus increasing the provision of fresh air within the station and secures improvement to the current situation in terms of thermal comfort.

7.2.4 In addition, the new Station Entrance Hall on Cannon Street will be wide open and linked by a set of triple escalators to the Northern Line platforms allowing fresh air to circulate. The natural process of air circulation will be achieved thanks to the air pushed by the trains arriving at the station.

Platform Screen Doors

7.2.5 Platform screen doors (PSDs) were considered for the BSCU. However, the current design is to provide ventilation of the tunnels via air exchange with the station, and the presence of PSDs would obstruct the heat from venting through the platforms, making thermal conditions in the tunnels and in the trains (which are not currently air-conditioned) unacceptable for passengers. The use of PSDs would therefore require additional ventilation to counterbalance this effect including either increased auxiliary power of fans or added draught relief.

7.2.6 In addition, the wider Northern Line would have to adopt the concept of PSDs in order to make this option viable for the BSCU and therefore full height PSDs are not proposed.

7.2.7 Partial height PSDs (i.e. Platform Edge Doors), which do not significantly affect the air exchange, and therefore would have minimal impact on energy usage, could be incorporated in the design for safety reasons. However, inclusion at this stage could restrict door configuration of any future trains; therefore Platform Edge Doors are not proposed at this stage.

Promotion of Daylighting

7.2.8 Daylighting will be promoted wherever feasible in order to reduce energy consumption associated with artificial lighting. However, as the BSCU is situated in dense urban environment with the vast majority of areas underneath buildings or below ground, the potential of utilising daylighting is limited.

7.2.9 Daylighting will be utilised where a façade exists along a building envelope by maximising transparent areas. Generous headroom between surface level and the maintenance soffits will improve daylight penetration to the new Station Entrance Hall and top of the escalators.

7.2.10 The potential of utilising light tubes for transport of light to locations below ground was also considered, however, found infeasible due to space constraints.

Thermal Mass

7.2.11 Thermal mass is a design concept utilising the abilities of the mass of the structures to store heat and minimise temperature fluctuations. Thermal mass will be used wherever feasible to efficiently manage the risk of overheating.

Efficient Envelope and Reduced Air Permeability

7.2.12 The main benefit of airtight and well insulated envelopes is the minimisation of heat losses in winter.

7.2.13 Based on the preliminary estimations (see Section 6 for baseline energy breakdown) the heat demand of the development will be limited compared to the other energy uses such as ventilation, or electrical consumption associated with lighting and escalators.

7.2.14 In addition, the nature of the London Underground station does not allow for airtight construction as a consequence of the natural ventilation strategy and the movement of passengers in and out of the station. Staff areas are the only parts that are considered to benefit from efficient envelope and air permeability.

7.2.15 Therefore, it is considered that improved thermal insulation and airtight construction is not practical for the majority of the BSCU. *The Building Regulations ADL* limiting U-values and air permeability will be applied to the BSCU where appropriate.

Energy Awareness Scheme for Staff

7.2.16 This Energy Statement proposes a number of technologies, which may be unfamiliar to the staff responsible for daily operation of the station. To realise the potential of the design fully, a good and complete initial asset handover to operational staff is essential.

7.2.17 To achieve an efficient handover, the principal contractor will identify a schedule of training for the relevant operational staff covering:

- design strategy;
- installed systems and key features (maintenance, operation, replacement, and repair);
- documentation to be provided; and
- training responsibilities.

7.2.18 Training sessions will be held to the satisfaction of operational staff in each field of expertise.

Humped Alignment

7.2.19 Humped alignment means that the station is raised above the inter-station alignment. Trains entering the station roll up the ‘hump’ and require less energy for braking; they also use less energy to accelerate when leaving the station as they roll off the hump. In addition, by incorporating humped alignment the depth of the stations is reduced, which consequently reduces the lengths of stations’ escalators.

7.2.20 Although the energy savings will be primarily associated with the rolling stock, the humped alignment will also have an indirect beneficial impact on the energy consumption of the station (e.g. the energy for braking dissipates as heat, therefore reducing the need for braking would result in lower temperatures in the tunnel/platforms minimising the need for cooling/mechanical ventilation).

7.2.21 Humped alignment is included in the design of the new running tunnel as far as practicable. To quantify the benefits arising from this measure, a complex simulation model would be required, including multi-train simulations, which is not considered proportionate for the purposes of this Energy Statement. Therefore, the reduction in CO_2 emissions associated with incorporation of humped alignment has not been quantified or included in calculations.

7.3 Energy Efficient Design

7.3.1 Based on the results of the demand assessment (presented as baseline energy consumption under Section 6), the BSCU's highest loads are associated with uses such as auxiliary energy, lighting and lifts, escalators and moving walkways. All these uses are fuelled by electricity and therefore represent the best potential for CO_2 emissions savings.

7.3.2 The key energy efficiency measures, which have been considered for integration into the BSCU, are included in the following sub-sections.

Energy Efficient Lighting and Controls

7.3.3 High efficiency ballasts (devices designed to limit the amount of current in an electric circuit) will be specified to maximise operational efficiency serving as a tool for energy saving. The best available technology will be specified considering the whole life cost of the system (i.e. low energy, low maintenance and long life fittings). Light Emitting Diodes (LEDs) are currently considered the most appropriate lighting technology for the BSCU. LEDs are recommended for specification and are also included in the Energy Statement calculations.

7.3.4 Lighting levels will be specified in line with document *Lighting of LUL Assets* (Transport for London, 2011), which lower the levels of lighting required compared to the previous LUL standards.

7.3.5 Lighting zones and controls will be provided as appropriate to cater for different operational needs. This will also allow an appropriate level of lighting to be selected at different periods in order to minimise energy consumption.

7.3.6 Lighting in public circulation areas will be controlled via a programmable lighting control system. Lighting in back of house areas will be controlled via local manual light switches and/or presence detectors (Passive Infra-Red (PIR) sensors). This will allow efficient management, which will prevent the lighting being switched on when not needed, but still ensure that high security standards are maintained.

7.3.7 To maximise the benefits of sophisticated lighting, the station staff will be appropriately trained on how to efficiently control the lighting system (see Section 7.2 – Energy Awareness Scheme for Staff).

7.3.8 It has been estimated that the improved lighting strategy would represent one of the highest savings in CO_2 emissions associated with the operation of the BSCU.

Heat Recovery

7.3.9 Wherever feasible, waste heat from the station's operation will be recovered and reused. Mechanical ventilation heat recovery systems will be implemented in staff areas as appropriate.

7.3.10 Systems recovering heat from station equipment (for example waste heat associated with the operation of escalators) have been considered. However, proposed heat removal from the back of escalators is proposed as a dual purpose system incorporating smoke extract. As the heat rejection and smoke extract is a combined system, there is no ability to recover waste heat due to the fire rating constraints.

7.3.11 A dedicated (separate) heat rejection system would need to be designed, incorporating a wet system (i.e. chilled water utilised for heat recovery) and smoke extract system. This would however significantly add complexity to the M&E system.

7.3.12 The expected heat demand associated with the station is low and therefore heat recovery from station equipment could bring only a marginal reduction in overall CO_2 emissions of the BSCU.

7.3.13 Furthermore, additional auxiliary energy would be required to transfer the low grade waste heat to an Air Handling Unit (AHU), which would reduce the CO_2 emissions savings achievable by the system.

7.3.14 Due to the constraints listed above, this option is not proposed for the BSCU.

Efficient Cooling System

7.3.15 The temperatures on platforms and in trains result from a combination of external ambient temperature variation, driven by weather and seasonal cycles, occupancy and dissipation of heat through the operation of trains, which drives a daily temperature cycle. The most cost effective way to control temperatures is to increase the energy efficiency of train operation by using regenerative braking and sophisticated auto-driving software (although these elements do not form part of the BSCU); where this is insufficient or not possible, enhanced tunnel ventilation, and then water-based station cooling schemes can be implemented.

7.3.16 The current LUL cooling strategy is to control the incidence of heat strain, rather than deliver comfort at the warmest times via active cooling. The cooling strategy for future line upgrades is based on a requirement for mechanical cooling interventions only if average summer platform temperatures are predicted to exceed 32°C and consideration of cooling opportunities if temperatures exceed 30°C.

7.3.17 The BSCU will be addressing potentially higher temperatures on the Northern Line only as part of the LUL network strategy for cooling. Other lines, in particular the Central Line are being addressed separately.

7.3.18 To provide adequate thermal conditions on the Northern Line Platforms, whilst not increasing the energy consumption of the station associated with mechanical cooling, the design of the BSCU features a series of escalators to the surface, which will act as a ventilation shaft providing, alongside other passive design measures listed in Section 7.2, increased levels of natural ventilation.

7.3.19 The only areas of the BSCU that are currently expected to require mechanical cooling are staff mess room facilities and associated equipment/secure rooms in accordance with *LUL Standard 1-068.*

7.3.20 A number of options exist to provide mechanical cooling to these areas efficiently. Chilled water systems were considered at early stages and discounted due to the presence of water in the secure rooms that would be required. High efficiency Variable Refrigerant Flow (VRF) systems have been selected to provide all cooling loads of the BSCU. VRF systems benefit from better efficiencies and offer greater benefits in terms of space utilisation for central plant compared to dedicated splits systems.

Efficient Heating System

7.3.21 The heat profile of the BSCU is expected to be characterised by negligible loads in summer and relatively low loads in winter. A number of options have been considered to supply this demand.

7.3.22 Heating will be provided only within the staff areas (mess room, gateline attendants point and toilets) with thermostatic control to provide temperatures within the range of 19-25°C.

7.3.23 Gas fired heating systems are considered energy efficient, however, in this instance cannot be used because of safety risks. According to *Cat 1 Standard, 1-068, Cl. 3.3.1 There shall be no new or renewed gas, oil or solid fuel installations at sub-surface locations*.

7.3.24 The following sections of this report will discuss the potential for connecting the BSCU to a DEN or to provide heating by incorporating renewable energy technologies such as Air Source Heat Pumps (ASHP), Ground Source Heat Pumps (GSHP) and/or Solar Hot Water (SHW) systems. In this analysis, electrical heating is considered for staff areas for calculation purposes.

Thermal Zoning and Controls

7.3.25 The BSCU will incorporate appropriate zoning allowing for individual temperature control for different areas of the station as required.

Building Management System

7.3.26 A Building Management System (BMS) will be provided to control and monitor BSCU services. The BMS system will be installed as part of the BSCU and will allow energy monitoring and efficient control of the M&E systems. The BMS will be connected to the existing critical fault monitoring system.

Sub-metering of High Energy Consuming Uses and Zones

7.3.27 Energy metering of high consuming uses such as escalators, lifts, fans and pumps, lighting and small power, etc. will be provided as feasible to allow for efficient management. All sub-meters will be connected to the BMS.

Energy Display Devices

7.3.28 Energy display devices will be considered to show the energy performance of the station to staff and/or passengers once the BSCU is operational.

7.3.29 It is, however, not expected that significant CO_2 emissions savings would be achieved as a result of their installation.

Efficient Fans and Pumps

7.3.30 Although a natural ventilation strategy is promoted wherever feasible, mechanical ventilation will need to be installed in some areas. To reduce the energy associated with the mechanical ventilation system, high efficiency fans will be incorporated into the design including variable speed drives.

Efficient Office and Staff Equipment

7.3.31 Where provided, preference will be given to selecting office and staff equipment that is energy efficient, e.g. low energy computers and screens.

7.3.32 A number of small power uses will be outside of the control of LUL/TfL (e.g. advertising panels). However, where possible, LUL will encourage installers to reduce the energy by using low energy consuming technologies.

Efficient Lifts and Escalators

7.3.33 The operation of lifts, escalators and moving walkways represents one of the largest proportions of the overall station’s energy consumption.

7.3.34 A transport demand analysis was carried out at tender stage to determine the optimum number and size of the lifts and escalators.

7.3.35 A number of opportunities have been identified which would significantly reduce the energy consumption associated with the lifts and escalators that are specified as part of the BSCU.

7.3.36 The following measures for reducing the energy consumption of escalators are recommended to be considered at detailed design stage (and currently included in the Energy Statement calculations):

- variable frequency drives reducing the power demand from the motors; and
- eco-mode ensuring that when there is low escalator demand, the speed is automatically adjusted, hence power demand is reduced during quiet periods.

7.3.37 Lifts will be designed with:

- a low energy consumption drive system; and
- automatic shutdown of 75 per cent of lighting after the lift has been idle for a prescribed length of time.

7.3.38 In addition, the following energy saving measures will be considered for lifts at the detailed design stage (and currently included in the Energy Statement calculations):

- regenerative drive unit so that any energy generated is exported back to the electricity utility supplier or used elsewhere in the station;
- power standby features (shutdown of all lighting, ventilation and user displays after the lift has been idle for a prescribed length of time);
- LED lighting; and
- drive controller capable of variable-speed, variable-voltage, variable-frequency control of the drive motor.

7.4 Summary Be Lean Scheme

7.4.1 The enhanced scheme incorporates energy efficiency and passive design measures into the baseline scheme. The resulting savings in CO_2 emissions for the BSCU are savings that exceed those associated with the baseline scheme.

7.4.2 Table 7.1 and 7.2 summarise the conclusions of the feasibility analysis described in Section 7.3.

Table 7.1: Summary of Passive Design Measures and their Feasibility

	Measures: Be Lean - Passive Design	Feasibility	Potential for CO_2 savings	Note
1	Potential for natural ventilation	High	High	The design of the BSCU will promote natural ventilation wherever feasible. All public areas will be naturally ventilated.
2	Platform screen doors	Low	Low	PSD are not considered appropriate for the BSCU.
3	Promotion of daylighting	Low	Low	Generous headroom will improve daylight penetration to the new Station Entrance Hall and top of the escalators. The benefits of daylighting will be negligible as the majority of the areas are located underground.
4	Thermal mass	Medium	Low	Materials with high thermal mass will be used where feasible.
5	Efficient envelope and reduced air permeability	Low	Low	Limited only to staff areas (e.g. station office).
6	Energy awareness scheme	High	Low/Medium	Efficient operation of the station will be ensured by proper and effective asset handover.
7	Humped alignment	High	Low / Medium	Humped alignment will be incorporated in the design.

Key: *Green – measures accounted for within the 'be lean' calculations.*

Red – measures identified as not feasible for the BSCU.

Amber – measures are being taken forward to the next stages of the project, however, have not been currently included in the Energy Strategy calculations.

Table 7.2: Summary of Energy Efficiency Measures and their Feasibility

	Measures: Be Lean - Energy Efficiency	Feasibility	Potential for CO_2 savings	Note
1	Energy efficient lighting and controls	High	High	Appropriate low energy, low maintenance and long life lighting fittings will be specified allowing zoning and including controls as appropriate.
2a	Heat recovery – Mechanical Ventilation Heat Recovery (MVHR)	High	Low	MVHR will be specified for areas where air leakage rates are controllable.
2b	Heat recovery – station equipment	Medium	Low	Waste heat recovery from the station equipment is not considered feasible.
3	Efficient cooling system – staff areas	High	Medium	High efficiency VRF system will be specified to areas requiring mechanical cooling. All public areas will be naturally ventilated.
4	Efficient heating system	Low	Low	Applicable to staff offices, server and transformers rooms. Electrical system is being proposed due to safety standards.
5	Thermal zoning and controls	High	Low	M&E design will allow appropriate zoning of the building and appropriate controls.
6	Sub-metering of high energy consuming uses and zones	High	Low	Sub-meters will be specified to the relevant areas and energy uses and will be connected to BMS.
7	Building Management System	High	Medium	A new BMS will be specified.
8	Energy Display Devices	Low/ Medium	Low	Energy display devices to display energy consumption will be considered once the BSCU construction works are completed.
9	Efficient fans and pumps	High	High	High efficiency fans and pumps will be specified including variable speed drives.

	Measures: Be Lean - Energy Efficiency	Feasibility	Potential for CO_2 savings	Note
10	Efficient office equipment and staff appliances	High	Low	Appliances and equipment will be selected based on their whole life cost.
11	Efficient lifts and escalators	Medium	Medium	Energy saving lifts and escalators will be specified.
Key:	*Green – measures accounted for within the 'be lean' calculations.* *Red – measures identified as not feasible for the BSCU.* *Amber – measures are being taken forward to the next stages of the project, however, have not been currently included in the Energy Strategy calculations.*			

7.4.3 The passive design and energy efficiency measures considered feasible at this stage could provide a circa 23 per cent reduction over the baseline CO_2 emissions. The development's estimated energy consumption and CO_2 emissions breakdown is shown in Table 7.3.

Table 7.3: Estimated CO_2 Emissions for Baseline and Be Lean Scheme by Energy Use

Estimated CO_2 Emissions (tonnes CO_2/year)							
	Heating	**Cooling**	**Small Power**	**Lighting**	**Auxiliary**	**Escalators / Lifts/ other**	**Total**
Baseline Scheme	13	239	183	371	478	403	1,688
Be Lean Scheme	13	205	180	261	339	303	1,301

8 Be Clean – Efficient Supply of Energy

8.1 Introduction to Technology

8.1.1 Conventional thermal electricity generation is typically only around 40 per cent efficient. Almost all of the remaining 60 per cent is dissipated in the form of heat at the generator before any power is delivered to the distribution system, such as the national grid, where further grid losses are incurred. Overall, national electricity generation and distribution is only about 35 per cent efficient.

8.1.2 Combined Heat and Power technology converts natural gas into both electrical power and heat in a single process at the point of use. Combined Heat and Power is more energy efficient due to the utilisation of the waste heat by-product of the electricity generation process and minimal distribution losses, compared to grid electricity, due to its close proximity to the load, which results in CO_2 emissions savings and potential utility cost benefits.

8.1.3 Whilst CHP technologies simultaneously produce heat and power, tri-generation implies the simultaneous production of power (electricity), heat and cooling from a single fuel (i.e. CCHP).

8.1.4 A DEN is a system for distributing heat generated in a centralised location. The energy centre serving the area often includes a CHP plant. A DEN with CHP is considered one of the most cost-effective ways of cutting CO_2 emissions for multi-building applications, and has one of the lowest CO_2 footprints of all fossil generation plants. Additionally, DENs are prioritised by regional and local planning authorities. Specifically, *Policy 5.5* of *The London Plan* expects 25 per cent of the heat and power used in London to be generated through the use of localised decentralised energy systems by 2025.

8.2 Applicability to the BSCU

8.2.1 As required by *The London Plan* and local planning policies, consideration has been given to the use of a decentralised energy supply and connection to existing/proposed CHP distribution networks.

Energy Supply from Local DEN

8.2.2 The BSCU could be designed to connect to the Citigen DEN and procure heat from this network.

8.2.3 See Appendix B – London Heat Map for information on the current Citigen network and its location.

8.2.4 The heat load of the BSCU is estimated to be circa 25MWh/year. The heat profile is expected to be characterised by negligible loads in summer and relatively low loads in winter.

8.2.5 These characteristics suggest that the potential CO_2 emission reductions associated with the heat provided by the DEN would be minimal. Based on the results of the preliminary analysis, the cost and embodied energy associated with the infrastructure required to allow this connection would significantly exceed the benefits of the connection.

Recovery of Waste Heat

8.2.6 Initial consideration has been given to utilising waste heat from the tunnels and supplying it to an OSD or other locally available DEN.

8.2.7 Although a number of studies have been prepared by the GLA and TfL to explore the potential of waste heat recovery from London Underground tunnels, this is currently not a well-established technology. It is being pioneered in London Borough of Islington where the heat recovered from a ventilation shaft of the London Underground Network is to be utilised within the Bunhill Heat and Power network.

8.2.8 According to the document *The Potential for Heat Recovery from London Underground Stations and Tunnels* (Gilbey, Duffy and Thompson, 2011) the wider utilisation of waste heat from London Underground Network is constrained mainly by the relatively low grade of heat, the costs and challenges of capturing and transporting heat and difficult financial justification.

8.2.9 The GLA's report *London's Zero Carbon Energy Resource Secondary Heat* (GLA, 2013b) concluded that recovering heat from London Underground Network at a macro scale has both a limited capacity and a high cost. However, the report suggests that such systems may be viable on a local scale, particularly in conjunction with supplying cooling services. The BSCU does not include mechanical cooling for the tunnels and/or platforms (as outlined in Section 7.3, subsection *Efficient cooling system*), which limits the viability of waste heat recovery.

8.2.10 Due to the relatively low heat demand associated with the BSCU, an additional challenge would be to find an appropriate consumer for the recovered heat. Limitations associated with interconnecting the station with an OSD are further explored in the following section.

8.2.11 Additionally, waste heat recovered from tunnels would add complexity to the M&E systems and have considerable space implications.

8.2.12 Therefore, waste heat recovery from the tunnels is not proposed as part of the BSCU.

Integration with an Over Site Development

8.2.13 Opportunities for the connection of the BSCU to an OSD's energy centre were investigated at the early tender stage. The benefits of such a connection could include the following:

- increased efficiency of plant equipment;
- reduced station's plant rooms space requirements; and
- potential to make efficient gas fuelled systems acceptable due to the reduced safety risks associated with the location of the energy centre above ground.

8.2.14 Although these benefits are attractive there remain both technical and legal issues to delivering them. These arise because the station and OSD, although desiring to present a unified structure to the urban realm need to remain separate structures to ensure continuous operation of the railway independent of the status of the OSD.

8.2.15 TfL is actively participating in a number of initiatives to understand the legal and technical challenges around the capture and utilisation of waste heat, for instance the work at Bunhill in Islington which is part of the European Union (EU) funded CELSIUS project. However these initiatives are not currently at a stage where they can deliver robust design principles which can be incorporated within the BSCU design. The BSCU will co-operate with the relevant teams within TfL so that as standards for both the technical and legal interface emerge they can be incorporated where appropriate.

On-site Combined Heat and Power

8.2.16 Based on initial estimates, the heating base loads of the BSCU will not support efficient operation of an on-site CHP plant. Specifically, hot water loads are expected to be negligible and the station's space heating loads alone are would not enable efficient year round operation of a CHP unit.

8.2.17 Additionally, the on-site plant room is restricted in terms of space and safety requirements (i.e. the requirement to avoid gas within the underground station environment if possible). An on-site CHP plant is therefore not proposed.

On-site Combined Cooling Heat and Power

8.2.18 A CCHP system is a CHP system with the inclusion of an absorption chiller (i.e. a chiller driven by heat) to provide space cooling from the CHP waste heat recovery system. This potentially allows the system to function effectively through the summer period when space heating requirements are low.

8.2.19 Due to the high capital costs for CCHP, limited expected site heating and cooling loads and therefore limited improvement in CO_2 savings offered by the CCHP system, the level of additional plant space and system complexity, CCHP is not proposed for the BSCU.

8.3 Summary Be Clean Scheme

8.3.1 The *be clean* analysis outlined the opportunities to connect to an OSD and/or Citigen DEN and to install an on-site CHP/CCHP, however, mainly due to the low heat demand associated with the BSCU and the constraints associated with the site, none of the options were found feasible or viable.

9 Be Green – Renewable Energy Technologies

9.1 Site Constraints

9.1.1 In line with *The London Plan*, consideration has been given to the inclusion of renewable energy technologies within the BSCU. Renewable technologies that have been examined but rejected are analysed in detail in Appendix C – Appraisal of Renewable Energy Technologies.

9.1.2 Overall, there are a number of constraints associated with the site of the BSCU when considering the installation of renewable energy technologies. Firstly, the majority of the upgrades will be located underground and will be surrounded by a dense network of tunnels. The above ground areas are located in the heart of the City of London closely surrounded by commercial buildings.

9.1.3 The BSCU is also located in the Bank Conservation Area and there are a number of listed buildings nearby, including the Grade I listed St. Mary Abchurch. The southern half of the Whole Block Site falls within the London View Management Framework Protected View 5A.2 from Greenwich Park (wider setting) and the southern edge of the Whole Block Site falls within the Protected View 4A.1 from Primrose Hill to St Paul's Cathedral (background).

9.1.4 Finally, an OSD will be developed on top of the BSCU further constraining the areas available for renewable technologies.

9.2 Summary Be Green Scheme

9.2.1 A number of renewable energy technologies have been considered for the BSCU under the *be green* scheme. None of the assessed technologies were found feasible for installation as part of the BSCU.

10 Proposed Energy Statement

10.1.1 In line with the local and regional policy guidance, the analysis presented in this report showed that the energy consumption and consequently CO_2 emissions associated with the operation of the BSCU can be reduced by implementation of passive design and energy efficiency measures.

10.1.2 The proposed strategy presented in this report would allow the BSCU to achieve a **23 per cent reduction** in CO_2 emissions over the baseline.

10.1.3 The key energy saving features of the BSCU include:

- natural ventilation for public areas;
- humped alignment;
- high efficiency lighting and intelligent controls;
- high efficiency cooling system for staff areas and communication rooms;
- efficient fans and pumps including variable speed drives;
- Building Management System and sub-metering strategy;
- low energy lifts, escalators and moving walkaways; and
- energy awareness schemes and efficient asset handover.

10.1.4 The analysis has determined that there are no on-site low or zero carbon technologies viable for the BSCU.

10.1.5 The CO_2 emissions and CO_2 emission savings are shown in Table 9.1.

Table 9.1: CO_2 Emissions for the Energy Strategy Stages

Carbon Dioxide Emissions (Tonnes CO_2 Annually)			
Assessment	**Total BSCU**	**Savings**	**Percentage Improvement**
Baseline	1,688	-	-
After energy demand reduction (Be Lean)	1,301	387	23%
After low carbon technology (Be Clean)	1,301	0	0%
After renewables (Be Green)	1,301	0	0%

11 Conclusions

11.1.1 This Energy Statement was developed to assess the available options for providing heating, cooling and electrical demands for the BSCU, whilst minimising energy consumption and consequently overall CO_2 emissions.

11.1.2 Energy consumption during construction has been estimated and a number of measures identified as part of this Energy Statement to reduce the CO_2 emissions associated with construction activities.

11.1.3 Although the majority of the BSCU consists of a non-building infrastructure, the Mayor's Energy Hierarchy applicable to buildings has been followed to ensure that the BSCU maximises its potential to contribute to the Mayor's and TfL's ambitions to reduce CO_2 emissions associated with transport in London.

11.1.4 A wide range of energy saving measures has been considered for the BSCU. Those measures identified as feasible are being taken forward to the detailed design stages of the project with an aspiration to achieve operational CO_2 emissions savings of **23 per cent as a minimum over the baseline** (considering total energy uses).

11.1.5 To further reduce CO_2 emissions, an analysis of the feasibility of LZC energy technologies has been undertaken. It has been demonstrated that no on-site low or zero carbon technologies are feasible or viable for the BSCU.

11.1.6 To ensure energy efficient operation, a comprehensive commissioning strategy and energy management and targeting system will be implemented and the relevant staff will be provided with information and guidance on how to use energy efficiently.

11.1.7 In addition, the Energy Statement will be reviewed and revised through each design stage and will fulfil the role of the Carbon and Energy Efficiency Plan required by TfL's Pathway process.

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Appendix A – Policy Review

A.1 National Policy

A.1.1 The Government has launched a raft of measures to combat global warming, climate change and promote reductions in energy or CO_2, and other greenhouse gas emissions.

Energy Act 2013 (Her Majesty's Office, 2013a)

A.1.2 The *Energy Act* makes a provision for the setting of a decarbonisation target range, duties in relation to it and for the reforming of the electricity market for the purposes of encouraging low carbon electricity generation.

Climate Change Act 2008 (Her Majesty's Office, 2008)

A.1.3 The *Climate Change Act* sets up a framework for the UK to achieve its long-term goals of reducing greenhouse gas emissions by 34 per cent over the 1990 baseline by 2020 and by 80 per cent by 2050 and to ensure steps are taken towards adapting to the impact of climate change.

Climate Change and Sustainable Energy Act 2006 (Her Majesty's Office, 2006)

A.1.4 The *Climate Change and Sustainable Energy Act* enhances the contribution of the UK to combating climate change and securing a diverse and viable long-term energy supply.

Our Energy Future – Creating a Low Carbon Economy (Department for Transport, 2003)

A.1.5 This White Paper sets a target for 20 per cent of electricity to be produced from renewable sources nationally by 2020, with a 60 per cent reduction in CO_2 emissions by 2050 (from 2003 levels).

The Carbon Plan: Delivering Our Low Carbon Future (Department of Energy and Climate Change, 2011)

A.1.6 This plan sets out the Government's plans for achieving the emissions reductions commitment made in the *Climate Change Act 2008*. A pathway consistent with meeting the 2050 target is outlined.

A.1.7 This publication brings together the Government's strategy to curb greenhouse gas emissions and deliver climate change targets.

National Planning Policy Framework (Department for Communities and Local Government, 2012)

A.1.8 The *NPPF* sets out the Government's planning policies for England and how these are expected to be applied. It is a material consideration in planning decisions. The document presents a series of policies that constitute the Government's view of what sustainable development in England means in practice for the planning system.

A.1.9 At the heart of the *NPPF* is a presumption in favour of sustainable development.

A.1.10 *Planning practice guidance* (*PPG*) was published by the Department for Communities and Local Government in March 2014. The *PPG* includes guidance on the implementation of the *NPPF*. The *PPG* incorporates guidance on climate change in planning for new development, covering relevant legislation and adaptation and mitigation measures, such as natural ventilation in buildings and avoiding solar gain.

A.2 Regional Policy

The London Plan (Greater London Authority, 2011)

A.2.1 The relevant policies from *The London Plan* are included in Section 3 of this Energy Statement.

Draft Further Alterations to The London Plan (Greater London Authority, 2014a)

A.2.2 This document was released for initial public consultation between January and April 2014. The relevant proposed altered policies have been reviewed and considered in the context of this report.

A.2.3 Specifically, *Draft Policy 5.4A Electricity and Gas Supply* states that developers, especially of major schemes, should engage at an early stage with relevant boroughs and energy companies to identify the gas and electricity requirements arising from their development proposals.

Sustainable Design and Construction Supplementary Planning Guidance (Greater London Authority, 2014b)

A.2.4 The Mayor published the *Sustainable Design and Construction Supplementary Planning Guidance (SPG)* to provide guidance to developers. This SPG lists the Mayor's standards, covering a wide range of sustainability measures that major developments are expected and encouraged to meet.

Delivering London's Energy Future: The Mayor's Climate Change Mitigation and Energy Strategy (Greater London Authority, 2011a)

A.2.5 The strategy sets out the Mayor's strategic approach to limiting further climate change and securing a low carbon energy supply for London.

A.2.6 To limit further climate change impacts the Mayor has set a target to reduce London's CO_2 emissions by 60 per cent on 1990 levels by 2025. The strategy details the programmes and activities that are on-going across London to achieve this.

A.2.7 This strategy also details policies and activities underway to reduce CO_2 emissions from new development and transport through *The London Plan* and the *Mayor's Transport Strategy*.

Energy Planning – Greater London Authority Guidance on Preparing Energy Assessment (Greater London Authority, 2014c)

A.2.8 This guidance provides details on how to address the Mayor's Energy Hierarchy through the provision of an energy assessment to accompany strategic planning applications.

Integrating Renewable Energy into New Developments: Toolkit for Planners, Developers and Consultants (London Renewables, 2004)

A.2.9 New developments are expected to be assessed using procedures set out in this publication. This document provides a review of the planning context, guidance on feasibility studies, case stories and cost models for a wide range of applications.

A.3 Local Policy

Core Strategy (City of London Corporation, 2011)

A.3.1 The relevant policies of the *Core Strategy* are included in Section 3 of this Energy Statement.

Draft Local Plan (City of London Corporation, 2013b)

A.3.2 The final stage of public consultation on the *Draft Local Plan* ended in February 2014. The *Draft Local Plan* sets out the future vision and key policies for planning within the City of London until 2026. It is anticipated that *The Local Plan* will be adopted in late 2014, replacing the *Core Strategy* and *Unitary Development Plan.*

A.3.3 The *Draft Local Plan* includes new policies for Development Management and although these policies have not yet been adopted draft policies *DM15.1* and *DM15.3* have been consulted with regards to this Energy Statement to ensure that the BSCU Project is developed in line with the principles of the emerging *Local Plan*.

Bank Conservation Area: Character Summary and Management Strategy Supplementary Planning Document (City of London Corporation, 2012)

A.3.4 This Supplementary Planning Document (SPD) states that it is important that sustainable development is sensitive to the historic environment. The development, including the incorporation of climate change adaptation measures, should have regard to the need to protect the historic significance of heritage assets.

A.3.5 The SPD also mentions that the Citigen CHP Network is proposed to be extended along London Wall at Bank Conservation Area's northern boundary. It is anticipated that in future buildings within the conservation area will make use of the network.

Consultation Draft Planning Obligations Supplementary Planning Document (City of London Corporation, 2013a)

A.3.6 The *Consultation Draft Planning Obligations SPD*, consultation on which ended in January 2014, sets out principles for how carbon offsetting will operate in the City of London and identifies the use of section 106 planning obligations as a means of delivery. These obligations are not yet in force.

A.4 Transport for London and London Underground Limited Standards and Guidance Documents

A.4.1 This section includes a number of relevant TfL documents within the LUL and TfL Management System. LUL's Management System conforms to the principles of ISO 14001.

London Underground Limited Standard 1-566 Monitoring Health, Safety and Environmental Performance (Transport for London, 2010)

A.4.2 The TfL Monitoring Health, Safety and Environmental Performance document requires the following indicators to be reported as outlined below:

a) tonnes of CO_2 produced (to be reported as annual figures). This indicator measures both direct and indirect CO_2 emissions.

i) Direct Emissions: are those from fuel combustion at premises or during service provision (e.g. diesel vehicle engines and gas boilers).

ii) Indirect Emissions: comprise those from electricity consumption where the generation of the electricity is upstream of LUL's activities. These are both operational (e.g. traction) and facility-based (e.g. offices).

b) grams of CO_2 emissions per passenger kilometre (km) (to be reported as annual figures).

c) total electricity consumption (MWh based on meter and billed data, reported as period figures).

d) electricity consumption per passenger km (to be reported as period figures).

London Underground Limited Standard 1-068 Station Mechanical Services, Utility Provision and Energy Management (Transport for London, 2011a)

A.4.3 The purpose of this standard is to define the requirements for operational property building mechanical services, the provision of utility connections and energy management. The standard covers hot and cold water systems; gas, oil and solid fuel systems; ventilation, comfort cooling, air conditioning and heating systems; mechanical services; electrical supplies; and energy management.

A.4.4 According to *LUL Standard 1-068*, all designs shall be optimised for energy use, whole life cost and all systems shall be designed to meet the requirements of the *Building Regulations ADL*. Designs are to be encouraged which will enable whole life energy consumption to be less than the regulatory requirements.

Health, Safety and Environment Report (Transport for London, 2012b)

A.4.5 Transport for London produces annually an integrated Health, Safety and Environment (HSE) Report, which focuses on TfL's strategic objectives and outcomes in relation to HSE.

A.4.6 The document reports on performance against TfL's target of reducing the normalised CO_2 equivalent (CO_2e) emissions from the main public transport services by 20 per cent in 2017/18 against a 2005/06 baseline. Normalised emissions are those associated with the main TfL public transport services, which include LUL.

A.4.7 An increase in passenger journeys by 5 per cent in 2012/13 on the London Underground Network contributed to a reduction in normalised emissions from 64 grams CO_2e per passenger km in 2011/12 to 61 grams CO2e per passenger km in 2012/13, meeting the 2017/18 target.

A.4.8 Absolute CO_2e emissions associated with the London Underground Network have only changed slightly in the past five years, however given the much greater power needs of the newer rolling stock, and the more intense service, this does represent a significant achievement.

A.4.9 As per *The London Plan* It is expected that over the next 10 years the capacity of London's public transport system will further increase. Improving the efficiency of TfL's operations is therefore considered to be essential if CO_2 emissions are to be minimised.

Business Plan 2011/12 – 2014/15 (Transport for London, 2011c)

A.4.10 Delivering a cleaner, greener outlook for London is a central part of TfL's current Business Plan 2011. This reflects TfL's strategic goal of tackling climate change and enhancing the environment and the need to reflect this in the way TfL delivers its business.

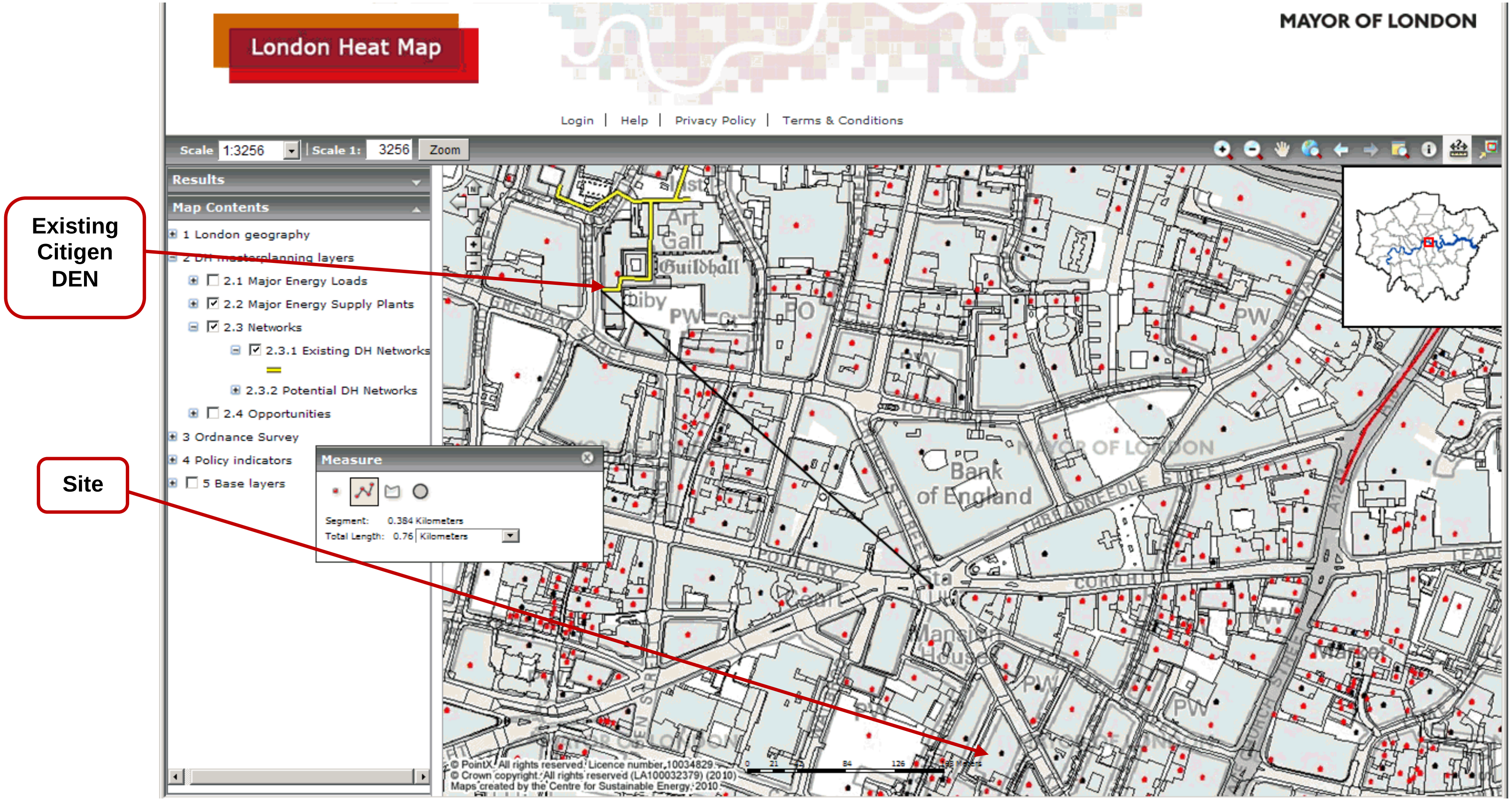
A.4.11 For example, LUL is working to establish new ways of sourcing decentralised and renewable energy. New processes are being put into place that can help LUL work with energy companies under the Government's current Feed in Tariff rules. It is also exploring possible partnerships with local energy providers in London.

Standard 1-066 Lighting of London Underground Limits Assets (Transport for London, 2011b)

A.4.12 This standard, updated in 2011, includes the required illuminance levels and general lighting requirements of the London Underground Network.

Appendix B – London Heat Map

Source: London Development Agency, London Heat Map http://www.londonheatmap.org.uk/Mapping/



Appendix C – Appraisal of Renewable Energy Technologies

C.1.1 In line with the Mayor's Energy Hierarchy the feasibility of renewable energy technologies has also been assessed for the BSCU.

C.1.2 There are a number of constraints associated with the site of the BSCU when considering installation of renewable energy technologies:

- the majority of the areas being developed as part of the BSCU will be located underground and will be surrounded by a dense network of tunnels;
- the over ground areas are located in the heart of the city closely surrounded by commercial buildings;
- the site is located in the Bank Conservation Area and there are a number of listed buildings nearby including the Grade I listed St. Mary Abchurch;
- the site falls within area of identified local views; and
- an OSD will be developed on top of the BSCU further constraining the areas available for renewable technologies.

C.1.3 As a consequence, none of the assessed technologies were found feasible or viable on-site. The outcomes of the feasibility analysis are presented in the following sections for each technology considered.

Wind Technology

C.1.4 The location of wind turbines is critical to their performance. They are typically situated in regions that frequently develop strong winds. London does not generally have a good wind climate for power generation – the high density of buildings considerably slows the wind as it passes across the city. Compared to open spaces with uninterrupted laminar air movement, the highly turbulent air movement in built up urban areas makes this technology poorly suited for this location.

C.1.5 Wind turbines are subject to vibration and would be detrimental to the sensitive building uses. There are also concerns that the inevitable blade wind noise could prove problematic with regard to the local residents. Alongside undesirable visual impacts of wind turbines and space constraints the reasons outlined above make wind technology impractical for the BSCU.

Solar Thermal (Solar Collectors)

C.1.6 Solar collectors use energy from the sun to provide domestic hot water (DHW).

C.1.7 The DHW demand of the BSCU is considered to be low to make this option viable.

C.1.8 In addition, an OSD will be developed on top of the BSCU and it is therefore expected that there will be no available area for incorporation of solar collectors.

C.1.9 Solar thermal systems are therefore not considered appropriate for the BSCU.

Photovoltaic Panels

C.1.10 Photovoltaic (PV) panels offer the opportunity to generate electricity from solar energy. As well as solar collectors, the feasibility of PV panels is dependent on the available sun exposed areas. No roof areas will be available as part of the BSCU and therefore PV panels are not considered feasible.

Borehole Cooling

C.1.11 Borehole cooling was considered to provide cooling loads of the BSCU.

C.1.12 Borehole systems may be either open, where water is extracted from a borehole and discharged through a heat exchanger to waste in a river or sewer. This could affect the local water table and permission would be required. In a closed system water is circulated through pipes extending below the water table.

C.1.13 Currently, the walls of the station box have very little penetration below basement excavation level. Due to the fact that there are a large number of tunnels present, there is only a very limited slice of ground available.

C.1.14 The *2012 Environment Agency report* (Her Majesty's Stationery Office, 2013b) on rising ground water indicates that there are many open loop schemes already installed or planned for this area. Borehole cooling could also deplete the aquifer (discharge to drain) or increase the temperature of the aquifer due to heat rejection (rejection borehole).

C.1.15 In addition to the site constraints, there is only a limited cooling demand associated with the BSCU. The design of the BSCU does not require cooling for the tunnels and public areas and mechanical cooling is specified only for limited staff areas and communication rooms.

C.1.16 Borehole cooling is therefore not considered a viable option for the BSCU.

Heat Pumps

C.1.17 As sunlight travels through the atmosphere and falls on the Earth's surface, it warms the air and ground, resulting in a large store of ambient heat energy. However, this heat energy is at low temperatures, usually below that comfortable for homes and workplaces. Heat pumps use electricity to 'pump' this heat to higher temperatures and transfer it into buildings. When run in reverse, heat pumps can provide air-conditioning to cool the inside of buildings in summer. There are two main types of heat pumps: Ground Source Heat Pumps (GSHP) and Air Source Heat Pumps (ASHP). In addition, heat pumps could utilise low grade waste heat from the underground tunnels.

Ground Source Heat Pumps

C.1.18 GSHP collect heat by laying pipes under large flat areas. Alternatively, vertical boreholes can be drilled. In order to ensure a sustainable utilisation of the ground/aquifer cooling and heat abstraction should be balanced over the year. This will however not be the case of the BSCU, which will on balance require more cooling (for staff areas and communication rooms) than heating.

C.1.19 The necessary heating loads could be provided by an OSD. However, the inter-reliance between Bank Station and an OSD is not possible because of LUL requirements on safety, security and durability and also due to commercial and legal issues (see Section 8.2, subsection Integration with an OSD of this Energy Statement).

C.1.20 In addition, the available ground for the installation of GSHP loops is limited as explained in the previous section (Borehole Cooling). Therefore, GSHP is not proposed for the BSCU.

Air Source Heat Pumps

C.1.21 Air Source Heat Pumps (ASHP) extract heat directly from the outside air and transfer it to water (in a water-based central heating system) or air inside buildings. ASHPs can provide both heating and cooling. However, ASHPs in cooling mode (referred to as a Variable Refrigerant Flow (VRF) system) are not considered to be a renewable technology and as such is included in the Section Be Lean of this Energy Statement (i.e. Section 7.7 – Efficient Cooling System)

C.1.22 This section assesses the feasibility of ASHPs to provide space heating requirements of the BSCU. Based on the initial heat demand analysis, the BSCU requirements are considered to be low (< 25MWh/year). Therefore, the savings associated with the ASHP in a heating mode would be less than 5 tonnes of CO_2 per year corresponding to a 0.25 per cent improvement.

C.1.23 ASHPs would require additional plant space, which is currently not available due to the site constraints of the BSCU. In addition, the system would add to the complexity of the M&E services and therefore ASHPs are not proposed.

Other Heat Pump Systems

C.1.24 Waste heat recovery from the tunnels has been considered for the BSCU. The temperature of the tunnels waste heat is too low for direct use. It is therefore necessary to ‘upgrade’ this heat to a useful temperature using heat pumps.

C.1.25 However, waste heat recovery was found not viable for the BSCU (see Section 8.2 – BSCU to Recover Waste Heat of this Energy Statement).

Biomass

C.1.26 Biomass heating works effectively where it supplies the base heating load all year round. However, the implementation of biomass has issues related to space constraints, transport, supply chain and air quality:

- a biomass boiler would require additional plant room space, and fuel storage;
- transportation of biomass into central London is inherently not a sustainable activity;
- although the biomass supply chain is rapidly developing, there are constraints linked to the sustainability of biomass sources (i.e. uncertainties about the provision of biomass from certified sources); and
- biomass boilers emit more NO_X and PM10 (i.e. particles with a diameter smaller than 10 μm) than conventional gas boilers, which would cause air quality concerns, particularly considering the BSCU is located in an Air Quality Management Area (AQMA). Additionally, according to the document *Clearing the air: The Mayor's Air Quality Strategy (*Greater London Authority, 2010) there is a risk that the widespread inclusion of biomass boilers in developments could compromise the achievement of local air quality objectives in London. The City of London also does not wish to see biomass technology proposed in the area.

C.1.27 The biomass boilers are therefore not considered to be viable for the BSCU.

Energy from Waste

C.1.28 Methane gas from sewage or waste can be captured and used for firing boilers.

C.1.29 The BSCU will not generate sufficient waste to make this option worthwhile. Moreover plant space requirements and emissions (air quality and odour) would be an issue. This option is therefore not considered to be feasible.

Micro-Hydro

C.1.30 Turbines placed within a flow of water produce mechanical energy that drives a generator that converts the mechanical energy into electrical energy.

C.1.31 This option is not feasible for the BSCU as there is no suitable running watercourse passing through the site, and this option therefore cannot be applied as part of the BSCU.

Fuel Cells

C.1.32 A fuel cell is an electrochemical device that produces electricity by using hydrogen (H_2) or other hydrogenous compounds as a fuel. Heat is generated as a by-product of the process and can be used for other purposes such as heating and hot water generation. Fuel cells using hydrogen are considered a locally clean technology, but if running on other fuels, a fuel cell will emit CO_2. Currently, most fuel cells use hydrogen derived from gas.

C.1.33 Fuel cells come in a variety of forms and run on variety of fuels. Environmental performance will greatly vary depending on the fuel production processes, but the following positive aspects are common to all fuel cells:

- NOx and PM_{10} emissions are much lower than any other combustion based process;
- CO_2 emissions of gas fired fuel cells are comparable or lower than standard combustion based CHP systems;
- high fuel flexibility (hydrogen, bio-gas, biodiesel, natural gas, etc.);
- very high availability (more than 98 per cent);
- efficiency not affected by part load operation conditions;
- ability to modulate quickly to adapt electricity generation to demand;
- high modularity: fuel cells can be “stacked” to follow for example a phased construction program;
- enhanced energy security by allowing a wider choice of fuels; and
- potential to produce energy cleanly in the hypothesis of the development of the hydrogen economy.

C.1.34 There are also some negative aspects of fuel cells, which are mainly linked to the immaturity of the technology and are due to be reduced in the future. The following should be noted:

- high capital costs;

- maintenance expertise and replacement parts supply chain are not developed at the moment, and contribute to the whole life cost of the technology;
- adjoining systems (water treatment, backup gas tanks, etc.) add to the plant size requirements; and
- life expectancy of the fuel cells is low.

C.1.35 There are two potential options for how to incorporate fuel cells into a London Underground project. The first option would be a transport application of fuel cells to power the trains. This option would however have to wait until the upgrade of the existing train stock, which is outside of the scope of the BSCU. In addition, there is currently no commercial application of a fuel cell train and the only existing technologies of this kind are experimental.

C.1.36 The second option would utilise gas fuelled stationary fuel cells, which could produce electricity and heat as a CHP technology. However, the heat loads of the BSCU are estimated to be too low to make this option worthwhile. Fuel cells are therefore not considered feasible.

Kinetic Energy Harvesting

C.1.37 Tiles have been developed, which convert the kinetic energy from pedestrians' footsteps into renewable electricity, which can be stored in a lithium polymer battery or used to power low-wattage, off-grid applications like street lighting, displays, speakers, alarms, signs, and advertising.

C.1.38 The CO_2 emissions savings potentially achievable by this technology are estimated to be very low and would represent only a fraction of a percentage reduction of the total development's CO_2 emissions. This technology could however be incorporated as part of the energy awareness scheme to promote green energy to general public.

C.1.39 Kinetic energy from footfall is not proposed for the BSCU, because there is currently a very high payback period associated with it making this opportunity unviable.