MASTERPLAN – SUSTAINABILITY STATEMENT

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1.0 INTRODUCTION

This Sustainability Statement summarises the findings of the Sustainability Appraisal conducted for the outline planning submission for the regeneration of Crystal Palace Park, which can be found in Appendix 1. The Energy Statement, which can be found in Appendix 2, has also been summarised in this statement.

The London Development Agency (LDA) (hereafter referred to as the ‘Applicant’) is seeking to obtain planning permission for the regeneration of Crystal Palace Park (hereafter referred to as the ‘Park’). The LDA’s vision for the Park is a revived metropolitan park of the 21st century, which meets the needs of local people, sports people and the public throughout the region, as well as providing a valued leisure, educational and recreational resource. It is anticipated that the regeneration and rejuvenation will provide a catalyst to the wider regeneration of the area. The Masterplan, which forms the basis of the planning application, has been developed by Latz and Partner and is subsequently referred to as the ‘Proposals’.

This Sustainability Statement, prepared by Waterman Environmental, accompanies the planning application as a supporting statement and describes the approach that the team has taken to sustainability during the design process and the extent to which the proposals accord with the principles of sustainable development.

Opportunities for incorporating sustainable features into the Proposals have been explored throughout the evolving design process with the aim of achieving the highest level of practicable sustainable design. Consideration has therefore been given to the latest standards in sustainable design outlined in the ‘London Plan’ (Ref 1), the Supplementary Planning Guidance (SPG) on ‘Sustainable Design and Construction’ published by the Greater London Authority (GLA) (Ref 2) as well as following best practice within London Borough of Bromley’s UDP (Ref 3).

The LDA are the Mayor’s agency responsible for driving London’s sustainable economic growth and they work to deliver the Mayor’s vision for London to be a sustainable world city with strong, long-term economic growth, social inclusion and active environmental improvement. The LDA has stated in the Crystal Palace Park Planning Framework (Ref 4) that “the new park design, aims to bring the much loved park back to its former glory, by interpreting its past into a functional and sustainable park for the future.” The LDA’s vision for a sustainable Park and the supporting core principles that are set out by the Planning Framework document have also been key in driving the integration of sustainable standards in the evolving design process.
The Park was created in 1854, when Joseph Paxton’s Crystal Palace was re-located there in its enlarged form, following its original construction for the Great Exhibition of 1851 (in Hyde Park). Since completion of the Park and the fire in 1936 which destroyed Crystal Palace, many alterations have been made to the original Paxton design, although some features do still remain today.

In the 1950s and 60s the National Sports Centre (NSC) and Athletics Stadium were conceived and built with the intention of them forming part of a larger Masterplan for a ‘sports park’, however only Queen Elizabeth’s Jubilee Stand was added in 1977 and the rest of the Masterplan was left unrealised. In 2003, Sport England made the decision to close the NSC as they were no longer able to maintain the increasing subsidy necessary to keep the facility open (but the centre was never closed). The Mayor of London and the LDA recognised the value of the NSC as an asset for London and for sport and took control (from Sport England) of the NSC as part of London’s bid for the 2012 Olympics. In March 2006, the London Borough of Bromley (LBB), following negotiations with the LDA and Sport England, granted the LDA a 125 year lease for the NSC with the option to take on responsibility for the whole Park by 2009. The NSC is a Grade II* listed building and the Proposals for the Park look at refurbishing and updating its facilities.

The LDA is committed to promoting the regeneration of south London through improvements in the sporting, recreational and educational facilities of Crystal Palace Park and in October 2005 they published their vision for Crystal Palace in the document ‘Crystal Palace Park Planning Framework’. Following extensive consultation on the document an addendum was published in February 2007. In August 2006, the LDA appointed Latz and Partners from among 20 landscape architects practices from Britain, Europe and America to lead the detailed masterplanning and regeneration of the Park and to submit a planning application to LBB in autumn 2007. Latz + Partner is an award winning international landscape architectural practice and they were appointed by a panel, which included representatives from the LDA, English Heritage, LBB and community representatives from the Crystal Palace Park working group.
3.0 THE SITE AND SURROUNDINGS

Crystal Palace Park is located in South London within the London Borough of Bromley (LBB) close to the boundaries of the London Boroughs of Lambeth, Southwark, Lewisham and Croydon. The Park is centred at National Grid Reference (NGR) 534300, 170900 and its location can be seen on Figure 1, with the planning application boundary shown on Figure 2. The extent of the planning application boundary, which encompasses the Park, is hereafter referred to as the ‘Site’. At just under 80 hectares the Park is one of the largest parks in southeast London.

The Site is bounded by:
- Crystal Palace Park Road to the north and north east;
- Thicket road to the east;
- Anerley Hill, Ledrington Road and the railway corridor and Crystal Palace Station to the south; and
- Crystal Palace Parade to the west.

There are five main entrances to the Park which are referred to as ‘Gates’; ‘Anerley Hill/Crystal Palace Station Gate’ to the south; ‘Norwood Triangle’ located at the junction of Crystal Palace Parade, Anerley Hill and Westow Street, ‘Rockhills’ to the northwest; ‘Sydenham’ to the northeast along Crystal Palace Park Road, and ‘Penge’ at the junction of Crystal Palace Park Road and Thicket Road in the east.

Crystal Palace Park is subject to a number of planning and heritage designations. The Park, with the exception of the area formerly occupied by the Palace designated as a Conservation Area, and much of the Site is recognised by the LBB’s Unitary Development Plan (UDP) as a Site of Nature Conservation Importance (SNCI) of Borough Grade I. The Park is also a site of archaeological importance as well as being registered as a Grade II* listed Park in the Register of Parks and Gardens (one of only 28 in England to have this grade). LBB has additionally designated the majority of the Site as Metropolitan Open Land (MOL) which thereby affords it the same protection as Green Belt, with the exception of the area in the centre of the Park around the NSC and Athletics Stadium. The Park also contains a number of listed and locally listed buildings and structures (included in Table 3.1).

The Park consists of open parkland (open grassland and semi-mature and mature trees) with assorted pathways, car parking facilities and access roads. There are a number of buildings associated with Park maintenance, sport and recreation and these are mostly located in the centre of the Park. These buildings include the Grade II* listed National Sports Centre (NSC) which is a classic example of 1960’s modernist architecture and the Grade II Athletics Stadium. Other key elements of the Park include the listed terraces located in the eastern part of the Park and the central Paxton Axis (Grand Centre Walk) which runs from the terraces to Penge Gate in the east. World class sporting events and other major events are held at the Park, including the Athletics Grand Prix.

The Park contains a recently restored traditional hawthorn Maze, a Boating Lake, although boating no longer takes place. The Park also hosted a children’s farm (Capel Manor Farm), which is due to reopen in October 2007 as part of a new horticultural and animal husbandry project. The BBC transmission mast is located in the Palace Terrace part of the Park. The Crystal Palace Caravan Club site is also located in this part of the Park.

The area around the Park is predominantly suburban particularly to the north with large residences along Crystal Palace Park Road and beyond in Lower Sydenham and Dulwich. To the south of the Site the neighbourhood areas are more urban in nature and in areas around the Park there are a number of residential estates. To the west, Crystal Palace Parade maintains the sense of grandeur of the original design of the park. Town centres in close proximity to the Park are Upper Norwood to the South West, Penge to the East and Anerley to the South. Of these, Upper Norwood relates most directly to the Park and provides a mix of uses and facilities.
Site location of Crystal Palace Park at the intersection of the five boroughs of Southwark, Lewisham, Bromley, Croydon and Lambeth
Crystal Palace Park — Masterplan

THE SITE AND SURROUNDINGS

3.0

Crystal Palace Park
planning application boundary
3.1 Key Environmental Constraints/Opportunities

The existing Site and its surrounding area presents a number of important considerations in both environmental and sustainability terms, including a number of heritage designations. Therefore, a number of key constraints and opportunities have been identified, as listed in Table 3.1, which have required careful consideration during the development of the Park proposals. Key environmental issues have been considered in the design development and the Environmental Impact Assessment (EIA) which has been undertaken to ensure all potential environmental impacts are appropriately mitigated through the design. This has included the assessment of a wide range of issues and the resulting Environmental Statement (ES) supports the planning application.

Table 3.1: The Site and Surrounding Land Uses

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>On Site</th>
<th>Surrounding Site</th>
</tr>
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<tbody>
<tr>
<td>Conservation Areas</td>
<td>The Park, with the exception of the Palace Terrace to the far west, is designated as a Conservation Area. The policies within the UDP seek to preserve and enhance Conservation Areas (Policy BE11) and any development must have special regard to LBB’s Supplementary Planning Guidance (Ref. 7) particularly in relation to the scale, height, form, massing and detailed design of any built form.</td>
<td>Belvedere Road Conservation Area (Bromley) approximately 250m south west from Anerley Hill road - primarily large Victorian villas built after the erection of the Crystal Palace. Weston Hill Conservation Area (Lambeth) – Next to Anerley Hill junction area was influenced by the construction of Crystal Palace and occupies a significant plateau position between Crystal Palace Park and the downward slopes of Gipsy Hill and Central Hill. Upper Norwood Triangle Conservation Area (Croydon) - Starting from Anerley Hill junction and running south west away from Crystal Palace Park.</td>
</tr>
<tr>
<td>Views</td>
<td>The Park is designated within the LBB Adopted UDP as a ‘Major Skyline Ridge’. The BBC transmission mast within the Park is designated as a ‘Landmark’ and the panoramic view from Addington Hills towards the Park is considered to be of Local Importance.</td>
<td>The panoramic view from Addington Hills towards the Park is considered to be of Local Importance.</td>
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</tbody>
</table>
### Table 3.1: Table 3.1 (continued)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>On Site</th>
<th>Surrounding Site</th>
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</thead>
<tbody>
<tr>
<td><strong>Heritage Features</strong></td>
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<tr>
<td>The Crystal Palace National Sports Centre (NSC) (Grade II*)</td>
<td>- Central location within the Site</td>
<td>Crystal Palace Lower Level Station (Grade II) - Southern border of the Site</td>
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<tr>
<td>The Upper and Lower Terrace of the Crystal Palace Gardens (Grade II) - to the west of the Site</td>
<td></td>
<td>Railway Bridge locally listed structure within Crystal Palace Park Conservation Area - Crossing Thicket Road at the southern edge of the Conservation Area</td>
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<tr>
<td>Pedestrian subway under Crystal Palace Parade (Grade II)</td>
<td></td>
<td>Houses around eastern and northern perimeter of the Park (75-81 Thicket Road, 1-15 Crystal Palace Park Road, 29a Crystal Palace Park Road, 35-69 Crystal Palace Park Road, 71 Crystal Palace Park Road) (19 and 20), locally listed buildings within Crystal Palace Park Conservation Area</td>
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<tr>
<td>27 Prehistoric Dinosaurs on islands and land facing the lower lake (Grade I) - South east corner of the Site</td>
<td></td>
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<tr>
<td>New Dinosaur sculptures at Crystal Palace Park (incorporated with Grade I listing of the dinosaurs) - South east corner of the Site</td>
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<tr>
<td>Limestone Cliff sculptures and Lead Mine at Crystal Palace Park (incorporated with Grade I listing of the dinosaurs) - South east</td>
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<tr>
<td>Bust of Sir Joseph Paxton (Grade II) - South east on the Paxton Axis</td>
<td></td>
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<tr>
<td>Cast Iron Gate Piers (Grade II) - Located off Crystal Palace Parade, where Paxton once lived, north west corner of the Site.</td>
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<tr>
<td>Water Tower Foundations, locally listed building within Crystal Palace Conservation Area - On the north side of Anerley Hill at the western corner of the Park.</td>
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<tr>
<td>Gorilla Statue, locally listed statue within Crystal Palace Conservation Area - To the south of the cricket ground</td>
<td></td>
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<tr>
<td>NSC, Jubilee Stadium, locally listed building within Crystal Palace Conservation Area - To the south of the NSC</td>
<td></td>
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<tr>
<td>NSC hostel tower (The Lodge), locally listed building within Crystal Palace Conservation Area - To the west of the NSC</td>
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<tr>
<td>Staff houses - Locally listed buildings within Crystal Palace Conservation Area - To the west of the NSC</td>
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<tr>
<td>Caretakers lodge, Locally listed building within Crystal Palace Conservation Area - To the west of the NSC</td>
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<tr>
<td>Royal Naval Volunteer Trophy, locally Listed structure within Crystal Palace Park Conservation Area - Housed in a pavilion to the west of the cricket ground</td>
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<tr>
<td>Fountain basin and farm at Crystal Palace Park, locally Listed structures within Crystal Palace Park Conservation Area - At the southern edge of the Park</td>
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<tr>
<td>Sculptural collection at Crystal Palace Park, locally Listed sculptures within Crystal Palace Park Conservation Area - Kept at the rear of the information centre</td>
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Table 3.1 (continued)

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<td>Transport, Assessment and Movement</td>
<td>Currently access to the Park is disjointed with the infrastructure geared towards car accessibility rather than cycle or pedestrian access and this has meant a large provision of car parking within the Park. A confusing experience for cyclists and pedestrians to orientate within the Park.</td>
<td>The Park is serviced by both mainline rail and London bus services a short distance away. Two mainline stations operate within close proximity to the Park. Crystal Palace Station is situated just outside Station Gate and has frequent services to central London and to the south it is linked to Gatwick Airport and Brighton. Penge West Station to the east of the Site is serviced by Southern railways and linked to Sutton, Caterham and Tattenham as well as to London Bridge. Within 20 minutes a significant number of inner London Boroughs south of the River Thames area able to access the Park via the mainline stations. The bus interchange located at the southwest corner of the Park is serviced by around 13 bus routes giving access to Oxford Circus, Plumstead, Blackheath, Orpington, Croydon, Wallington, Morden, Clapham Common, Vauxhall and Brixton. By bus the Park is accessible to approximately 650,000 local residents within 45 minutes off-peak. The East London Line which is due to start operation in 2010 will run from Crystal Palace Station via New Cross Gate up to Dalston Junction. A proposed Croydon Tramlink extension from Beckenham Junction up to Anerley Hill Bus interchange, providing links to Croydon and Wimbledon is being considered and the Masterplan has been developed to accommodate this route if it is approved.</td>
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<td></td>
<td>Currently the Site provides good vehicular access with the main access point through Anerley Hill via Cintra Gate which links to internal roads within the Park. In terms of car parking facilities, there are extensive areas within the Site around the main entrances and a central car park serving the NSC. There are approximately 710 permanent spaces within the Site distributed between the NSC and the other visitor car parks at Penge and Sydenham Gates. There is significant additional overflow parking available within the site for use during high attendance events. Approximately 2,000 vehicles can be accommodated in the Lower Terrace. In addition, a further 1,000 vehicles can be accommodated on-street along the internal park road network. Pedestrian access is available through a number of entrances around the perimeter of the Park with the main entrances being the Fisherman’s Gate, Penge Gate, Sydenham Gate and Anerley Gate. Within the Site, the network of routes for pedestrians and cyclists is unclear and confused, hampered by a maze of temporary and permanent fencing creating barriers to the free movement of visitors. Sitting within the centre of the Site, the NSC complex effectively splits the Site into two, not only creating a physical barrier, particularly for those with disabilities, but also a significant visual intrusion reducing the openness of the Site. Many of the existing routes in the Site are not cycle friendly due to the large number of stairs and the variation in levels, particularly around the NSC and Athletics Stadium. Currently busy main roads on three sides of the Site, Crystal Palace Parade, Crystal Palace Park Rd and Anerley Hill Road act as a barrier to non-vehicular access to the Site. At the Upper Norwood triangle, pedestrians must negotiate the busy Anerley Hill junction by way of a number of lengthy pedestrian crossings and at Canada Gate, the footway ends abruptly forcing pedestrians into the road. The London Cycle Network provides cycle routes to and through the Park but again access is via busy junctions and once in the Park poor signage and fencing hampers movement. The Site is part of a network of green spaces that form a ‘green chain’ through South East London. Crystal Palace Park is the largest of these green spaces.</td>
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| Archaeology    | A comprehensive Cultural Heritage Assessment was undertaken by the Museum of London Archaeological Service (MoLAS) in 2004 which identified the Park to have a number of sites with some archaeological potential. LBB has (subsequently) identified the Crystal Palace Park as an Area of Archaeological Significance within its UDP (Policy BE16). An archaeological evaluation was undertaken in 2007 to supplement this study as part of the EIA. The Park has a low archaeological potential for remains from the prehistoric, Roman, and early to late medieval periods. However, a number of features associated with the former Crystal Palace and its landscaped setting (i.e. Paxton’s Park) have been identified, and below ground remains may also survive, such as the footings of buildings. Well-preserved remains of these features would be of considerable significance. | A number of statutory ecological and non-statutory designated sites are present within 300m of its boundary. These include:  
- Sydenham Hill wood and fern bank, Local Nature Reserve- 300m northwest  
- Dulwich and Sydenham hill woods, Site of Metropolitan Importance - 200m north  
- Hillcrest Estate Woodland, Site of Borough Importance (Grade I) - 110m north  
- Dulwich Upper woodland, Site of Borough Importance (Grade I) - 110m west  
- Gipsy Hill railway cutting, Site of Borough Importance (Grade II)- 225m west  
- Sydenham Wells Park Site of Local Importance 225m north |
| Ecology        | The Site is not subject to any statutory wildlife designations; however, 49.15 hectares of the Park have been designated as a Site of Importance for Nature Conservation (SINC) by LBB due to the breeding birds and waterfowl around the Tidal Lakes and the green areas within the Park. There are seven other SINC's within 1 km of the Site boundary. The Site is not subject to any statutory wildlife designations; however, 49.15 hectares of the Park have been designated as a Site of Importance for Nature Conservation (SINC) by LBB due to the breeding birds and waterfowl around the Tidal Lakes and the green areas within the Park. There are seven other SINC's within 1 km of the Site boundary. |
4.0 THE PROPOSALS

The LDA is seeking to rejuvenate Crystal Palace Park to provide first class leisure, educational and recreational facilities and the aim is that the Park should be an exemplar modern sustainable Park. The Proposals will celebrate the heritage, landscape, sport and ecology of the Park.

Latz + Partner’s initial ideas were developed from the Crystal Palace Park Planning Framework’s and focus on greening the centre of the Park currently dominated by car-parking and tarmac roads. The key elements of the Masterplan Proposals include: the preservation of the historic structures within the Park, refurbishment of the NSC and repair of the various listed structures including Paxton’s terraces; improving the quantity and quality of the parkland; enhancing its biodiversity and providing improved access and movement within the Park.

A number of existing buildings are proposed to be demolished and a number of new Park related buildings are proposed with an aim to improved facilities including a new Regional Sports Centre and a new museum building on the Palace Terrace, two greenhouses on the Terraces, provision of a new cafe information centre to replace the existing structure in the Tidal Lakes area and a new cricket pavilion to upgrade the current structure. Finally, the Proposals are designed to reduce the sports-related infrastructure and car parking in the centre of the Park and free up space for pedestrians.

The Proposals can be divided into the following elements:

- Full and partial demolition of buildings and structures including removal of hard surfaces;
- Change of use of caravan site to part residential and part public open space;
- Change of use of former museum to park ranger’s facility;
- Erection of park related buildings of up to 4,927 sq m including park rangers buildings, children’s nursery, shops, cafe, toilets, greenhouses, kiosks, central pavilion and cricket pavilion
- Erection of Regional Sports Centre (Class D2) of up to 14,900 sq m including indoor swimming pool;
- Erection of 2 blocks of permanent residential dwellings (Class C3) of up to 3,899 sq m with a maximum of 5 storeys at Rockhills and erection of 6 blocks of permanent residential dwellings (Class C3) of up to 1,620 sq m with a maximum height of 4 storeys at Sydenham providing a total of up to 180 permanent residential dwellings;
- Erection of an education and training facilities including residential accommodation (Class D1/Sui Generis) of up to 926 sq m;
The planning application comprises an outline application for the Masterplan, a Listed Building Consent Application for the works to the NSC (including detailed landscape proposals around the perimeter of the NSC) and a Conservation Area Consent Application for the demolition of a number of buildings and structures within the Conservation Area. More detail on the Proposals for each zone within the Park is set out below:

The Masterplan Proposals have developed and defined as different zones (as shown in Figure 3) which relate to the original design of the Park and each of these can be seen as having a different function.

- Part demolition of linked structures and external alterations to existing National Sports Centre;
- Engineering and landscape works including water features;
- Construction of a tree-top walkway;
- Creation of adventure playgrounds and a skate park;
- Alterations to land surrounding existing park ranger’s office to form park ranger’s maintenance yard;
- Construction of museum / interpretation centre (Class D1) with viewing platform comprising up to 830 sq m, together with the change of use of subway to museum / interpretation centre;
- Erection of community centre;
- Formation of new vehicular and other access;
- Construction of parking areas and related works; and
- Associated works.

**The Palace Terrace**
Connections to the Site from Crystal Palace Parade will be improved with the construction of pathways and access points. Tree planting on the original Site will further help to reflect the original dimensions of the former Crystal Palace and this area is proposed to provide facilities for small to medium sized events. Additionally, the listed Subway will be refurbished and a new museum built over it. Finally there will also be provision of an area for the erection of small retail kiosks on the Palace Terrace.

**The Italian Terraces**
The listed terraces are to be refurbished and the construction of two sunken gardens is proposed. Two glass houses are proposed at either end of the terraces with associated Park uses including cafe and educational facilities. Pathways and access points together with service infrastructure will be provided to enable the terraces to continue to be used for events.

**Anerley Hill Edge**
Here it is proposed that by removing the wall at Anerley Hill edge and opening up the gate, the Masterplan will provide a more inviting access to the Park and facilitate extensive views into it. Crystal Palace Station is also located here and the Proposals will reopen the exit from the station directly into the Park. The Crystal Palace museum building will be converted into accommodation for Park Rangers and a Park information point. The Lodge tower building which currently provides temporary accommodation for athletes and school parties will be removed from the Park and a replacement College and Lodge building will be built to the west of Crystal Palace station.

**Traditional Landscape**
The hard surfaced car parking in this area of the Site will be removed and returned to Parkland. The ground levels of the area will also be re-profiled and features would include an adventure play area and skate park built on the foundations of the current locally listed Lodge building, replanting and profiling of Rosary mound featured in Paxton’s original Park design, and a central pavilion for use by Park rangers, local police and Park users. Finally, the existing pathways would be reconfigured and the outdoor tennis courts would be removed.

**Central Area (NSC and Athletics Stadium)**
The listed NSC building would be retained along with the Athletics Stadium and be refurbished. The alterations to the NSC are mostly internal and are subject of an application for listed building consent. Surrounding buildings would be removed in order to re-establish Paxton’s original axis and to reduce the impact of the building on the Park landscape. Furthermore by removing the raised entrance walkway and raising the ground level around the NSC the building could be more integrated into the Park. The demolished buildings would be replaced by a new Regional Sports Centre with a reconfigured athletics track to the west of the NSC closer to Crystal Palace station. The Athletics Stadium would be restructured, removing both existing stands and creating a reduced seating capacity, grassed seating stadium with a covered seating area fronting the proposed Regional Sports Centre. Once the new purpose built Regional Sports Centre has been built as part of the reconfigured stadium it is hoped that the NSC will host a range of functions and activities such as dry sports and other events.
The Lower Lakes

The proposals here include re-using the City Farm as well as landscape improvements including upgrading pathways, removing fencing and restoring water features. The current cafe and information centre would be replaced and the new facility would include a dinosaur interpretation facility, boathouse and children’s play area. The intention is that the environs around the Grade I listed dinosaurs would be improved by reducing the fenced areas and other landscape improvements.

Cricket Ground

There would be regarding of ground levels and landscape improvements around the edge of the Park and provision of a new cricket pavilion in this area together with relocation of the children’s play area to another area of the Park, improved access to Crystal Palace Park Road and reinforcement of the main pathway. Villas provide an important edge boundary to the Park and were part of the original concept and it is proposed that villas lost since the 1870s would be replaced to continue the villa edge to the Park. The Park Management facility would be relocated near Sydenham Gate.

English Landscape

The English Landscape area would be extended to Crystal Palace Parade and improved access would be created through a new gateway at Rockhills Gate. Proposals for this area include improvements to the Concert Bowl and its surrounding lake, restoration of the maze, creation of a treetop walk and a nursery themed play area accessible outside nursery hours. The existing caravan park would be relocated in order to free up additional parkland which can be publically accessible. Residential accommodation and community facilities would be provided at the edge of the Park close to the Rockhills Gate.
The delivery of the Masterplan has been separated into key phases and each phase must be able to function independently but also form an integral part of the overall Masterplan for the Park. At this stage the phasing and procurement is very indicative as implementation will be heavily dependent on the when funding is secured for the various components of the Proposals. The indicative key phases can be summarised as follows:

**Phase 1 -**
**The approximate construction time for Phase 1 is estimated to be two years and the works would include:**
- Targeted archaeological and environmental site investigation across the site including the Palace Terrace and Terraces;
- Removal of fencing to a minimum and selected tree removal (in accordance with the tree management strategy); and
- Finalising the configuration of the City Farm (building XXII) and restoration of the Paxton Fountain basin as well as landscape configuration around other small elements throughout the entire Park.

**Phase 2 -**
**The approximate construction time is estimated to be two years and would include:**
- Tree removal and ground remodelling of the Palace Terrace and contamination remediation works on the Palace Terrace;
- Creation of the following features: the Southern Sunken Garden; water features include ponds and fountains; and playgrounds;
- Excavation of the storage ponds located below the Terraces (in the Transitional Landscape);
- Ongoing restoration of the entire Terrace structures;
- The former CPP museum (building II) would be refurbished to allow this building to be utilised as a Park Rangers Facility; and
- Initial works to restoration of the Paxton Subway (building V), preparation works for the new Museum (building 07) and the College and Lodge (building 06) would also be undertaken.

**Phase 3 -**
**The approximate construction time is estimated to be two years and would include:**
- Completion of the Palace Terrace including: ground remodelling and remediation works;
- Excavation for and tree planting; the provision of service infrastructure to the Palace Site; and other landscape works;
- Completion of the northern part of the Terraces including excavation and landscaping of the northern sunken gardens and connected water features;
- The area to the north of the National Sports Centre (NSC) (building XXVII) within the Central Area would be used for stockpiling and materials handling;
- Completion of the water features on the Palace Terrace and Terraces;
- Ongoing restoration of the full length of the Terrace structures, the Park Ranger Building (building 10) would be dismantled, relocation and operational. Landscape around Sydenham entrance would also be undertaken;
- Completion of construction works for the new Museum (building 07) and the Palace Site Kiosks (building 06).

**Phase 4 -**
**The approximate construction time for phase four is estimated to be two and half years and would include:**
- Anerley Hill Edge ground remodelling and landscape works;
- Penge Gate alterations would be undertaken;
- Landscaping of the area surrounding the new Penge Café and Dinosaur Interpretation Centre (building 13) contained in the Lower Lakes; and
- The reconfiguration of the Fisherman’s Gate (Cricket Ground zone) and connections to the surrounding area;
- Remodelling and planting of the Rosary and the upgrade of the Concert Bowl (including changing the lake profile), including improvements to the Lake;
- Construction of the South Greenhouse, the Sydenham Villas (building 11) and the Penge Café and Dinosaur Interpretation Centre (building 13); and
- The re-development of Rockhills entrance and construction of the Rockhills Residential (dwelling, café and community facilities) (buildings 8a and 8b), (which is tied to the break clause in the Caravan Club lease in 2019). It would be noted that the timing for Rockhills and Sydenham Villas is dependent on the availability of these sites as well as funding.

**Phase 5 -**
**The approximate construction time is estimated to be three years and would include:**
- The section of the Paxton Axis within the Transitional Landscape, the Central Area would be completed (including demolition, ground remodelling and landscaping);
- The southern parts section of the Transitional Landscape and the Central Area would be completed (including demolition, ground remodelling, landscaping and creation of water features);
- Works would be undertaken to the Rockhills Gate entrance to the north-west of the English Landscape and the landscaping works around the North Greenhouse;
- Ground raising would occur around the NSC (Phase 1 landscape works), reconfiguration to the entrance to the NSC;
- Commencement of construction of the Regional Sports Centre (RSC) and construction of the Central Pavilion); and
- Further landscape work to the Transitional Landscape and implementation of landscape features (such as playgrounds).
Phase 6 -  
The approximate construction time is estimated to be two years and would include:  
Landscape works to the Tidal Lake;  
Demolition, ground remodelling and landscaping (including water features) of the northern section of the Transitional Landscape;  
Construction of the following landscape features; the Treetop Walk, the restoration of the Maze and the conversion of the former Lodge Tower into playground; and  
Cessation of stockpiling and materials handling around the NSC; and  
Conversion of the NSC into a multifunctional dry sports facility (post 2012).

Phase 7 -  
The approximate construction time is estimated to be one year and would include:  
This phase finalises the landscape treatment for the NSC (‘Phase 2′ landscape works) including the area to the north of the NCS which has been utilised for stockpiling and materials handling; and  
Completion of landscaping to the English Landscape and water features within the English Landscape and around the NSC.

Phase 8 -  
Construction time for this phase is estimated to be two and a half years and would include:  
The re-grading and re-instatement of the Cricket Pitch and construction of the Cricket Pavilion (building 12).

Phase 9 -  
This phase is the final phase and is estimated to take one and a half years and would include:  
The erection of the North Greenhouse; and  
Completion of the configuration around the Italian Terraces and completion of landscaping of the Rockhills zone.
Many definitions of sustainable development exist, although the common objective for all is the integration of economic, social and environmental issues to ensure a better quality of life for people today, without compromising the needs of future generations. In March 2005, the government launched its new strategy for sustainable development entitled ‘Securing the Future’ (Ref. 5). The strategy sets out a clear commitment to Government action on sustainable development. As such, the UK planning system aims to achieve sustainable development.

5.1 NATIONAL POLICY OBJECTIVES
The Government is committed to a planning system which creates sustainable communities and delivers sustainable development. Consequently, planning has a critical role in supporting the Government’s objectives for sustainable development. Whilst sustainability issues are contained within various different Government policies, the new and emerging Planning Policy Statements (PPS’s) are designed to achieve a positive approach to assist in the delivery of sustainable development.

The key national sustainability objectives are encompassed within ‘Planning Policy Statement (PPS) 1: Delivering Sustainable Proposals’ (Ref. 6), PPS 22: Renewable Energy (Ref. 7) and PPS 10: Sustainable Waste Management (Ref. 8). These documents actively encourage development to:

- Reuse previously developed land;
- Promote mixed-use developments;
- Encourage high density urban development;
- Provide ready access by public transport to work, education and health facilities, shopping and leisure and social services;
- Reduce car dependence by facilitating walking, cycling and public transport use;
- Provide a range of dwelling types, employment, leisure and community facilities;
- Protect and enhance biodiversity;
- Incorporate renewable energy technologies such as biomass heating, wind turbines, photovoltaic cells and Combined Heat and Power (CHP) systems;
- Use design and technologies to reduce waste generation and energy use; and
- Ensure access to public and open spaces.

5.2 REGIONAL POLICY OBJECTIVES
5.2.1 The London Plan, 2004
At a regional level, ‘The London Plan’ sets out the Mayor of London’s spatial development strategy for London. The Plan promotes economic development and the creation of wealth in Greater London through embracing the principles of sustainable development and providing better integration between land use and transport planning. The Plan contains a number of policies directly related to energy and sustainability. In particular, Policy 4B.6 states that the highest standards of sustainable design should be sought. After an extensive consultation process a number of alterations were adopted as part of the London Plan in December 2006. Included in these alterations was an update on existing waste policies to set new targets for recycling and composting of household waste and to introduce additional new focus on waste minimisation, re-use and development of waste resource parks. In addition, the Alterations introduce new policies on management of construction and demolition, and hazardous waste.
5.2.2 Sustainable Design and Construction
Supplementary Planning Guidance, 2006

The Supplementary Planning Guidance (SPG) document 'Sustainable Design and Construction' was published by the GLA in May 2006 provides additional information to support the implementation of the London Plan. The SPG provides specific guidance for achieving the highest standards of sustainable design and construction and therefore supports implementation of Policy 4B.6 of the London Plan. The SPG is applicable to all building types and associated spaces, with specific information on different building types provided where relevant. The SPG provides guidance on the way that the measures identified in Policy 4B.6 can be implemented to meet the London Plan objectives and therefore the SPG is structured around these factors. In particular, the SPG notes the importance of sustainable design and construction in achieving targets set for energy use. The SPG also highlights that buildings are responsible for 80% of London's carbon dioxide (CO2) emissions and sets out the essential standards that all developments which are referable to the Mayor must achieve. It also provides the Mayor’s preferred standards, which are based upon current industry best practice.

5.2.3 The Mayor’s Energy Strategy, 2004

‘The Mayor’s Energy Strategy: Green Light to Clean Power’ (Ref. 9) was published in February 2004 and sets out the Mayor’s proposal for changing the way energy is supplied and used within London over the next 10 years and beyond. The Strategy defines the ‘Energy Hierarchy’. The hierarchy aims to guide decisions about which energy measures are appropriate in particular circumstances. It also aims to ensure that London’s energy needs are met in the most efficient way. The stages of the hierarchy are defined as: (i) use less energy (be lean); (ii) use renewable energy (be green); and (iii) supply energy efficiently (be clean). In order to meet the requirements of the London Plan, an energy assessment for a development must demonstrate how this energy hierarchy has been adhered to in order to meet the predicted energy demand. The energy assessment for the Proposals is summarised in Section 7.2 of this Sustainability Statement.

5.2.4 Action Today to Protect Tomorrow: The Mayor’s Climate Change Action Plan, 2007

The Mayor’s Climate Change Action Plan ‘Action Today to Protect Tomorrow’ (Ref 10) was published in February 2007 and the purpose of the strategy is to set out an agenda for London to cut its carbon dioxide emissions by focusing on actions that deliver the most significant carbon dioxide savings at lowest cost. It summarises the origin of carbon dioxide emissions within London and projected growth in emissions. The Mayor will report annually on progress made towards targets for emissions reduction set out in the Plan.

5.2.5 Connecting with London’s Nature: The Mayor’s Biodiversity Strategy, 2002

The Mayor’s Biodiversity Strategy (Ref 11) was published in July 2002 and sets out proposals for promoting and protecting biodiversity in London, including ensuring that there is no overall loss of wildlife habitats in London, and that more open space is created and made accessible to all Londoners. A number of other related guidance documents include ‘Design for Biodiversity’ (Ref 12), a guidance document produced by the London Development Agency in conjunction with Natural England (formerly English Nature), the GLA and London Biodiversity; ‘Building Green – A Guide to Using Plants on Roofs, Walls and Pavements’; and, ‘Protected Species in London’,(Ref 13) published in July 2005.

5.2.6 Cleaning London’s Air: The Mayor’s Air Quality Strategy, 2002

The Mayors’ Air Quality Strategy ‘Cleaning London’s Air (Ref 14) was published in September 2002 and aims to minimise the adverse effects of air pollution on human health and the environment and to improve London’s air quality to meet the objectives set out by the Government’s National Air Quality Strategy. Following the commitment within the Mayor’s Air Quality Strategy, Best Practice Guidance (Ref 15) was published in November 2006 to control dust and emissions from construction and demolition.

The Mayor’s municipal waste strategy ‘Rethinking Rubbish in London’ (Ref 16) published in September 2003 contains policies to manage London’s municipal waste through to 2020 in accordance with the Waste Hierarchy and proposals to implement these policies. Many of the existing proposals for implementation are now out of date or have been met. As such, the Strategy is currently being updated and will be re-published to provide new and revised policies and proposals for waste management until 2020.

Making Waste Work in London: The Mayor’s Draft Business Waste Management Strategy (Ref 17) published in May 2007 refers to commercial, industrial, construction, demolition, excavation and hazardous waste produced by businesses operating in the public, private, voluntary and community sector and sets out proposals for dealing with this waste, which makes up three quarters (13.8 million tonnes) of London’s waste overall. It focuses on ensuring that businesses use resources productively and that the economic opportunities for reprocessing and managing waste within London are maximised.

As of October 2007, the draft strategy is undergoing formal public consultation and is due to be adopted and published early on in 2008.

5.2.8 Water Matters: The Mayor’s Draft Water Strategy, 2007

The Draft ‘Water Matters’ strategy (Ref 18) published in March 2007 examines how water resources could be used more effectively and how problems related to flooding could be reduced. The Draft is currently out for consultation with the London Assembly and the Functional Bodies. A revised draft will be published for public consultation later in 2007.

5.3 LOCAL POLICY OBJECTIVES

5.3.1 London Borough of Bromley Unitary Proposals Plan, July 2006

London Borough of Bromley Unitary Development Plan (UDP) sets out the planning polices for developing land, protecting the environment and improving the transport systems within Bromley. The Council has recognised that in order to build sustainable communities that planning has a key role to play. Therefore, in line with the principles of relating to sustainable communities contained within PPS1 and The London Plan, the policies in the LBB UDP collectively aim to:

- Ensure high quality development through good and inclusive design, and the efficient use of resources;
- Contribute to economic development;
- Protect and enhance the natural and historic environment, and;
- Ensure that development supports existing communities and contributes to the creation of safe, sustainable, liveable and mixed communities with good access to jobs and key services for all.

5.3.2 London Borough of Bromley Local Development Framework

The Planning and Compulsory Purchase Act 2004 (Ref 19) brought about a change in the planning system to a two tier system of Regional Spatial Strategies (RSS) and Local Development Frameworks (LDF). These will be gradually phased in by LBB in accordance with a Local Development Scheme (LDS).

The core strategy Issues and Options which will consider policy are yet to be completed and are due for consultation from March 08 - April 08. Furthermore, a draft SPG titled ‘Green Building Design and Construction’ is due to be progressed forward as an SPD.
5.4 Crystal Palace Park Planning Framework

The Crystal Palace Park Planning Framework published in October 2005 and the subsequent Addendum, published in January 2007 outlines the LDA’s vision for Crystal Palace Park and the NSC in order to provide guidance on proposals by setting down clear principles against which those proposals will be assessed. The Framework is not intended to be a prescriptive document. It sets out broad principles which aim to ensure future proposals maintain high standards in terms of quality and design and that new initiatives are properly integrated within Crystal Palace Park with an overall aim of rejuvenating and promoting the regeneration of the Park and its surroundings. 

The Planning Framework is a non-statutory document which has not been formally adopted by LBB but has been subject to extensive consultation. The Framework should be read in conjunction with the London Plan and the LBB UDP and any proposals will be assessed against the principles set out in this document along with regional, national, UDP and relevant SPG guidance.

The Planning Framework documents together with the results of the consultation exercise are available on the LDA’s website.

5.5 The London Development Agency (Lda) Sustainability Objectives

The LDA are the Mayor’s agency responsible for driving London’s sustainable economic growth and they work to deliver the Mayor’s vision for London to be a sustainable world city with strong, long-term economic growth, social inclusion and active environmental improvement. Sustainability for the LDA is about the long-term economic, environmental and social implications of the way the LDA works. The LDA also has an important role in delivering against the Mayor’s priority of tackling climate change. The LDA has a Health and Sustainability Advisory Group which has been established to make strategic recommendations concerning the integration of health and sustainability development into LDA programmes and projects.

The LDA’s overall vision for Crystal Palace Park is stated in the Crystal Palace Park Planning Framework as:

“Our vision is for repair and rejuvenation, creating a revived metropolitan park of the twenty-first century, which meets the needs of local people, sports people, and the public at large and provides valued leisure, education and recreational resource.”

The Crystal Palace Park Planning framework also outlines the LDA’s vision for the Park in relation to sustainability, which is stated below:

“....for the Park to be a showcase for sustainability, embracing the latest technologies and thinking in terms of renewable energy, reusable water, the efficient management of waste, construction and design and in the overall management of the Park so that Crystal Palace Park becomes the first truly sustainable Park in the UK”

In order to support the visions for the Park the LDA has set out in the Planning Framework document five core principles for rejuvenation and regeneration of the Park have also been established and are outlined below:
Core Principles

- **A Revived Metropolitan Park**
  To create a Park which acknowledges its historical past, yet embraces the twenty-first century through its design, the range of activities and its accessibility, and acts as a catalyst for the regeneration of Crystal Palace Park and the wider area.

- **A Sports and Events Park**
  Which celebrates its sporting and events past, and casts this in a rejuvenated Park with improved sporting and event facilities to host a wide range of events and activities in a spectacular setting and in state-of-the-art facilities - from sporting and musical to historical and horticultural.

- **A Sustainable Park**
  Which embraces the principles of sustainable development and inclusive design in respect of its physical, social and economic context by improving the distinctive nature of the Park and its surrounding area, thereby enhancing environmental quality and maximising opportunities for the local community both now and in the future.

- **An Accessible and Integrated Park**
  Which is better connected with the surrounding area and London, is accessible to all with improved gateways and is safe and convenient to navigate around.

- **An Educational Park**
  Which enables visitors to learn and enjoy the Park and its facilities, building on improved interpretation facilities for the Park in terms of nature and ecology, sustainability, natural history (such as the dinosaurs), the geology of the Park, and the provision of educational facilities within the Park: a learning experience of stunning landscape setting.
As highlighted in section 5, the LDA has developed a clear vision of sustainability for the Park, which is support by a number of key principles. In order to achieve the LDA’s vision for a sustainable Park and to meet the sustainable policy objectives that apply to the application, a robust sustainability approach was adopted for the Proposals and this can be divided into seven key components:

1. Desktop Review & Sustainability Checklist;
2. Workshops & technical studies;
3. Assessment of the Energy Demand of the Proposals, the evolution of an Energy Strategy and the production of an Energy Statement;
4. Consultations;
5. Undertaking of an independent sustainability review by Waterman Environmental. This was to ensure that all practicable sustainability options for the Proposals had been appropriately considered and implemented;
6. Undertaking of a Sustainability Appraisal of the Proposals; and
7. Implementation Plan and Review.

ZEF (UK) Ltd, sustainability and low energy consultants, were appointed by Latz & Partner to take forward items 1 to 2 and to develop a sustainability strategy for the Proposals. Subsequently, Waterman Environmental provided input by undertaking a review of the strategy and to complete a Sustainability Appraisal of the Proposals. The engineering consultancy Hoare Lea was also commissioned to further develop the energy calculations prepared by ZEF (UK) Ltd and to prepare an Energy Statement to accompany the planning application.

A brief summary of the above components is provided below. All components have fed into the Sustainability Appraisal which provides a more comprehensive coverage of sustainability issues relevant to the Proposals. The full Sustainability Appraisal is presented in Appendix 1 of this Sustainability Statement with a summary of the key findings of the appraisal presented in section 7 of this statement. The Energy Statement is attached as Appendix 2 to this statement.

6.0 APPROACH TO SUSTAINABILITY FOR THE PROPOSALS

6.1 DESKTOP REVIEW & SUSTAINABILITY CHECKLIST

This commenced with an initial desk-top review of all relevant national, regional and local level policy documents summarised in Section 5 of this Sustainability Statement. The result was the development of a bespoke Sustainability Appraisal checklist against which the Proposals has been appraised. The Sustainability Appraisal checklist comprises the checklist of measures outlined in the Mayor’s ‘Sustainable Design and Construction’ SPG. That is:

- Reuse of land and buildings;
- Maximise use of natural systems;
- Conserve energy, water and other resources;
- Reduce noise, pollution, flooding and microclimatic effects;
- Ensure developments are comfortable and secure for users;
- Conserve and enhance the natural environment and biodiversity;
- Promoting sustainable waste behaviour; and
- Sustainable construction.
In addition, relevant issues from the LBB UDP (2006) were added to the Sustainability Appraisal checklist to support and enhance the main headline issues listed above. Furthermore, given the significance of promoting sustainable transport modes, a transport section was also added to provide a more comprehensive coverage of sustainability issues specific to the Proposals.

In addition to the sustainability objectives provided by key planning policies the main drive for the sustainability strategy has come from the LDA’s vision for sustainability in the Park. As such each section of the appraisal checklist also provides a summary of the key principles and objectives the LDA are striving to achieve and how the proposals accord with these principles.

6.2 WORKSHOPS & TECHNICAL STUDIES

The LDA is committed to the practical achievement of sustainability as set out in all the policies and guidance documents summarised within Section 6 of this Sustainability Statement. Accordingly, to demonstrate this, a number of workshops and design team meetings were held with the design team in order to consider the Proposals against a set of sustainability objectives derived from these policies and documents. The workshops also offered an opportunity to consider the sustainability of the Proposals and to identify further opportunities which will achieve the LDA’s vision for a sustainable Park. A number of technical studies were undertaken to inform this process including studies on waste, water and energy. The results of other studies which were undertaken as part of the EIA also informed the design process.

6.3 ASSESSMENT OF ENERGY DEMAND

Following the energy hierarchy the total building energy demands and associated CO2 emissions were predicted for the base case of the proposals, and then the savings that could be made through energy efficient building design, other energy efficiency measures, efficient supply of energy, incorporation of appropriate renewable energy sources and connection to heating networks were predicted.

Hoare Lee consulting engineers produced the Energy Statement that is provided as a supporting document to this Sustainability Statement and includes:

- A review of applicable policies;
- An energy demand assessment outlining the estimated annual kilowatt hours per year demand and overall CO2 emissions for the operational Proposals;
- A review of the measures incorporated to reduce energy demand including built form, building fabric and installed services;
- Consideration of connection to the existing district heating system;
- A technical assessment of CHP, including the use of tri-generation;
- An assessment of the feasibility of a range of renewable energy technologies for the Site;
- Consideration of supply to the nearby district heating system;
- A review of the CO2 savings associated with water management practices at the Site; and
- A summary of the energy related features of the Proposals and the associated CO2 savings.

The conclusions of the Energy Statement are summarised in Section 7.3 of this Sustainability Statement and the full statement can be found at Appendix 2.
6.4 CONSULTATION

Several consultation exercises have been undertaken in developing the Proposals for the Park with a combination of LBB and key stakeholders including members of the local community. Extensive public consultation was undertaken in developing the Planning Framework document. Consultation continued during the design of the Proposals going forward for planning including the local dialogue process.

The Crystal Palace Park Dialogue Group has worked closely with Latz & Partner, responding to emerging proposals before they have been finalised. It was also agreed that a wider public engagement process be set up to involve members of the public and other organisations. A detailed description of the work undertaken to consult on proposals for the Park is provided in the Statement of Community Involvement (SCI) which accompanies the planning application.

A number of topic based workshops with local planning authorities and statutory consultees to discuss and agree the approach and methodology of certain assessments were undertaken including consultation with with the Greater London Authority regarding the energy strategy, consultation with LBB about the site wide waste strategy and consultation with the Environment Agency regarding the Flood Risk Assessment.

Consultation will continue throughout the planning process and during the detailed design and reserved matters applications.

6.5 INDEPENDENT SUSTAINABILITY REVIEW

A review of progress with the strategic sustainability objectives set for the project was undertaken by Waterman Environmental to ensure that all practicable sustainability options for the Proposals had been appropriately considered and implemented and in order to complete the sustainability appraisal and produce this statement. This independent review identified energy and carbon; water conservation; living surfaces; and health and well-being as being key areas of opportunity within the Proposals. The review assisted the design team in achieving a holistic approach to sustainability for the Proposals. These issues have all been incorporated into the Sustainability Appraisal, presented in Section 7 of this Sustainability Statement.

6.6 SUSTAINABILITY APPRAISAL

Following completion of the review, Waterman Environmental conducted a Sustainability Appraisal of the Proposals against the sustainability checklist. The full results of the appraisal are provided in Appendix 1. The key sustainability commitments identified by the full appraisal are summarised in Section 7 of this report.

6.7 IMPLEMENTATION PLAN AND REVIEW

It has been recognised the LDA that the delivery of the Proposals will occur across a number of phases as identified in Section 4 with a target completion date in 2018. It is acknowledge that sustainability standards in this time are likely to become more stringent. In order to ensure that the Proposals continue to achieve high standards of sustainability, regular reviews of the objectives will be required as detailed design and reserved matters applications are developed. This will enable adjustments to the principles outlined in this statement to be made to meet new standards and to accommodate new technologies, where feasible. The principles outlined in this document are key commitments and their delivery in each area or phase of the Park will require individual consideration during the detailed design process. As such, the implementation section of this statement (Section 9) indicates how this will be undertaken during this process to ensure these principles are effectively delivered through all phases of the project.
7.0 SUSTAINABILITY PERFORMANCE OF THE PROPOSALS

The Sustainability Appraisal, presented in Appendix 1, was used as a tool to assess how the Proposals comply with the Mayor’s essential and preferred standards as set out in the ‘Sustainable Design and Construction’ SPG, local planning policy requirements and the LDA’s vision for a sustainable Park as defined by the Crystal Palace Park Planning Framework document. The compliance criteria used in the Sustainability Appraisal is set out at the start of the full appraisal. The following section of this Sustainability Statement provides a summary of the main sustainability commitments and initiatives which will be implemented as part of the Masterplan and summarises the findings of the Sustainability Appraisal.

7.1 LAND USE AND BUILDINGS

London has a large population and a relatively small land area. The Mayor’s standards therefore aim to reuse previously developed land and use all developable land as efficiently as possible. Existing buildings should be reused where practicable and all development should follow the principles of good design as set out in London Plan Policy 4B.1. The LDA has expressed a clear vision that seeks to repair and rejuvenate the Park following the core principles of sustainable development. The proposals seek to address the principles of the London Plan policy and address the LDA’s vision through the following initiatives:

- Proposed land uses and the scale and massing of buildings will be appropriate for a contemporary Park and will support the regeneration aspirations whilst respecting the planning and historic designations of the Park.
- The built form elements of the proposals will be integrated into the landscape and will be designed to provide maximum flexibility for future uses.
- The existing museum (the old engineering school), the NSC and the Capel Manor Buildings will be re-used following refurbishment and the Rangers Maintenance Building will be relocated and refurbished to improve building quality and performance. The remainder of the buildings will be demolished following a full retention option appraisal including the existing Park Rangers Building and office, Jubilee Stand, Café (near the Penge Gate) and this will provide an opportunity to improve quality in terms of building materials and the efficiency of performance.
- The use of existing and new roof space will be maximised through the incorporation of green roofs and renewable technologies.
- The principles of good building design have been adopted in line with the London Plan.
- A commitment has been made to achieve a minimum of a BREEAM rating of ‘Very Good’ for all non-residential buildings with an aspiration to achieve ‘Excellent’.
- A commitment has been made to achieve a minimum of Code for Sustainable Homes rating of level 4* for all residential buildings.

7.2 MAXIMISE USE OF NATURAL SYSTEMS

The overall objective is to minimise the use of natural resources and maximise the comfort of those who use the building by selecting an appropriate location, employing good urban design and using natural ventilation systems and passive solar gain. Given current knowledge of the likely effects of climate change, buildings in London will need to adopt these natural systems wherever feasible. The proposals seek to maximise the use of natural systems including the following:

- The building façade design will maximise the use of natural daylight.
- The use of natural ventilation will be maximised in most buildings with the exception of the sports facilities that required higher levels of ventilation due to the nature of their use.
- Solar shading has been incorporated into the design of the buildings to prevent overheating.
7.3 CONSERVATION OF NATURAL RESOURCES

It is important that buildings and developments make the most efficient use of natural resources such as energy, water and the raw materials used in construction. The LDA’s sustainable vision for the Park seeks to conserve the use of natural resources through incorporating the latest technology when considering the use of renewable energy, the reuse of water and the effective management of water and materials.

Since the beginning of the industrial revolution, the concentration of greenhouse gases in the atmosphere including CO2 has risen. Approximately 50% of the UK’s CO2 emissions are attributable to energy used in heating, lighting and cooling of buildings and a further 10% from energy used during the production and transportation of materials and the construction of buildings. An additional 22% is due to the energy consumed by occupants travelling between buildings. As well as producing CO2, fossil fuels such as oil, coal and gas are finite resources and therefore should be used as efficiently as possible. During the development of the proposals a number of energy studies were undertaken, the outcome of which are presented in the Energy Statement attached as Appendix 2 of this statement. In summary the proposals incorporate the following to ensure the efficient use of energy:

**Energy**
- A 40% reduction in carbon dioxide (CO2) emissions over and above the new Approved Document Part L of the Building Regulations 2006
- A commitment to source 20% of the Proposals’ energy demands from renewable sources
- Promotion of natural heating and cooling systems where possible, use of high performance glazing and solar shading to reduce solar gain
- A commitment to achieve a minimum of Code for Sustainable Homes rating of level 4* on all residential buildings
- A commitment to install a range of energy efficiency measures including the use of energy efficient plant, recovery systems, intelligent buildings controls and lighting systems

**Materials**

When considering the use of materials in developments it is important to use finite natural resources, such as building materials, as efficiently as possible. The construction industry uses approximately 6 tonnes of building material per person per year. Each material has a number of environmental impacts resulting from its production, transportation, use, maintenance and final disposal. The sustainable approach involves reducing the quantity of material used in the first instance and using materials that have the least environmental impact during their entire life-cycle. Consideration has been given to the efficient use of materials and the Proposals include the following initiatives:

- A commitment to use at least 50% of timber from sustainable sources with an aspiration to achieve 90% where possible
- A commitment not to use peat in landscaping and to only specify weathered limestone for maintaining or enhancing heritage features in the Park
- A demolition protocol will be followed such as the Institute of Civil Engineers (ICE) protocol and this will be implemented in line with a Construction Environmental Management Plan (CEMP)
- The use of local materials will be considered and specified where possible
- The use of new aggregates will be minimised with an aspiration to use 100% of demolition materials (subject to their suitability for use) being used for landscaping or as sub-base for building construction
- At least 10% of the total value of materials will be derived from recycled/reused content products and materials with a commitment to specify a higher percentage where possible during detailed design phases
Water

Water is also becoming an increasingly scarce resource, particularly in south-east England, as demand continues to grow. To satisfy this increase in demand, new sources of water and associated infrastructure are needed. However, this is expensive, energy intensive and damaging to the environment and therefore measures should be taken to reduce water consumption where possible. During the development of the Proposals a number of water studies were undertaken. The studies form technical appendices supporting Chapter 14, Water Resources and Flood Risk, of the Environmental Statement (ES). The following water initiatives have been incorporated into the Masterplan proposals:

- A Flood Risk Assessment has been undertaken in line with PPS25 and the onsite storage will ensure discharge rates to the existing drainage system will be maintained and the design has given due consideration to the effects of climate change in the future.
- A commitment to achieve a Code for Sustainable Homes rating of level 4* in residential buildings will require water consumption to be no higher than 105 litres/person/day
- 100% metering for all buildings will be specified to allow monitoring of Park usage and that of tenants
- Implementation of sustainable urban drainage (SUDS) systems within the Park by combining site natural gravity channels with ponds, reed beds and aesthetic water features
- Installation of rainwater harvesting and reuse systems on all buildings

7.4 COMMUNITY AND HEALTH & WELLBEING

Developments must be comfortable and safe for use by all sections of society including older people, women, children and young people, black and minority ethnic groups, disabled people and all cultures and religions. The LDA’s core principles for the Park highlight the importance of achieving an inclusive design, addressing a balance of physical, social and environmental factors. The principles also seek to fully maximise the opportunities created in rejuvenating the Park for the local community now and in the future. The availability of external space is one key factor that affects the quality of life of the local residents. Coupled with these principles the internal environment, daylight and low noise are the key determinants of a healthy living environment. The proposals will contribute to the LDAs vision by:

- A commitment to achieve Lifetime Homes Standards on all residential units
- Security in the Park to be improved through the encouragement of a greater human presence in the Park, passive surveillance, CCTV, lighting design and the provision of central contact points for police assistance
- Full consideration has been given to compliance with the Disability Discrimination Act requirements in the Park, associated buildings and residential units
- Provision of new education and training facilities that would be suitable to a wide variety of groups within the community
- Enhancement and protection of cultural heritage buildings, structures and features in the Park
- Improved provision of sports facilities and public amenity space that will enhance health recreation and leisure activities both for local and the wider community
- An aspiration to achieve the Green Flag Awards and potentially the Green Heritage Site. Green Heritage Site status promotes the value of, and best practice in, the care and upkeep of parks and green spaces that are of local or national historic interest
7.5 NATURAL ENVIRONMENT & BIODIVERSITY

The conservation of biodiversity is another essential element of sustainable development. The LDA’s core principles acknowledge the importance of enhancing environmental quality. Two key causes of reduced biodiversity are created through habitat loss and habitat fragmentation. During the planning of developments, an opportunity exists to lessen or remove the causes of reduced biodiversity. Sites that already have significant ecological resources should ensure that preservation and enhancement are key considerations during the development of landscaping proposals. The Park is recognised in many ways for it contribution both to biodiversity and the variety of habitats it supports. This has therefore been a key consideration the design of the proposals so that the Park achieves the following in the future:

- A net gain of open space in the Park by park fringes being maximised for recreational use and habitat creation. The location and relocation of buildings and car parking facilities to the periphery of the Park.
- A net gain of biodiversity through the enhancement and protection of existing habitats and creation of new habitat areas.
- Protection of existing habitats and species in compliance with all applicable legislation through the implementation of phased redevelopment.
- Extension of water features and improvement in water quality across the Park.
- An Environmental Impact Assessment has been undertaken to identify and mitigate any adverse environmental impacts of the Proposals and a Construction Environmental Management plan will be implemented to manage construction related impacts.

7.6 WASTE

The most sustainable approach to waste management is to reduce the overall amount of waste generated ‘at source’. Wastes that are generated should be reused wherever possible, or recycled as the next best environmental option. The least sustainable waste option is disposal (e.g. to a landfill site). Key consideration also needs to be given to the storage of waste both during construction and operational phases of development to prevent pollution of the environment. The LDA’s sustainable vision for the Park places an emphasis on the effective management of waste during all phases of design, construction and management. A side wide waste strategy was developed for the Proposals, which can be found as a technical appendix to Chapter 19 ‘Waste Management’, of the ES. Key waste initiatives that have been incorporated into the scheme include:

- Demolition waste will be reused on site (except for any contaminated or hazardous material, which will be treated and disposed appropriately). Excavated materials will also be reused on site with an aspiration to achieve a cut and fill balance.
- Provision of suitable waste and recycling storage for all end users within the residential elements to meet the requirements of a Code for Sustainable Homes rating of level 4* for recycling provision.
- Commercial waste facilities to be provided to achieve 70% recycling targets.
- A Site Waste Management Plan to be adopted.
- Recycling facilities to be provided for green waste from the Park.

7.7 SUSTAINABLE CONSTRUCTION

The demolition and construction phase of the redevelopment can have a significant impact on the local environment, neighbouring residents, employees in the area and the general public. Sustainable construction requires the prudent use of new and existing resources, the efficient management of the construction process and consideration of potential adverse environmental impacts on local sensitive receptors. The proposals will look to implement the following initiatives:

- A Construction Environmental Management Plan (CEMP) will be implemented to control and reduce on site environmental impacts during demolition and construction works. The requirements of the CEMP will ensure that all applicable legislation is met and best practice followed during the construction phase of development.
- Registration to the Considerate Constructors Scheme will be a tender requirement for all developers and contractors.
- The control of dust and emissions will be implemented through the CEMP and will follow best practice guidance such as the Mayors best practice guidance for the control of dust and emissions.
- Modern Methods of construction will be used through the construction phases of the development to aid the reduction of waste production.
- A consultation process will be maintained, which will include the provision of a Community Liaison Officer, to provide information and advice to the local community during the construction process.
7.8 TRANSPORT & ACCESS

Certain modes of transport which use significant amounts of energy are a major source of greenhouse gases and air pollution and raise other considerations such as congestion and safety. The promotion of more sustainable modes of transport, encouraging accessibility to jobs, shopping, leisure facilities and services by public transport, walking and cycling, and reducing the need to travel, particularly by private car, are key aims of sustainable development. These are also key aims for the LDA in creating a sustainable Park. In addition one of the core principles of the LDA’s vision for the Park is to achieve and accessible and integrated Park that is well connected to the surrounding area that is safe and convenient to navigate around. Therefore the proposals incorporate the following transport and access initiatives to address these core principles:

- The provision of improvements for pedestrians and cyclists by creating a pathway structure giving priority to the movements of pedestrians and cyclists over vehicle users.
- Provision of cycle facilities both in terms of parking provision and hire facilities in key locations around the Park.
- The implementation of car access and parking to be kept to key areas located predominantly on the perimeter of the Park.
- Implementation of a travel plan to encourage and promote sustainable transport during both construction and operational phases of the redevelopment, to include effective events management.
- Enhanced entrances to the Park and provision of key navigation points around the park pathway network to aid usability and navigation around the Park.

7.9 ECONOMIC & SKILLS

The creation of employment opportunities and the strengthening of local economies are recognised within the context of sustainable development as being of equal importance to environmental and other considerations. To meet the challenges of sustainable development, a skilled and adaptable labour force and a flexible labour market is necessary. The LDA’s vision considers the promotion of jobs and employment, better education and training opportunities are essential in the successful rejuvenation of the Park and providing ongoing regeneration opportunities to the surrounding area. The proposals will contribute to the LDAs visions through:

- The Creation of jobs during the demolition and construction phases of development.
- The Creation of jobs through extending and enhancing the facilities within the Park, in particular through new events that will be staged at the Park.
- Attraction of additional visitors to the Park and nearby vicinity which in the long term could inject more financial benefit into the Park and its surrounding area, in particular to local businesses.
- Encouragement of community outreach and educational programmes including partnership working for schools and other community groups. The staging of events and provision of facilities such as cafes and retail uses in the Park that will attract revenue generation assisting with the regeneration of the Park and the surrounding area.
8.0 IMPLEMENTATION

As outlined in section 6, the Applicant recognised that due to the timescales anticipated for the delivery of the Proposals sustainability standards were likely to become more stringent. In order to ensure that the Proposals continue to achieve the high standards of sustainability that are required by the sustainability vision set out by the LDA, regular reviews of the sustainability initiatives and commitments would be required especially as the detailed design and reserved matters applications were developed.

It is proposed that a Sustainability Implementation Plan and review programme would be established to ensure the delivery of sustainability initiatives identified and to assess how standards of sustainability can be improved during each phase of the Proposals taking into consideration new sustainability standards and technology options.

The Applicant has made a commitment to revise and update the proposed sustainability initiatives in light of any future changes in planning policy and other best practice standards. Elements such as sustainable building design and renewable energy options identified in this statement would be taken forward through the detailed design stage and reserved matters applications. During these stages appropriate sustainability appraisal of the options identified would be undertaken and where the opportunity exists to improve on the initiatives stated, these would be thoroughly explored and implemented where feasible.

During the detailed design phases the BREEAM and Code for Sustainable Homes assessments would also be undertaken. As part of standard procedures for the assessment process, opportunities to improve the ratings and the measures required in order to achieve this are identified. These options would once again be subject to appropriate appraisal and would be implemented where feasible.

Many of the sustainability initiatives and commitments identified in this statement will need to be delivered through a variety of strategies and management plans that will be developed to support the implementation of the Masterplan. The strategies and management plans that would be prepared for the implementation of the Masterplan and the ongoing Park management that would support the delivery of sustainability initiatives include:

- Construction Environmental Management Plan (CEMP);
- Archaeological method statements and mitigation strategies;
- Environmental Site Investigation method statements and remediation strategies;
- Events Strategy;
- Green Travel Plan;
- Interpretation Strategy;
- Conservation Management Plan;
- Tree Management Strategy;
- Maintenance and Management Plan;
- Waste Strategy;
- Ecological Management Plan; and
- Water Strategy.

The development of these documents provides an opportunity to review and identify any adjustments in the sustainability standards that can be achieved over and above those stated so far and to include any revised initiatives identified during the detailed design and reserve matters application process.
9.0 SUMMARY

This Sustainability Statement has described the approach that the team has taken to sustainability during the design process and the extent to which the proposals accord with the principles of sustainable development. It summarizes the findings of the full sustainability appraisal (Appendix 1) undertaken for the Proposals and the results of energy studies that are presented in the Energy Statement (Appendix 2).

Opportunities for incorporating sustainable features into the Proposals have been explored throughout the evolving design process with the aim of achieving the highest level of practicable sustainable design. Consideration has therefore been given to the latest standards in sustainable design outlined in national, regional and local planning policy. The LDA’s clearly stated vision for a sustainable Park has also been key in driving the integration of sustainability into the design.

Overall, the sustainability summary based on the findings of the sustainability appraisal has shown that the Proposals accord with many of the goals of sustainable development. The findings indicate that the Proposals would make a substantial contribution to local biodiversity, sport offer, education, conservation and enhancement of heritage assets and would provide a catalyst for regeneration in the area. There is also a considerable commitment to reduce the potential environmental impacts of the Proposals and to enhance the Parks natural assets such as the existing habitats and biodiversity and its heritage features. The proposals also seek to conserve the use of natural resources such as energy, water and materials and promote efficiency with a view to mitigating the likely effects of climate change in the future.

Consideration has also been given to the delivery of the sustainability initiatives identified and this has been supported with the identification of plans and strategies that will be key in this process. This statement has also highlighted the commitment that Applicant has made to reviewing and improving sustainability standards where feasible, in light of merging standards or best practice as the Masterplan is delivered. Opportunities for undertaking future reviews and sustainability appraisals during the detailed design and reserved matters applications have already been highlighted and will assist in allowing the LDAs vision of a sustainable Park to be achieved.
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12.0 APPENDICES
MASTERPLAN – SITE WIDE ENERGY STRATEGY

Crystal Palace Park

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3.0 ENERGY EFFICIENT DESIGN

4.0 POWER, HEATING AND COOLING INFRASTRUCTURE

5.0 FEASIBILITY ASSESSMENT OF CHP AND CCHP

6.0 RENEWABLE ENERGY FEASIBILITY ASSESSMENT

7.0 CONCLUSIONS AND RECOMMENDATIONS

AP APPENDICES

Appendix A – Energy Benchmarks
Appendix B - CHP and CCHP assessment
Appendix C - Comparison of Renewable Energy Technologies
EXECUTIVE SUMMARY

This report describes the proposed site-wide energy strategy for the outline planning submission for the regeneration of Crystal Palace Park.

The project comprises a maximum 40,000 sqm of sports facilities, a number of leisure and community facilities including museums and greenhouses, and residential accommodation.

The overall strategy will reduce carbon emissions by 40% below 2006 Part L Building Regulation requirements. The key features of the energy strategy are:

- **Energy efficiency measures shall be included to reduce carbon emissions by 15% beyond 2006 Part L Building Regulation standards.** This will be assured through the stipulation of this requirement in the relevant design codes for each phase. A review of standards will be undertaken at each stage. The detailed energy statements for each phase will be required to confirm that they have designed buildings to these standards. Measures will typically include improved insulation levels, improved airtightness, energy metering, low energy fans and pumps and more energy efficient lighting and controls.

- **Combined heat and power (CHP) and Combined cooling, heat and power (CCHP) plant is predicted to deliver a further 12% carbon reduction for the whole site.** The main energy-intensive buildings will be linked to district heating systems and source a large proportion of their heat and power from the community energy networks. Tri-generation, using absorption chiller plant associated with the CHP plant, will be provided in the National Sports Centre (NSC) energy centre, and will cover a significant proportion of the predicted Regional Sports Centre (RSC) and NSC chilled water load. CHP-led district heating systems are also proposed for the Rockhills and Sydenham residential clusters.

- **A further 20% carbon reduction will be delivered by the use of on-site renewable energy sources in the form of biomass heating and solar water heating.** There are also opportunities for educational renewable energy features at the site, such as photovoltaic (PV) installations connected to lighting or fountain pumps; these will be assessed in detail in the phased applications.

- The design codes for each phase will require achievement of **Code for Sustainable Homes Level 4 for the residential areas, and of a BREEAM ‘Very Good’ standard for the non-residential areas.** Target levels will be reviewed at each stage in line with contemporary standards.

The overall carbon emission reductions achieved by the proposed measures are summarised in the following table and figure.

<table>
<thead>
<tr>
<th>Measures</th>
<th>Estimated annual carbon dioxide emissions</th>
<th>Savings in emissions due to each step</th>
<th>Aggregate saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline scheme (Part L compliant)</td>
<td>3,835</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Energy efficient scheme</td>
<td>3,259</td>
<td>576</td>
<td>576</td>
</tr>
<tr>
<td>Energy efficient scheme with CHP/CCHP</td>
<td>2,863</td>
<td>396</td>
<td>972</td>
</tr>
<tr>
<td>Energy efficient scheme with CHP/CCHP and renewables</td>
<td>2,290</td>
<td>572</td>
<td>1,544</td>
</tr>
</tbody>
</table>

Figure 1: Proposed site-wide carbon reduction strategy at Crystal Palace Park

Table 1: Proposed site-wide carbon reduction strategy at Crystal Palace Park
1 INTRODUCTION

Crystal Palace Park comprises an area of roughly 80 hectares (198 acres), making it one of the largest parks in southern London. The Masterplan intends to rejuvenate this historic venue into a 21st century Park of local, regional, national and international significance. The project comprises a maximum 40,000 sqm of sports facilities, a number of leisure and community facilities including museums and greenhouses, and residential accommodation. The Masterplan intends to be highly sustainable, addressing current and future needs while respecting the Park’s heritage and its Grade II* listed status.

This energy strategy includes the National Sports Centre (NSC), covered by an application for listed building consent, and the proposed Regional Sports Centre (RSC).

The site-wide energy strategy is based on the development of the following areas:

Table 2: Indicative schedule of accommodation of the Crystal Palace Park Development

<table>
<thead>
<tr>
<th>Space</th>
<th>Footprint area</th>
<th>Gross External Area</th>
<th>Expected use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lodge</td>
<td>714-924</td>
<td>4,140</td>
<td>Accommodation for college students and NSC users</td>
</tr>
<tr>
<td>Current Crystal Palace Park museum</td>
<td>230</td>
<td>460</td>
<td>Park maintenance headquarters</td>
</tr>
<tr>
<td>New Crystal Palace Park museum</td>
<td>877.5-1,143</td>
<td>3,971</td>
<td>Museum</td>
</tr>
<tr>
<td>Park rangers' building</td>
<td>426-526</td>
<td>526</td>
<td>Office / maintenance</td>
</tr>
<tr>
<td>Palace kiosks</td>
<td>30-83.5</td>
<td>84</td>
<td>Kiosk</td>
</tr>
<tr>
<td>Sydenham residential</td>
<td>1,134-1,614</td>
<td>6,480</td>
<td>Residential</td>
</tr>
<tr>
<td>Subtropical (South) greenhouse</td>
<td>2,033-2,322</td>
<td>1,480</td>
<td>Greenhouse</td>
</tr>
<tr>
<td>Penge gate café</td>
<td>390-590</td>
<td>832</td>
<td>Café and exhibition space</td>
</tr>
<tr>
<td>Regional Sports Centre (RSC)</td>
<td>10,910-14,500</td>
<td>27,500</td>
<td>Large sports centre, including swimming pool</td>
</tr>
<tr>
<td>Central pavilion</td>
<td>34-53</td>
<td>53</td>
<td>Exhibition / community space</td>
</tr>
<tr>
<td>National Sports Centre (NSC)</td>
<td>10,500</td>
<td>12,357</td>
<td>Dry sports centre</td>
</tr>
<tr>
<td>Rockhills - block1</td>
<td>322-670</td>
<td>770</td>
<td>Community facilities</td>
</tr>
<tr>
<td>Rockhills - block2</td>
<td>930-1,262</td>
<td>5,779</td>
<td>Residential</td>
</tr>
<tr>
<td>Rockhills - block3</td>
<td>2,347-2,637</td>
<td>9,707</td>
<td>Residential</td>
</tr>
<tr>
<td>Cricket pavilion</td>
<td>161-261</td>
<td>261</td>
<td>Sports centre</td>
</tr>
<tr>
<td>Temperate (North) greenhouse</td>
<td>2,126-2,397</td>
<td>1,680</td>
<td>Greenhouse</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>76,080</strong></td>
<td></td>
</tr>
</tbody>
</table>
The approach to reducing carbon emissions in the site-wide energy strategy is firstly to reduce energy demand through efficiency/passive design measures, secondly to incorporate gas-fired combined heat and power (CHP) and, where feasible, combined cooling, heat and power (CCHP), and thirdly to include renewable energy to further reduce carbon emissions. There is a commitment to provide on-site renewable energy generation to contribute to a carbon emissions reduction of 20%.

In summary the energy hierarchy applied to Crystal Palace Park is ‘be lean’, ‘be clean’ and ‘be green’:

Be Lean
(Be Energy Efficient)

Be Clean
(Incorporate Low Carbon Energy Sources)

Be Green
(Incorporate Renewable Energy Sources)

The Crystal Palace Park energy strategy takes an overall approach to carbon reductions, applying passive design and energy efficiency to the whole site, then applying low and zero carbon technologies where they are the most appropriate to the size and type of use of the buildings. The energy strategy therefore takes advantage of particular energy requirements and locations of the buildings, while also incorporating educational opportunities in the Park’s buildings which will attract a large public. The design of highly efficient buildings, through passive measures and specification of high performance materials and services, aims to create buildings which are contemporary, innovative and distinctive, utilising modern construction methods and prefabrication techniques and that are exemplary in terms of sustainability and environmental design.

After implementation of passive design, energy efficiency and CHP/CCHP, an overall target of reducing carbon emissions by 20% through the use of renewable energy sources is applied, with an additional requirement for the residential units to meet Code for Sustainable Homes Level 4 and for the non-residential buildings to reach a ‘Very Good’ BREEAM level. Target carbon reduction levels will be reviewed at each stage in line with contemporary standards.

In order to assess the energy demand for the site at master planning stage, ‘good practice’ benchmarks have been used to determine the baseline energy consumption. These baseline benchmarks for fossil fuel consumption, electricity consumption and hot water demand are shown in Appendix A. Specific park uses for lighting and pumping are as estimated by ZEF UK LTD, as also detailed in Appendix A.
The predicted energy demand and carbon emissions for the baseline scheme are summarised in Table 3 and Figure 3. The energy clusters referred to in Figure 3 are energy networks delivering heat and power to several buildings, and are detailed in section 5.

It should be noted that the reserved matters applications will require building specific assessments of energy demand using government-approved Part L Building Regulation methodologies such as Standard Assessment Procedure (SAP) for dwellings and Simplified Building Energy Method (SBEM) for non-dwellings.

Table 3: Predicted energy demand and carbon emissions for Crystal Palace Park baseline scheme

<table>
<thead>
<tr>
<th>Space</th>
<th>Estimated annual gas consumption kWh/yr</th>
<th>Estimated annual electricity consumption kWh/yr</th>
<th>Estimated annual CO2 emissions from gas kg CO2/yr</th>
<th>Estimated annual CO2 emissions from electricity kg CO2/yr</th>
<th>Estimated Total CO2 emissions kg CO2/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lodge</td>
<td>745,200</td>
<td>256,163</td>
<td>144,569</td>
<td>108,101</td>
<td>252,669</td>
</tr>
<tr>
<td>Current Crystal Palace Park museum</td>
<td>27,255</td>
<td>11,385</td>
<td>5,287</td>
<td>4,804</td>
<td>10,092</td>
</tr>
<tr>
<td>New Crystal Palace Park museum</td>
<td>343,094</td>
<td>203,712</td>
<td>66,560</td>
<td>85,967</td>
<td>152,527</td>
</tr>
<tr>
<td>Park rangers' building</td>
<td>31,166</td>
<td>13,019</td>
<td>6,046</td>
<td>5,494</td>
<td>11,540</td>
</tr>
<tr>
<td>Palace kiosks</td>
<td>1,253</td>
<td>529</td>
<td>529</td>
<td>529</td>
<td>529</td>
</tr>
<tr>
<td>Sydenham residential</td>
<td>437,400</td>
<td>218,700</td>
<td>84,856</td>
<td>92,291</td>
<td>177,147</td>
</tr>
<tr>
<td>Subtropical (South) greenhouse</td>
<td>117,808</td>
<td>65,120</td>
<td>22,855</td>
<td>27,481</td>
<td>50,335</td>
</tr>
<tr>
<td>Penge gate café</td>
<td>398,029</td>
<td>235,290</td>
<td>77,218</td>
<td>99,292</td>
<td>176,510</td>
</tr>
<tr>
<td>Regional Sports Centre</td>
<td>5,445,000</td>
<td>1,980,000</td>
<td>1,056,330</td>
<td>835,560</td>
<td>1,891,890</td>
</tr>
<tr>
<td>Central pavilion</td>
<td>4,579</td>
<td>2,719</td>
<td>888</td>
<td>1,147</td>
<td>2,036</td>
</tr>
<tr>
<td>National Sports Centre</td>
<td>1,464,305</td>
<td>593,136</td>
<td>284,075</td>
<td>250,303</td>
<td>534,378</td>
</tr>
<tr>
<td>Rockhills - block1 - community facilities</td>
<td>72,188</td>
<td>12,705</td>
<td>14,004</td>
<td>5,362</td>
<td>19,366</td>
</tr>
<tr>
<td>Rockhills - block2 - residential</td>
<td>390,083</td>
<td>195,041</td>
<td>75,676</td>
<td>82,307</td>
<td>157,983</td>
</tr>
<tr>
<td>Rockhills - block3 - residential</td>
<td>655,223</td>
<td>327,611</td>
<td>127,113</td>
<td>138,252</td>
<td>265,365</td>
</tr>
<tr>
<td>Cricket pavilion</td>
<td>37,114</td>
<td>15,034</td>
<td>7,200</td>
<td>6,344</td>
<td>13,544</td>
</tr>
<tr>
<td>Temperate (North) greenhouse</td>
<td>125,370</td>
<td>73,920</td>
<td>24,322</td>
<td>31,194</td>
<td>55,516</td>
</tr>
<tr>
<td>Crystal Palace Park specific energy use - lighting</td>
<td>100,000</td>
<td>0</td>
<td>42,200</td>
<td>42,200</td>
<td>42,200</td>
</tr>
<tr>
<td>Crystal Palace Park specific energy use - pumps</td>
<td>50,000</td>
<td>0</td>
<td>21,100</td>
<td>21,100</td>
<td>21,100</td>
</tr>
<tr>
<td>TOTAL</td>
<td>10,293,812</td>
<td>4,354,806</td>
<td>1,997,000</td>
<td>1,837,728</td>
<td>3,834,728</td>
</tr>
</tbody>
</table>
Figure 3: Estimated carbon emissions breakdown for the baseline Crystal Palace Park development

Key
- Energy cluster A
- Energy cluster B
- Energy cluster C
- Buildings not included in energy clusters

- Specific energy use - pumps
- Specific energy use - lighting
- Temperate (North) greenhouse
- Cricket pavilion
- Rockhills - block 3
- Rockhills - block 2
- Rockhills - block 1
- National Sports Centre
- Regional Sports Centre
- Lodge
- Current CP museum
- CPP museum
- Park rangers' building
- Palace kiosks
- Sydenham residential
- Subtropical (South) greenhouse
- Penge gate café (incl. dinosaur exhibition)
- Central pavilion
- National sports centre
3 ENERGY EFFICIENT DESIGN

The site-wide energy demand will be reduced so that carbon emissions are 15% lower than baseline 2006 Part L performance. This requirement will be passed on to the individual developers that will deliver the specific buildings, within the relevant Design Codes and contractual obligations. Target carbon reduction levels will be reviewed at each stage in line with contemporary standards. A Part L assessment will at detailed stages be carried out on every building.

It is envisaged that this 15% improvement in carbon emissions beyond Part L 2006 will be achieved by a number of ways including:

### Optimising the Built Form for Passive Design

- The amount and type of glazing, along with the shape, location and functionality of the windows, are key factors in the effective control of heat losses and gains to the building. The proportions of glazing should be optimised on each façade to balance the energy requirements with the need for views and the specific internal environments in museums and greenhouses, thus reducing both the winter heating and the summer cooling requirements.

- Good daylighting in the apartments and public buildings can be considered in order to limit the need for artificial lighting energy that would normally constitute significant annual carbon emissions.

- Reducing the thermal transmittance of the building envelope by increasing insulation will help reduce heating demand and result in lower heating energy consumption. U-values for external walls, glazing, roofs and floors are likely to exceed the minimum target requirements of 2006 Part L.

### Efficient Building Services Strategies

- Minimising air leakage through airtight construction can reduce energy loads in all types of buildings.

- Low energy ventilation strategies such as natural ventilation in residences (or mechanical ventilation with efficient heat recovery provided carbon savings can be shown) and mixed mode or low fan consumption mechanical ventilation in public buildings can be applied.

- Thermal mass is useful to stabilise internal temperatures in winter and summer. In particular, exposed concrete ceilings allow buildings to benefit from night time cooling, accumulating ‘coolth’ at night and releasing it during the day, therefore reducing the risk of overheating.

- Air to air heat recovery and variable speed fans installed within air handling plant, where provided, so as to recover the heat in the extract airstreams prior to the exhaust of vitiated air to atmosphere, and minimise energy use required for supplying and exhausting air.

- High efficiency electronic lighting ballasts and high efficacy lamps.

- Passive infra red and daylight responsive lighting control where possible in common and landlord areas

- Photocell switched external lighting.

- Energy meters in the heating supplies to each apartment to facilitate effective feedback, monitoring and control.

- Energy metering of the central plants enabling effective energy monitoring against benchmarks, facilitating feedback and appropriate action

- Individual room temperature controllers and thermostatic control valves for all heating and cooling (where fitted) systems.

To evaluate the energy consumption of the energy efficient scheme, the following improvement factors were applied to the good practice energy consumption benchmarks used for the baseline scheme:

| Table 4: Energy-efficient scheme: Improvement factors applied to good practice benchmarks |
| --- | --- | --- |
| Residential buildings | Non-residential buildings |
| Gas consumption for DHW | 0.05 | 0.05 |
| Gas consumption for space heating | 0.3 | 0.25 |
| Electricity consumption | 0.15 | 0.1 |
The predicted energy demand and carbon emissions for the proposed energy efficient scheme are summarised in the following table:

**Table 5: Predicted energy demand and carbon emissions for Crystal Palace Park energy efficient scheme**

<table>
<thead>
<tr>
<th>Space</th>
<th>Estimated annual gas consumption kWh/yr</th>
<th>Estimated annual electricity consumption kWh/yr</th>
<th>Estimated annual CO₂ emissions from gas kg CO₂/yr</th>
<th>Estimated annual CO₂ emissions from electricity kg CO₂/yr</th>
<th>Estimated Total CO₂ emissions kg CO₂/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lodge</td>
<td>633,420</td>
<td>230,546</td>
<td>122,883</td>
<td>97,291</td>
<td>220,174</td>
</tr>
<tr>
<td>Current Crystal Palace Park museum</td>
<td>20,986</td>
<td>10,247</td>
<td>4,071</td>
<td>4,324</td>
<td>8,395</td>
</tr>
<tr>
<td>New Crystal Palace Park museum</td>
<td>264,183</td>
<td>183,341</td>
<td>51,251</td>
<td>77,370</td>
<td>128,621</td>
</tr>
<tr>
<td>Park rangers’ building</td>
<td>23,997</td>
<td>11,717</td>
<td>4,656</td>
<td>4,944</td>
<td>9,600</td>
</tr>
<tr>
<td>Palace kiosks</td>
<td>1,127</td>
<td>0</td>
<td>0</td>
<td>476</td>
<td>476</td>
</tr>
<tr>
<td>Sydenham residential</td>
<td>360,855</td>
<td>185,895</td>
<td>70,006</td>
<td>78,448</td>
<td>148,454</td>
</tr>
<tr>
<td>Subtropical (South) greenhouse</td>
<td>90,712</td>
<td>58,608</td>
<td>17,598</td>
<td>24,733</td>
<td>42,331</td>
</tr>
<tr>
<td>Penge gate café</td>
<td>318,423</td>
<td>211,761</td>
<td>61,774</td>
<td>89,363</td>
<td>151,137</td>
</tr>
<tr>
<td>Regional Sports Centre</td>
<td>4,356,000</td>
<td>1,782,000</td>
<td>845,064</td>
<td>752,004</td>
<td>1,597,068</td>
</tr>
<tr>
<td>Central pavilion</td>
<td>3,526</td>
<td>2,447</td>
<td>684</td>
<td>1,033</td>
<td>1,717</td>
</tr>
<tr>
<td>National Sports Centre</td>
<td>1,200,730</td>
<td>533,822</td>
<td>232,942</td>
<td>225,273</td>
<td>458,215</td>
</tr>
<tr>
<td>Rockhills - block1 – community facilities</td>
<td>55,584</td>
<td>11,435</td>
<td>10,783</td>
<td>4,825</td>
<td>15,609</td>
</tr>
<tr>
<td>Rockhills - block2 - residential</td>
<td>321,188</td>
<td>165,785</td>
<td>62,433</td>
<td>69,961</td>
<td>132,394</td>
</tr>
<tr>
<td>Rockhills - block3 - residential</td>
<td>540,559</td>
<td>278,470</td>
<td>104,868</td>
<td>117,514</td>
<td>222,383</td>
</tr>
<tr>
<td>Cricket pavilion</td>
<td>28,578</td>
<td>13,530</td>
<td>5,544</td>
<td>5,710</td>
<td>11,254</td>
</tr>
<tr>
<td>Temperate (North) greenhouse</td>
<td>102,971</td>
<td>66,528</td>
<td>19,976</td>
<td>28,075</td>
<td>48,051</td>
</tr>
<tr>
<td>Crystal Palace Park specific energy use - lighting</td>
<td>100,000</td>
<td>0</td>
<td>42,200</td>
<td>42,200</td>
<td></td>
</tr>
<tr>
<td>Crystal Palace Park specific energy use - pumps</td>
<td>50,000</td>
<td>0</td>
<td>21,100</td>
<td>21,100</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>8,322,342</strong></td>
<td><strong>3,897,258</strong></td>
<td><strong>1,614,534</strong></td>
<td><strong>1,644,643</strong></td>
<td><strong>3,259,177</strong></td>
</tr>
</tbody>
</table>

Figure 4a-d: A range of energy saving measures are envisaged to reduce energy consumption by 15% including high performance glazing with internal blind, controllable external louvres, low energy lighting and energy metering.
The corresponding estimated breakdown of carbon emissions for the proposed energy efficient scheme is shown in the following figure.

Figure 5: Estimated carbon emissions breakdown for the energy efficient Crystal Palace Park development

- Specific energy use - pumps
- Specific energy use - lighting
- Temperate (North) greenhouse
- Cricket pavilion
- Rockhills - block 3 6.8%
- Rockhills - block 2 4.1%
- Rockhills - block 1 0.5%
- National Sports Centre 14.1%
- Regional Sports Centre 14.1%
- Sydenham residential 4.6%
- Subtropical (South) greenhouse
- Penge Gate café (incl. dinosaur exhibition)
- Palace kiosks
- Park rangers' building
- Current CP museum
- CPP museum
- Lodge 6.8%

Key
- Energy cluster A
- Energy cluster B
- Energy cluster C
- Buildings not included in energy clusters
- Central pavilion
4 POWER, HEATING AND COOLING INFRASTRUCTURE

The assessment of the energy efficient Crystal Palace Park, detailed previously in Figure 5, shows that the main energy users and sources of carbon emissions will be the Regional Sports Centre and National Sports Centre, which are predicted to contribute to over 60% of the total Crystal Palace Park carbon emissions. These buildings are therefore particularly targeted at in the energy strategy, as low and zero carbon technologies applied to these buildings would significantly contribute to the Park’s overall carbon strategy.

In addition, because of the commitments on the Rockhills and Sydenham residential accommodation to achieve a Code for Sustainable Homes Level 4, low and zero carbon technologies were implemented on these blocks and on the community facilities of Rockhills block 1.

It is therefore proposed that the RSC, NSC and residential accommodation buildings be linked by three energy networks delivering heat and power. Within each cluster, all buildings will be connected to the district heating network. Possible extensions of these networks to include buildings of relative proximity were also considered, as detailed in Table 6 (overleaf).

Table 6 shows that at this stage extension of the networks to other buildings would only marginally increase the proportion of carbon emissions covered by these networks (by approximately 2%). Furthermore, because of the distance from the buildings to the main clusters, the density of the networks would decrease and distribution heat losses would then become significant.

The other buildings of the Masterplan represent a small proportion of the Park’s total energy consumption and carbon emissions (i.e. less than 20% of the total site emissions), and are geographically isolated from these clusters. Linking them to a community network would require high investment costs, without delivering significant carbon savings. These individual buildings would likely be more efficiently served by on-site high-performance plant. The associated trenching and man hole covers may also be inappropriate in this parkland location, which is a conservation area, Grade II* listed and Metropolitan Open Land.

It is therefore not recommended at this stage to include further buildings in energy clusters. It should be noted that this proposed strategy does not prevent future extensions of the networks, should it be considered technically and financially viable at further stages. Opportunities for extending the energy networks will be reviewed in detailed phases.
The proposed energy networks would cover the majority (approximately 80%) of the total Crystal Palace Park energy requirements and carbon emissions. The networks are described in Figure 6, along with possible future extensions and possible locations for the energy centres in each cluster. Each network will be served by a single energy centre. It is proposed that the energy centre for the NSC/RSC cluster be located in the existing plant room of the NSC, and use the existing chimney for flues. Extension to include the Central Pavilion in Cluster A is not recommended, as it is not expected to have any noticeable effect on the site’s carbon emissions, as shown in Table 6.

Further carbon reductions will be achieved through renewable energy systems installed in the Lodge, new Crystal Palace Park museum and Penge gate café/exhibition space, considering the contribution of these buildings to the Park’s overall carbon emissions but also the potential education value of innovative energy systems installed on these buildings, which are expected to have a large number of visitors. These renewable energy systems are also represented in Figure 6.

The measures proposed in the current strategy, and represented in Figure 6 (opposite), mean that low and zero carbon strategies are applied to buildings covering nearly 95% of the Crystal Palace Park estimated carbon emissions.

### Table 6: Crystal Palace Park energy clusters

<table>
<thead>
<tr>
<th>Energy network cluster</th>
<th>Buildings included in the cluster</th>
<th>Proposed energy strategy</th>
<th>Possible future extensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum Gross External Area</td>
<td>Proportion of site carbon emissions covered</td>
<td>Buildings possibly included</td>
</tr>
<tr>
<td>A RSC/NSC</td>
<td>Regional Sports Centre National Sports Centre</td>
<td>39,857 m²</td>
<td>63.1%</td>
</tr>
<tr>
<td>B Sydenham</td>
<td>Sydenham residential development</td>
<td>6,480 m²</td>
<td>4.6%</td>
</tr>
<tr>
<td>C Rockhills</td>
<td>Rockhills blocks 2 and 3 – residential units Rockhills block 1 – community facilities</td>
<td>16,256 m²</td>
<td>11.4%</td>
</tr>
<tr>
<td>Total</td>
<td>62,593 m²</td>
<td>79.0%</td>
<td>65,113 m²</td>
</tr>
</tbody>
</table>
Figure 6: Proposed energy clusters at Crystal Palace Park

Key
- Cluster A Buildings
- Cluster B Buildings
- Cluster C Buildings
- Stand Alone Buildings
- Cluster A Boundary
- Cluster B Boundary
- Cluster C Boundary
- Potential cluster extension
- Planning Boundary
- Pump
- Proposed district heating networks
- Possible locations for energy centres

[Diagram showing proposed energy clusters at Crystal Palace Park with various buildings and infrastructure.]
5 FEASIBILITY ASSESSMENT OF CHP AND CCHP

The feasibility of incorporating combined heat and power (CHP) and combined cooling heat and power (CCHP) has been assessed on the basis of the following:

- Assessment of carbon savings achieved
- Ability to accommodate the plant within the development
- Cost effectiveness.

The carbon factors used in the analysis are taken from the Part L Building Regulation Approved Documents, 2006 and are given in Appendix B.

The diagram below shows how CHP makes a more efficient use of primary energy compared to the conventional scenario of importing electricity from the grid and using gas fired boilers.

Tri-generation, also known as Combined Cooling, Heat and Power (CCHP), uses all or part of the heat generated by the CHP to drive an absorption chiller, which produces chilled water to meet on-site cooling requirements.

Figure 7: Indicative CHP primary energy use

Figure 8: Schematic showing how CHP can be connected to other heating plant in an Energy Centre
Essentially, each community heating/CHP scheme is made up of three main elements, outlined below:

i. The Energy Centre which accommodates the CHP plant, other heating plant and associated pumps, pressurisation sets and thermal stores.

ii. The district heating network that distributes heat from the Energy Centre to the end-users

iii. The Heat Interface Units (HIU) that connect each apartment/building to the heating network.

Figure 9: Typical district heating trench configuration

Figure 10: Typical Heat Interface Unit required in dwellings and other buildings connected to the district heating network
(Units designed for apartments are approximately the size of a small wall mounted combination boiler)
The figure below shows an indicative Energy Centre layout.

Assessment of Combined Heat and Power (CHP)

It is proposed that a CHP plant be installed in the energy centre of each energy network.

In order to assess the carbon reductions that can be achieved by CHP it is assumed that the CHP thermal output will deliver the base thermal load, i.e. domestic hot water consumption, which exists as the base load throughout the year.

The outcome of the CHP feasibility assessment is that the provision of a CHP plant feeding each of the district heating networks could reduce total Crystal Palace Park carbon emissions by approximately 333,478 kg CO$_2$/yr, equivalent to a further 10.2% carbon reduction on the overall development, after the energy efficiency measures described in Section 4 are implemented. Details of the contributions of CHP plants in each Crystal Palace Park energy cluster are given in table 7 (overleaf).

Figure 11: Indicative Energy Centre Layout
The proposed CHP capacity would cover the domestic hot water of the RSC/NSC and Rockhills and Sydenham residential accommodation units. It would also cover the base electrical consumption of these clusters (i.e. around one third of the RSC/NSC electrical consumption, and around 60% of Rockhills and Sydenham residential accommodation electrical consumption). In total, CHP plant would cover 77% of the domestic hot water load, and 31% of the electrical consumption of Crystal Palace Park. Increasing the size of the CHP plant serving the residential clusters is therefore not recommended, as it would likely produce excess electricity, which would need to be exported to the national grid. This is not economically viable under current UK electricity tariffs.

**Assessment of Combined Cooling, Heat and Power (CCHP)**

An assessment of the carbon reduction potentially achieved by CCHP shows that the relative advantage compared to conventional vapour compression chillers depends on the efficiency, i.e. coefficient of performance (COP), of the alternative plant, the efficiency of the CHP engine (especially the electrical efficiency), and the fuel carbon factors used in the assessment. Tri-generation, using the carbon factors for fuel established in the Building Regulation Part L Approved Documents, 2006, allows the carbon factor for displaced grid electricity arising from on-site power generation to be higher than the carbon factor of power imported from the grid. Essentially this means that there will be carbon savings using tri-generation compared to typical vapour compression efficiencies. Assumptions on which calculations of carbon savings are based are shown in Appendix B.

### Table 7: Predicted energy contribution and carbon reductions from the proposed CHP plants in Crystal Palace Park energy centres

<table>
<thead>
<tr>
<th>Cluster</th>
<th>CHP Electrical rating</th>
<th>CHP Thermal rating</th>
<th>CHP running hours</th>
<th>Net annual CO₂ savings</th>
<th>Proportion of annual cluster electricity consumption</th>
<th>Proportion of annual cluster domestic hot water load</th>
<th>Net annual CO₂ reduction for cluster</th>
<th>Net annual reduction for total Crystal Palace Park</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSC+NSC</td>
<td>210</td>
<td>345</td>
<td>3942</td>
<td>234,150</td>
<td>36%</td>
<td>100%</td>
<td>11.4%</td>
<td>7.2%</td>
</tr>
<tr>
<td>Rockhills</td>
<td>70</td>
<td>104</td>
<td>4015</td>
<td>73,610</td>
<td>63%</td>
<td>106%</td>
<td>19.9%</td>
<td>2.3%</td>
</tr>
<tr>
<td>Sydenham</td>
<td>33</td>
<td>55</td>
<td>3102.5</td>
<td>25,718</td>
<td>55%</td>
<td>105%</td>
<td>17.3%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Total</td>
<td>313</td>
<td>504</td>
<td>333,478</td>
<td></td>
<td>10.2%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 8: Estimated yearly cooling load in the RSC and NSC

<table>
<thead>
<tr>
<th>Estimation</th>
<th>Estimated annual cooling load (excl. fans and pumps)</th>
<th>Estimated cooling-related emissions (excl. fans and pumps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSC+NSC</td>
<td>356,400 kWe/yr</td>
<td>150,401 kg CO₂/yr</td>
</tr>
<tr>
<td>Rockhills</td>
<td>1,247,400 kWh/yr</td>
<td>45,055</td>
</tr>
<tr>
<td>National Sports Centre</td>
<td>106,764 kWh/yr</td>
<td>373,674</td>
</tr>
<tr>
<td>Total</td>
<td>463,164 kWh/yr</td>
<td>195,456</td>
</tr>
</tbody>
</table>

The only buildings likely to have substantial cooling loads for a significant number of hours per year, and therefore CCHP can be considered, are the Regional Sports Centre (RSC) and National Sports Centre (NSC). The feasibility of linking a CHP plant with absorption chillers in the energy centre located in the NSC, using a cooling district network to distribute chilled water to these buildings, has therefore been assessed. The following table shows the estimated cooling load and corresponding carbon dioxide emissions from the RSC and NSC, assuming energy reduction and energy efficiency measures described in section 4 have been implemented. This table shows that the cooling requirements in the RSC and NSC would represent about 6% of the energy-efficient Crystal Palace Park total carbon emissions.
As a theoretical exercise, i.e. ignoring economic issues, the total potential carbon savings possible from a CCHP plant serving the NSC and RSC have been considered. An assessment of the overall carbon reduction achieved if 100% of the RSC and NSC cooling load was supplied by tri-generation, assuming a COP of 3.5 for conventional chillers, shows that a carbon reduction of about 132,930 kgCO$_2$/yr could be achieved, equivalent to a 4% reduction of the energy efficient site emissions. In practice, an absorption cooling plant would not normally be sized to deliver the whole cooling load. A more practical engineering design strategy would be for the absorption cooling plant to deal with 30% to 50% of the annual cooling load. This energy strategy assumes that the chillers would meet approximately 35% of the cooling load of the RSC and NSC, allowing and increase in capacity of the CHP plant serving the CHP and NSC. The theoretical savings arising from tri-generation are then likely to be of the order 62,930 kgCO$_2$/yr, i.e. emissions savings of approximately 2% of the site’s total emissions. The size of CHP plant serving the NSC and RSC sports centres is limited by the domestic hot water load. Indeed, as detailed in table 7, the proposed CHP plant covers around 100% of the domestic hot water requirements but only about 35% of the electrical requirements. By using heat from the CHP plant in an absorption chiller to produce chilled water, tri-generation therefore allows an increase in the size of the CHP plant. The following table details the sizes and contributions of CHP and absorption chillers in the NSC energy centre serving the NSC and RSC with cooling, heating and power. It is assumed that the CCHP plant could run 7 hours per day throughout the year, and contribute to covering up to 70% of the NSC and RSC electrical requirements, without this leading to producing excess power at any time (as this would otherwise require to export to the national grid). Please note that this is a large contribution to the cluster’s electrical requirements, and would require careful management. Using absorption chillers would therefore allow to meet a larger proportion of the NSC/RSC electrical requirements, and up to a third of the NSC/RSC cooling load. Compared to using a CHP plant only, CCHP would increase carbon savings by approximately 62,930 kgCO$_2$/yr, representing 2% additional carbon savings on Crystal Palace Park estimated total annual emissions.

CCHP is proposed, although it should be noted that the carbon case is relatively marginal and is sensitive to assumptions on the efficiency and carbon factors used in the assessment. Providing the absorption chiller and district cooling infrastructure for CCHP represents a significant investment relative to the carbon savings that may be achieved. 

CHP/CCHP plant at Crystal Palace Park will therefore represent a significant contribution to the overall energy requirements and carbon emissions strategy, as it will cover approximately 77% of the total Park domestic hot water load, 49% of the total Park electricity demand, and 35% of the RSC/NSC cooling load, leading to an estimated 12% CO$_2$ emissions reduction.

### Table 9:
Predicted energy contribution and carbon reductions from the proposed CHP and CCHP plants in Crystal Palace Park NSC/RSC energy centre

<table>
<thead>
<tr>
<th>Notional specifications of CHP engines and absorption chillers</th>
<th>Electrical output from CHP or CCHP</th>
<th>Heating output from CHP or CCHP</th>
<th>Estimated annual cooling output from CHP or CCHP</th>
<th>Annual carbon dioxide savings on energy efficient scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kWh/yr % of cluster electrical load (incl. cooling) kWh/yr % of cluster domestic hot water load kWh/yr % of cluster cooling load</td>
<td>kgCO$_2$/yr % of cluster carbon emissions % of total site carbon emissions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case 1: (210kWe, 345kWt) CHP</td>
<td>827,820 36%</td>
<td>1,359,990 100%</td>
<td>0 0%</td>
<td>234,150 11.4% 7.2%</td>
</tr>
<tr>
<td>Case 2: (490kWe, 658kWt) CCHP CHP + 220kWc absorption chiller</td>
<td>1,568,550 72%</td>
<td>1,359,990 100%</td>
<td>559,801 35%</td>
<td>297,082 14.5% 9.1%</td>
</tr>
</tbody>
</table>
6 RENEWABLE ENERGY FEASIBILITY ASSESSMENT

It is intended that carbon emissions for the whole Crystal Palace Park development be reduced by 20% using on-site renewable energy generation, after the incorporation of passive design and energy efficiency measures, and CHP/CCHP.

The feasibility of the full range of renewable energy sources has been evaluated. All systems were sized and appraised according to their potential to meet the energy requirements of the buildings of Crystal Palace Park, and in order to contribute to deliver the overall 20% carbon reduction. The results of the assessment, showing for each system the theoretical size required in order to cut the total Crystal Palace Park carbon emissions by 20%, are shown in Appendix C. A summary of the renewable energy evaluation is shown overleaf.
### Table 10: Summary of renewable energy feasibility assessment for Crystal Palace Park energy strategy

<table>
<thead>
<tr>
<th>Renewable energy system</th>
<th>Comment on site potential and cost</th>
<th>Application for Crystal Palace Park</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar water heating panels</td>
<td>Relatively large are required for solar panels, equivalent to 2-3sq.m. per residential unit. Solar thermal output from panels conflicts with heat output from CHP and therefore not compatible with the proposed CHP /district heating system.</td>
<td>Recommended on buildings with a significant domestic hot water load which are not linked to district heating schemes, to meet part of the overall 20% target.</td>
</tr>
<tr>
<td>Ground source heat pumps</td>
<td>Relatively high capital investment required in drilling and installation of closed loop or open loop borehole ground heat exchangers. Only suitable for low temperature heating systems with flow temperatures around 50 deg. C. Accurate predictions of the performance would require ground surveys.</td>
<td>Not recommended for the energy clusters as not easily compatible with CHP/district heating system due to different temperature regimes, and because of uncertainties of performance. Opportunities will be reviewed in future stages for individual buildings with suitable sizes and load profiles.</td>
</tr>
<tr>
<td>Biomass heating boilers</td>
<td>Relatively low capital cost. Biomass heating boilers can be accommodated in Energy Centre(s) and connected to same heating system as CHP and gas-fired heating plant. There are several woodchip suppliers available in the region.</td>
<td>Recommended as renewable energy source to meet part of the overall 20% target.</td>
</tr>
<tr>
<td>Biomass CHP</td>
<td>Biomass CHP is an emerging technology and not effectively tested in the UK at the scales considered.</td>
<td>Not recommended due to lack of experience and available technology in the UK.</td>
</tr>
<tr>
<td>Small vertical axis wind turbines</td>
<td>Relatively high number of turbines would be required to meet a significant proportion of the 20% target.</td>
<td>Not recommended at this stage due to high number of turbines required per carbon savings achieved. Possible applications will be reviewed at detailed stages, especially in view of educational opportunities.</td>
</tr>
<tr>
<td>Small horizontal axis wind turbines</td>
<td>Uncertain output at this stage, where wind patterns may be affected by neighbouring buildings and high trees. Would be required to meet a significant proportion of the 20% target.</td>
<td>Not recommended due to costs, high number of turbines required, uncertainty on the output, and visual impact in a conservation area with Grade II* listed status.</td>
</tr>
<tr>
<td>Photovoltaic (PV) modules</td>
<td>Would require a large area to make a significant contribution to the site’s energy requirements. Extremely high capital cost and payback period (over 100 years without grant)</td>
<td>Not recommended at this stage due to high costs. Possible applications, (i.e. Park’s lighting) will be reviewed at detailed stages, especially in view of potential educational purposes.</td>
</tr>
</tbody>
</table>
The recommended renewable energy strategy for Crystal Palace Park at this stage is detailed in table 11.

This strategy translates in renewable energy sources covering around 40% of the overall thermal requirements of the energy efficient Crystal Palace Park site.

This strategy is recommended at this stage. Potential alternative or additional opportunities have been considered, as listed in Table 10, and will be reviewed at detailed stages to ensure that the 20% carbon reduction from on-site renewable energy sources is met for the overall Masterplan proposals.

**Table 11:** Summary of renewable energy strategy for Crystal Palace Park

<table>
<thead>
<tr>
<th>Renewable energy source</th>
<th>Location at Crystal Palace Park</th>
<th>Size</th>
<th>Estimated contribution to energy requirements of the building(s) where the systems are installed (energy efficient scheme)</th>
<th>Estimated annual CO₂ reduction at Crystal Palace Park</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar water heating panels</td>
<td>Lodge</td>
<td>300 m²</td>
<td>53% of domestic hot water load</td>
<td>32,330 kg CO₂/yr 1.1%</td>
</tr>
<tr>
<td>Solar water heating panels</td>
<td>Penge Gate Café</td>
<td>70 m²</td>
<td>49% of domestic hot water load</td>
<td>7,540 kg CO₂/yr 0.3%</td>
</tr>
<tr>
<td>Biomass heating boilers</td>
<td>RSC + NSC</td>
<td>1100 kW</td>
<td>62% of heating load</td>
<td>429,700 kg CO₂/yr 15.0%</td>
</tr>
<tr>
<td>Biomass heating boilers</td>
<td>Rockhills</td>
<td>130 kW</td>
<td>60% of heating load</td>
<td>49,540 kg CO₂/yr 1.7%</td>
</tr>
<tr>
<td>Biomass heating boilers</td>
<td>Sydenham</td>
<td>60 kW</td>
<td>74% of heating load</td>
<td>22,860 kg CO₂/yr 0.8%</td>
</tr>
<tr>
<td>Biomass heating boilers</td>
<td>New CPP museum</td>
<td>80 kW</td>
<td>75% of heating load</td>
<td>30,490 kg CO₂/yr 1.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>572,481 kg CO₂/yr 20.4%</strong></td>
</tr>
</tbody>
</table>
7 CONCLUSIONS AND RECOMMENDATIONS

The energy strategy appraisal has shown that it is feasible to deliver the following:

- **15% carbon emissions reduction beyond 2006**
  Part L Building Regulation standards through passive design and energy efficiency - This will be assured through the stipulation of this requirement in the relevant design codes for each phase. A review of standards will be taken at each stage. The detailed energy statements for each phase will be required to confirm that they have designed buildings to these standards. Measures will typically include improved insulation levels, improved air-tightness, energy metering, low energy fans and pumps and more energy-efficient lighting and controls.

- **12% carbon emissions reduction through the use of Combined Heat and Power (CHP) and Combined Cooling, Heat and Power (CCHP) plants linked to three district heating schemes serving the majority of the energy users of Crystal Palace Park**
  Tri-generation, using absorption chiller plant associated with the CHP plant in the National Sports Centre energy centre, will cover a significant proportion of the predicted Regional Sports Centre and National Sports Centre chilled water load.

- **20% carbon emissions reduction by the use of on-site renewable energy sources**
  Biomass heating plants and solar water heating will be used to meet a large proportion of Crystal Palace Park thermal requirements.

The estimated overall carbon emission reductions achieved by the proposed measures are summarised below:

![Figure 12: Estimated annual carbon emissions at Crystal Palace Park, tonnes CO₂/yr](image)

Low and zero carbon technologies are expected to meet a minimum of 60% of the Crystal Palace Park’s thermal load and 30% of its electrical load, while having educational value by demonstrating a range of appropriate technologies. An overview of the measures proposed is shown in table 12 (overleaf).
### Table 12: Summary of low and zero carbon technology commitments and opportunities at Crystal Palace

<table>
<thead>
<tr>
<th>Building</th>
<th>Low and zero carbon technologies assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lodge</td>
<td>300m² of solar thermal panels meeting approximately half of the domestic hot water load.</td>
</tr>
<tr>
<td>New Crystal Palace Park museum</td>
<td>80kW biomass boiler meeting approximately 75% of the heating load</td>
</tr>
<tr>
<td>Sydenham residential</td>
<td>District energy network B (33kWe, 55kWt) CHP meeting approximately 55% of the electrical load and 100% of the domestic hot water load. 60kW biomass boiler meeting approximately 75% of the heating load</td>
</tr>
<tr>
<td>Penge gate café</td>
<td>70m² of solar thermal panels meeting approximately half of the domestic hot water load.</td>
</tr>
<tr>
<td>Regional Sports Centre</td>
<td>District energy network A (490kWe, 658kWt) CHP + 220kWc absorption chiller meeting approximately 70% of the electrical load, 100% of the domestic hot water load, and 30% of the cooling load. 110kW biomass boiler meeting approximately 60% of the heating load</td>
</tr>
<tr>
<td>Rockhills – blocks 1, 2 and 3 + National Sports Centre</td>
<td>District energy network C (70kWe, 104kWt) CHP meeting approximately 60% of the electrical load and 100% of the domestic hot water load. 130kW biomass boiler meeting approximately 60% of the heating load</td>
</tr>
<tr>
<td>Current Crystal Palace Park museum</td>
<td>No dedicated renewable energy system proposed at this stage because of the small associated energy consumption. High costs of PV modules, and uncertainties as to the performance of ground source heat pumps and small-scale wind turbines.</td>
</tr>
<tr>
<td>Park rangers' building</td>
<td>Opportunities will be reviewed at reserved matters application, particularly in view of potential educational purposes</td>
</tr>
<tr>
<td>Palais kiosks</td>
<td>• Opportunities for connection to the energy networks will be reviewed, in particular for connection of the North greenhouse to network C and Cricket pavilion and Park Rang for the building to network B.</td>
</tr>
<tr>
<td>Subtropical (South) greenhouse</td>
<td>• Remote buildings with hot water loads could offer an opportunity for solar water heating integration, while PV modules could be used to power the lighting and pumping installations.</td>
</tr>
<tr>
<td>Central pavilion</td>
<td></td>
</tr>
<tr>
<td>Cricket pavilion</td>
<td></td>
</tr>
<tr>
<td>Temperate (North) greenhouse</td>
<td></td>
</tr>
<tr>
<td>Lighting and pumps energy use</td>
<td></td>
</tr>
</tbody>
</table>
Summary of the energy strategy for the residential units

In order to meet minimum Code for Sustainable Homes Level 4 requirements, overall carbon emissions have to be reduced by at least 44% below 2006 Part L Building Regulations. This requirement is expected to be met on both Rockhills and Sydenham residential developments, as shown in the following figures.

Please note that the figures regarding the Rockhills residential scheme also include block 1, which is a small community space and is not required to show a 44% carbon reduction but was included because of its proximity to blocks 2 and 3, and because of its load profile.

Figure 13: Proposed carbon reduction strategy at Rockhills residential scheme
Estimated annual carbon emissions at Rockhills residential scheme, tonnes CO₂/yr

Figure 14: Proposed carbon reduction strategy at Sydenham residential scheme
Estimated annual carbon emissions at Sydenham residential scheme, tonnes CO₂/yr
APPENDICES

APPENDIX A – ENERGY BENCHMARKS

Chillers electrical consumption in the sports centres is estimated to account for 20% of the electrical consumption, using CIBSE Guide F benchmarks for good practice hotels with air conditioning and swimming pools.

<table>
<thead>
<tr>
<th>Space</th>
<th>Gas consumption for space heating kWh/yr/m²</th>
<th>Gas consumption for domestic hot water kWh/yr/m²</th>
<th>Electricity consumption kWh/yr/m²</th>
<th>Proportion of Gross External Area on which benchmark is applied</th>
<th>Benchmark Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lodge</td>
<td>120</td>
<td>120</td>
<td>82.5</td>
<td>0.75</td>
<td>CIBSE Guide F good practice - average halls of residence and hotel-halls</td>
</tr>
<tr>
<td>Current Crystal Palace museum</td>
<td>71</td>
<td>8</td>
<td>33</td>
<td>0.75</td>
<td>CIBSE Guide F good practice - naturally ventilated office, cellular</td>
</tr>
<tr>
<td>Crystal Palace Park museum</td>
<td>86</td>
<td>10</td>
<td>57</td>
<td>0.9</td>
<td>CIBSE Guide F good practice - average library and museum</td>
</tr>
<tr>
<td>Park rangers' building</td>
<td>71</td>
<td>8</td>
<td>33</td>
<td>0.75</td>
<td>CIBSE Guide F good practice - naturally ventilated office, cellular</td>
</tr>
<tr>
<td>Palace kiosks</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>1</td>
<td>Estimate</td>
</tr>
<tr>
<td>Residential - Rockhills blocks 2 and 3, and Sydenham</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td>0.75</td>
<td>Generic calculations on current good practice residential buildings</td>
</tr>
<tr>
<td>Subtropical (South) greenhouse</td>
<td>90</td>
<td>10</td>
<td>55</td>
<td>0.8</td>
<td>CIBSE Guide F good practice - average museum and retail warehouse</td>
</tr>
<tr>
<td>Penge gate café (incl. dinosaur exhibition?)</td>
<td>449</td>
<td>150</td>
<td>353.5</td>
<td>0.8</td>
<td>CIBSE Guide F good practice - average museum and restaurant</td>
</tr>
<tr>
<td>Regional Sports Centre</td>
<td>172</td>
<td>92</td>
<td>96</td>
<td>0.75</td>
<td>CIBSE Guide F good practice - combined sports centre</td>
</tr>
<tr>
<td>Central pavilion</td>
<td>86</td>
<td>10</td>
<td>57</td>
<td>0.9</td>
<td>CIBSE Guide F good practice - museum</td>
</tr>
<tr>
<td>National Sports Centre</td>
<td>103</td>
<td>55</td>
<td>64</td>
<td>0.75</td>
<td>CIBSE Guide F good practice - dry sports centre (local)</td>
</tr>
<tr>
<td>Rockhills block1</td>
<td>113</td>
<td>13</td>
<td>22</td>
<td>0.75</td>
<td>CIBSE Guide F good practice - community centre</td>
</tr>
<tr>
<td>Cricket pavilion</td>
<td>142</td>
<td>16</td>
<td>64</td>
<td>0.9</td>
<td>CIBSE Guide F good practice - dry sports centre (local)</td>
</tr>
<tr>
<td>Temperate (North) greenhouse</td>
<td>90</td>
<td>10</td>
<td>55</td>
<td>0.8</td>
<td>CIBSE Guide F good practice - average museum and retail</td>
</tr>
</tbody>
</table>
Energy consumption from Crystal Palace Park specific energy uses

The following figures result from a study by ZEF UK Ltd.

<table>
<thead>
<tr>
<th>Energy use</th>
<th>Estimated yearly electricity consumption</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystal Palace Park lighting</td>
<td>100,000</td>
<td>Energy efficient The lighting scheme has been designed to be energy-efficient through the use of energy-efficient appliances and controls restricting the number of operating hours. Therefore, maximum peak demand will be limited to approximately 65kW, and the number of yearly lighting hours will be limited to 1600 hours (i.e. a maximum of 4.5 hours a day of peak demand).</td>
</tr>
<tr>
<td>Crystal Palace Park pumping</td>
<td>50,000</td>
<td>Energy consumption will be limited through careful design and specification of the pumps. The total capacity will be limited to 24kW, with operating hours limited to a maximum of 6 hours per day on peak demand.</td>
</tr>
</tbody>
</table>
APPENDIX B
- CHP AND CCHP ASSESSMENT

The carbon factors used in the analysis of the carbon reductions achievable through CHP and CCHP are taken from the Part L Building Regulation Approved Documents, 2006:

**Carbon dioxide emission factors**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>kgCO₂/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>0.194</td>
<td></td>
</tr>
<tr>
<td>Electricity supplied by grid</td>
<td>0.422</td>
<td></td>
</tr>
<tr>
<td>Electricity displaced by on-site generation</td>
<td>0.568</td>
<td></td>
</tr>
</tbody>
</table>

The figure below shows how waste heat recovered from a CHP unit drives an absorption chiller to provide cooling. The table below shows the relative carbon emission figures arising from the operation of absorption cooling compared to conventional vapour compression chillers.

The CHP and trigeneration calculations used technical specifications from existing commercial CHP engines.

Assuming that the CHP and absorption chiller displace a chiller plant with a COP of 3.5, carbon emissions savings achieved by CCHP then amount to 0.082kgCO₂ per kWh of cooling produced.

**Comparison of absorption chiller performance against various conventional chiller plant efficiencies**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Coefficient of performance (COP)</th>
<th>Carbon emission arising from electricity used/displaced (kgCO₂ per unit kWh cooling)</th>
<th>Carbon emission arising from gas fuel used in absorption chiller (kg CO₂ per unit kWh cooling)</th>
<th>Net carbon emissions arising from use of system (kgCO₂ per unit kWh cooling)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorption chiller plant</td>
<td>0.7</td>
<td>-0.517</td>
<td>0.556</td>
<td>0.039</td>
</tr>
<tr>
<td>Conventional chiller plant</td>
<td>3.5</td>
<td>0.121</td>
<td>-</td>
<td>0.121</td>
</tr>
<tr>
<td>Conventional chiller plant</td>
<td>6</td>
<td>0.070</td>
<td>-</td>
<td>0.070</td>
</tr>
<tr>
<td>Conventional chiller plant</td>
<td>8</td>
<td>0.053</td>
<td>-</td>
<td>0.053</td>
</tr>
</tbody>
</table>
## APPENDIX C - COMPARISON OF RENEWABLE ENERGY TECHNOLOGIES

The following table shows a theoretical assessment of a range of renewable energy technologies. **Systems are sized to meet 20% carbon reduction on the total annual carbon emissions of the energy efficient Crystal Palace scheme, once CHP/CCHP is installed.** Sizes of the systems do not take into account technical, spatial and cost constraints. The system sizes are shown for comparison purposes only.

<table>
<thead>
<tr>
<th>Energy Supply</th>
<th>Indicative system capital cost (£)</th>
<th>Theoretical system size required to cut Crystal Palace Park emissions by 20% (shown for comparison)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar water heating Panels</td>
<td>Installed cost £800/m²</td>
<td>5,300 m²</td>
<td>Solar thermal panels are typically sized to meet a maximum 60% of the domestic hot water load</td>
</tr>
<tr>
<td>Ground Source Heat Pump (GSHP)</td>
<td>Installed cost £1800/kW (Source: Renewable Toolkit)</td>
<td>3,350kW</td>
<td>Ground source heat pumps are compatible with heating systems with flow temperatures of 50 deg.C. due to the optimum performance of the heat pump. Their performance is dependent about local ground conditions.</td>
</tr>
<tr>
<td>Biomass boilers (wood chip)</td>
<td>Installed cost £600/kW (Source: Renewable Toolkit plus allowance for storage)</td>
<td>1,560kW</td>
<td>This option would require potential fuel sources in the local area and the site would need to be designed to facility biomass delivery and storage.</td>
</tr>
<tr>
<td>Biomass CHP (wood chip)</td>
<td>Installed cost estimate based on £2720/kWe (Source: Renewable Toolkit)</td>
<td>Not sized as performance data at this scale is not available</td>
<td>Biomass CHP is still an emerging technology in the UK, particularly at medium and small scales.</td>
</tr>
<tr>
<td>Small Horizontal Axis Wind turbines</td>
<td>Installed cost £3000/kW (Renewable Toolkit)</td>
<td>56 No. 15kW turbines</td>
<td>Performance of the wind turbines will depend on local wind patterns.</td>
</tr>
<tr>
<td>Small Vertical Axis Wind turbines</td>
<td>Installed cost £3000/kW (Renewable Toolkit)</td>
<td>126 No. 6kW</td>
<td>Performance of the wind turbines will depend on local wind patterns.</td>
</tr>
<tr>
<td>PV modules</td>
<td>Installed cost £800/m² (Renewable Toolkit)</td>
<td>13,500 m²</td>
<td>This option would require architectural integration and if mounted panels are used, is dependent upon roof space availability</td>
</tr>
</tbody>
</table>
1 WIND TURBINES – SMALL SCALE

The two main types are 'Horizontal Axis' turbines, like "conventional" wind turbines and 'Vertical Axis' turbines (see images below). Vertical turbines are more numerous than horizontal turbines, but are less sensitive to variations in wind patterns than horizontal axis turbines.

The most common arrangement is a wind turbine mounted on a tower or mast, or, increasingly, small generators can be mounted on buildings, especially in urban areas.

Suitability

The topography and wind speed characteristics of an urban location usually limit suitability to "Micro" or at most "Small" turbines. However, these will generate only a very small part of the electricity load, e.g. for a 6 kW turbine, approximately 12 MWh/yr (source: London Energy Partnership). The electricity generated does, however, offset the higher cost of electricity compared to heat energy, and the higher carbon emissions from electricity generation. Turbines also make a clear instantly recognisable and very visible architectural statement.

A study carried out by ZEF UK LTD predicted that best locations for turbines at Crystal Palace Park is on the southern end of the western side of the Park, as this would harness South-West prevailing winds and is elevated compared to the rest of the site.
2 SOLAR PHOTOVOLTAICS (PVS)

Photovoltaic cells generate direct-current electrical energy when exposed to light. Solar cells are constructed from layers of semiconducting materials, including silicon, that absorb solar radiation, which displaces electrons within the material, thus starting an electrical current which can be directed through an external circuit. A whole PV-system consists of multiple solar cells connected together into panels.

There are two viable solar PV technologies.

a) **Solid PV modules** – these can be roof or façade mounted. They can be fitted in slates or shingles which are an integral part of the roof covering (looking similar to normal roof tiles).

b) **Solid PV integrated into glazing** – the gaps around the PV cells allow some daylight penetration. This can be used for partial shading in a glazed roof.

Ideally photovoltaics should face between south-east and south-west at an elevation of about 30-40°. However, in the UK, even flat roofs receive 90% of the energy of an optimum system. They should be in locations unshaded at all times of day if possible in order to avoid any reduction in the amount of electricity produced.

There should be very little maintenance as the technology has no moving parts. The output of the panel should be monitored and inspected.

**Suitability**

PV modules produce electricity, so they could be implemented on all buildings where there is an electrical load. However, their capital costs is relatively high compared to other renewable energy technologies that would produce the same amount of energy generation. However, despite the long financial payback period, Solar PV makes a very visible statement. PV is especially appropriate when used to replace other, possibly more expensive, cladding materials suited to prestige HQ buildings.
3 SOLAR THERMAL PANELS

Solar thermal (water heating) systems use energy from the sun to heat hot water. The system requires solar collectors on the roof linked to hot water storage cylinders.

Solar collectors could be mounted on the roof or actually form part of the roof fabric. They should be facing southeast to southwest and not be shaded in order to maximise annual thermal output. Therefore they should be located away from any obstruction or buildings which might overshadow them and multiple arrays of panels should be spaced by a sufficient distance to prevent one array overshadowing the other.

Solar collector systems can either use evacuated tubes or flat plate collectors. Evacuated tubes are more efficient but more expensive, but flat plate collectors can be integrated in the roof surface, making a cheaper and simpler installation.

Solar water heating depends on the amount of solar radiation, not on direct sunlight, so it can work even on cloudy days. However, in winter although a panel can help pre-heat hot water, top-up from another heat source would still be required.

Suitability

A Solar thermal system would be suitable for the supply of the summer hot water demand. The suitability of a system depends on the size of the hot water demand and the size of the array of panels that can be installed. Generally, office developments have a small hot water demand, but this depends on the number of toilets, kitchen facilities and showers.

Solar thermal systems will only ever economically produce part of the annual hot water requirements of the development (ie about 500 kWh/m$^2$/yr, typically sized to provide summer hot water). The technology is mature, low risk, has relatively short payback times and makes a clear architectural statement of corporate attitude to climate change. A solar water heating system requires occasional maintenance.
4 BIOMASS HEATING

“Biomass” is fuel derived from plants, including trees and grasses (willow, myscanthus), woody wastes (sawdust, joinery waste, pallets) and other plant-origin organic materials. Biomass can be burnt in biomass boilers for space heating and hot water.

Biomass is “carbon-neutral” because the carbon released as CO₂ gas during combustion is equal to the carbon absorbed from CO₂ in the air during growing. The only unbalanced carbon is from any fossil fuel (eg diesel) used in transport. Carbon savings using biomass instead of gas are approximately 169 gC/kWh, far exceeding the emissions from transport over, for example, 40 km of approximately 1.45 gC/kWh.

Biomass fuels comprise two main forms: wood chips and wood pellets:
- Wood chips are wood, chipped to a consistent size, made either from recycled or discarded wood or specially grown crops. Chips are the cheapest biomass fuel, and are suitable for systems larger than about 50 kW.
- Wood pellets are sawdust compressed into pellet form. Pellets have higher energy density than chips, and are easier to handle, so they are suitable for systems smaller than about 50 kW, but they are more expensive, so not normally suitable for larger systems.

Suitability

Biomass boilers could be suitable for the supply of the baseload winter heating and hot water demand.

Unlike natural gas and electric heating, to which energy is constantly and automatically supplied from a network, a biomass system relies on a store of fuel that needs to be supplied regularly by lorry deliveries.

A fuel supply study should be completed to validate the feasibility of biomass heating, which should include established local suppliers. There are currently a number of suppliers in the South-East of England. Furthermore, a preliminary study by ZEF UK LTD estimated that a potential 14,600kWh could be generated by collecting biomass from Crystal Palace Park through pruning, large thinning and dead tree removal.

There are different designs and options with regard to the size and position of the fuel stores. These include bunkers into which the wood fuel is tipped, external containerised fuel stores, static silos loaded from above, and building integrated stores into which fuel is blown. In principle, any of these could be used, as long as there is vehicle access to the proposed location of the boiler and store.

(left) Wood chips
(centre) Wood pellets
(right) Typical biomass boiler
5 BIOMASS COMBINED HEAT AND POWER (CHP)

Large scale biomass systems can be designed to operate as combined heat and power systems; the fuels are generally similar within certain constraints (see below), but the combustion process is more complex, with the benefit that system produces both electricity and heat, and as a result operates more efficiently overall.

Capital cost is between £2,500 - £3,000 per kW electrical for systems designed to burn biomass in the form of wood chips. System sizes are typically no smaller than 1000 kW.

Systems are appropriate where there is a mixed use, with a consistent base load for heat, and a local demand for electricity. A biomass CHP unit would be selected to provide the base load for heat, while another system fuelled by gas, or conventional thermal biomass, would supply peak loads.

Biomass for use in a CHP process must be specified to suit the combustion process:

Direct combustion systems burn the fuel like a conventional biomass boiler; use the heat to generate steam, and use the steam to generate electricity. The “waste” heat is collected via heat exchangers.

The fuel specifications for these systems is similar to conventional biomass boilers; because the systems tend to be larger, cheaper wood chip fuel would be used, and not wood pellet.

Gasification systems burn the fuel in an oxygen-free atmosphere to release combustible gases from the fuel. The gases are burnt in a gas turbine to generate electricity. The “waste” heat is collected via heat exchangers.

These systems have been developed for fossil fuels and also for the combustion of waste to produce energy. They are typically designed to use large particle size fuels and can be sensitive to dust and fine particles; the fuel supply must be controlled accordingly.

Suitability

CHP has the advantage that it can supply electricity in the case of a power failure, and can bring cost advantages in situations where a “private wire” is possible. However, biomass-CHP is still an “emerging technology” and requires detailed investigation (London Renewables Toolkit, 2004). The performance data used here are based on an equivalent gas fired CHP unit; 1 MWe generating 1,027 kWt and 1,304 kWt (Source: Ener-G Combined Power Ltd. “1027” natural gas system).
6 GROUND SOURCE HEATING/COOLING

Ground Source Heat Pumps (GSHP) extract heat from the ground and transfer it to a building, where heat is required for space heating and/or hot water. The heat extracted from the ground is a form of solar energy; the heat in the top layers of the ground comes from solar radiation. The ground source heat exchange system can be reversed and used as a cooling mechanism in summer, drawing heat out of a building and rejecting it into the ground when the ground temperature is cooler than the air above.

The temperature at which heat energy is delivered by GSHP, 30º – 50ºC is usually lower than for biomass or fossil energy boilers, which deliver at 80º - 90ºC.

Ground Source Heat Pumps are not a wholly renewable energy source as they are electrically driven, but they can be a "low carbon technology" because the heat pump uses 1 unit of electricity to yield up to 4 units of heat energy. The carbon emissions per unit of delivered heat are thus the equivalent of as little as 25% of the emissions from using electricity.

A ground source heat pump system can be wholly renewable if it is implemented as a "hybrid" with a local renewable electricity generating technology (eg wind or PV) or if it is powered by offsite-generated renewable electricity.

Ground source heat pumps are either:

- open-loop, abstracting and rejecting water to the aquifer below the site or to another source of water, e.g. a river. Open loop systems are rare for single-development applications.
- closed-loop, using circulation water contained in pipes which are in contact with the ground. Arrangements include vertical boreholes, horizontal coils and slinky coils, e.g. around the perimeter of a building.

Vertical closed loop systems use pipes placed in holes bored straight into the ground to a depth of 100 to 150 metres depending on ground conditions and size of system. Vertical systems thus require a suitable footprint area for the drilling rig at the construction stage. Prior to confirming feasibility of a vertical system, a geological investigation will be required to check ground conditions and provide cost certainty.

Horizontal closed loop systems use pipes in shallow trenches, and require a much larger surface area than a vertical bore hole.

Suitability

Ground source heat pump can provide heat for space heating and hot water and can potentially be used for cooling. However, they require a low temperature wet distribution system to exploit the output of the ground source heat pump. It should be noted that little maintenance is required for the ground pipes and the heat pump requires standard mechanical equipment maintenance.