MAITLAND PARK ESTATE REDEVELOPMENT

FEASIBILITY STUDY – RENEWABLE ENERGY & BIODIVERSITY

(Combination of Green Roofs & Solar Panels)

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BACKGROUND

Promoting sustainable construction, renewable energy sources, conserving and preserving biodiversity and mitigating the effects of climate change are, understandably, top priorities for the London Borough of Camden's Regeneration team.

Green roofs are considered key to adapting the built environment to the more extreme climatic conditions and reducing energy use and CO2 emissions. Living roofs have the potential to improve the resilience of our cities to the impacts of climate change by reducing storm water run-off velocity and volumes, and by increasing the cooling effect during hotter summers. They also bring many other wider environmental benefits.

For the Maitland Park Estate redevelopment there have been a number of interventions during the design development process that have sought to respond positively to these important issues and support a Lean, Clean, Green approach to the provision of new homes for the estate, not limited to the provision of green roofs and photo-voltaic panels.

A summary of the evolution of the scheme in this respect is offered below;

- Both solar panels and green roofs were proposed as part of the original scheme in accordance with local planning policy, which required green roofs to be installed where possible to increase the overall sustainability of the scheme.
- A revisit of the design in 2019 heralded a revised energy strategy focused heavily on renewable energy sources (ASHPs replacing gas boilers) in support of a Clean energy agenda.
- This improved energy strategy and subsequent demand on roof space for the associated plant was discussed with the Planning Team during pre-application meetings with the 2019 MMA DAS setting out the justification for omitting the green sedum roofs: "*installing sedum onto the areas in and around the plant would result in a piecemeal arrangement that would be costly, unlikely to flourish and difficult to maintain.*"

- During determination of the MMA, it was suggested that green roofs and PV panels can work together. As roof layout plans showing the extent of combined rooftop plant, PV panels and the resultant areas for green roofs were in the process of being finalised we were unable to demonstrate the associated space constraints to the team at the time.
- Through liaison with the LBC Planning Team, Quod resolved to agree the following condition which will be attached to the grant of the MMA application:

  Prior to commencement of development other than site clearance & preparation, relocation of services, utilities and public infrastructure and demolition, a feasibility assessment with the aim of maximising the provision of solar photovoltaics and green and/or other biodiverse roofs should be submitted to the local planning authority and approved in writing. The buildings shall not be occupied until the approved details have been implemented and these works shall be permanently retained and maintained thereafter.

  Reason: To ensure the development provides adequate on-site renewable energy facilities and to reduce the rate of surface water run-off from the buildings and limit the impact on the storm-water drainage system in accordance with policies CC1, CC2 and CC3 of the London Borough of Camden Local plan Policies.

This feasibility study has been prepared with input from multiple specialists and based on the emerging rooftop layouts, energy and sustainability strategies prepared for the Maitland Park development. It seeks to appraise a number of options in terms of their overall suitability in achieving our sustainability ambitions and the impact of each on buildability, maintainability, safety and compliance with the relevant policies among other key considerations.

Our recommendations are offered at the end of the report and based on a holistic assessment of all contributing factors, as descried in the following sections.

Option 1 – Intensive/Semi-intensive Green Roof

Intensive green roofs comprise a lush growth of vegetation and are based on a relatively nutrient rich and deep substrate. They are principally designed to provide amenity and are normally accessible for recreational use. They allow for the establishment of large plants and conventional lawns.

Intensive roofs traditionally require higher levels of maintenance, regular irrigation and applications of fertiliser. Due to the plants used, and the combined growing and drainage properties of the substrate, the weight of the intensive green roof system can be considerable. Substantial reinforcement of an existing roof structure or inclusion of extra building structural support may be required.

Structural Implications

Structural loading calculations must account for the saturated weight of the green roof, snow loads and any further imposed service loads, such as pedestrian access loads and point loads from features such as water features or intensive planting. The underlying roofing system (deck, insulation, waterproofing, geotextile layer and drainage/retention layer must all be capable of withstanding any point loads from the green roof installation and from any support elements included such as decking or paving.

Typical Intensive green roof dead loads - 200-500 Kg/m2 (full saturated) – this exceeds the loading threshold for the Maitland Park frames based on advice from the Structural Engineer.

Maintenance Regime

Intensive and semi-intensive green roofs require a similar level of upkeep as a traditional garden. This will include weeding, mowing, hedge trimming, fertilising and watering.

Regular irrigation is often required, subject to the plant specification and the climatic and microclimatic conditions prevailing at roof level. With a wider range of planting, using a more fertile growing medium, more regular fertilisation is required.

Safety & Access

Intensive green roofs require a higher standard of safety due to the increased frequency and density of visitors, whether to conduct maintenance or to enjoy the amenity benefit. Typically, additional measures, such as safety rails or barriers, are required for this type of roof and should be included as part of the original design. Fall restraint and/or fall arrest systems may also be suitable subject to the amenity intention.

Cost Implications

Intensive green roofs can vary in cost depending on the amount of vegetation cover and the type of vegetation. An indicative cost inclusive of waterproofing, insulation and irrigation systems will be significantly higher when compared to other green roof options and can be almost double that of a conventional roof construction.

Intensive Green Roofs and Photovoltaic Solar Panels

By their very nature, intensive green roofs are more appropriate for use as external amenity areas and this does not suit the functional rooftop environment for any of the buildings within the Maitland Park development (plant equipment and solar panels).

None of the rooftops of the buildings proposed for the development are overlooked and therefore the potential to provide visual amenity through an intensive green roof would be lost.

The rooftop areas of Aspen Court, Aspen Villas and Grafton Terrace are heavily occupied with plant and PV panels under the current design proposals and access will only be granted for maintenance and cleaning purposes. As such, the option to specify an intensive green roof combined with Photovoltaic solar panels is not considered appropriate or viable for the Maitland Park Development.

Option 2 – Extensive Green Roof / Biodiverse Roof

Extensive green/Biodiverse roofs are created primarily for biodiversity purposes and can aim to recreate or enhance the habitat for plants and animals lost by the development. This approach generally provides greater biodiversity interest than intensive roofs and extensive green roofs are designed to be relatively self-sustaining.

In most cases they are planted with, or colonised by, mosses, succulents, wild flowers and grasses that are able to survive on the shallow low-nutrient substrates that form their growing medium. They receive minimal management and usually no irrigation or fertilisation although it may be required initially until plants become established.

This category includes the 'Brown' biodiverse roof which is not purposefully planted. The growing medium is selected and installed to allow indigenous plant species to inhabit the roof over time.

Substrate depths may vary across the roof deck to promote a diversity of both shallow and deep rooted plants and ones which are more and less drought tolerant. Undulating substrate depths also create differing habitats for a greater range of invertebrate species. Pebbles, boulders, gravels, sands, branches and logs may also be placed within the system to offer suitable habitats.

A summary of extensive green/biodiverse roof types is offered below:

• mat based systems – have very shallow soils, typically between 20-40mm, are pre-grown to provide 100 per cent instant cover and generally consist of Sedum species and a wider selection of hardy plants which are drought intolerant and able to withstand extremes in climate. Sedum are able to survive on shallow substrate depths, lower nutrient levels and little or no irrigation requirement. However, the shallow substrates of mat based systems retain less rainfall and have less thermal mass. They are also restricted in the advantages they deliver for biodiversity.

• substrate based systems – are generally between 75mm and 150mm in depth, consisting of either a porous substrate or similar reused aggregates/recycled materials and planted with a variety of Sedum species, whether as plugs, cuttings or seeded. As substrate based systems are deeper than those that are mat based, they have potential to support a greater variety of species, hold significantly more rainfall to reduce surface water run-off and lessen the impact on the storm water drainage system, have a greater thermal mass and have greater evapotranspiration properties. A potential disadvantage is that they are heavier than mat based systems and take time to establish full vegetation cover, should that be required.

Structural Implications (Loads are full saturated)

Extensive green roof [sedum mat] 60-90 Kg/m2

Extensive green roof [substrate based] 80-150kg/m2

In the case of an inverted substrate based green roof there should be relatively limited or zero need for extra structural load. When an inverted roof system is used, the structural capacity to hold a green roof substrate-based system is already present in shingle or paving ballast, although water absorption would also need to be considered.

Level of Biodiversity

The Living Roofs guidance confirms that substrate-based 'Extensive Green Roofs' are likely to deliver the highest biodiversity value. This is echoed in the BRE guidance used by ecologists in ecological enhancement calculations (for BREEAM/HQM and also wider DEFRA biodiversity calculations):-

	land being used to compensate for impacts, either on the site or outside it as a biodiversity offset.
Green roof - Extensive green roofs	Extensive green roofs generally provide greater biodiversity interest than intensive roofs, but are considered to be less appropriate in providing amenity and recreation benefits. In most cases they are planted with, or colonised by, mosses, succulents, wild flowers and grasses that are able to survive on the shallow low-nutrient substrates that form their growing medium. (Greater London Authority, 2008)
Green roof - Intensive green roofs	Intensive green roofs are principally designed to provide amenity and are normally accessible for recreational use. They may be referred to as roof gardens or terraces. Generally intensive green roofs comprise a lush growth of vegetation and are based on a relatively nutrient rich and deep substrate. They allow for the establishment of large plants and conventional lawns. (Greater London Authority, 2008).
	Condition is defined as the quality of a particular habitat. For example, a habitat is in poor condition if it fails to support

Maintenance Regime

The "management" of a biodiverse type green roof depends upon what the client requires. It can be managed more heavily to produce a controlled "wildflower meadow" type environment. Less management input is required for a 'Brown' biodiverse roof and may lead to the development of vegetation which progresses naturally relating to the prevailing conditions.

Non-managed plant species

Where a self-vegetating 'Brown' biodiverse roof is specified careful consideration must be given to the suitability of the substrate composition to support the desired local species and ensure appropriate nutrient levels are achieved and maintained. Consideration should also be given to the maintenance regime that may be required to manage unwanted invasive species.

Generally, extensive green roofs need very low maintenance - a one to two year inspection regime will normally suffice to weed out unwanted plants, remove deep roots and, if necessary provide fertilisation. For the first year such work is generally covered by the installation team, after which it becomes the responsibility of the building management team.

Safety & Access

With access generally only required for maintenance works, some form of fall restraint and/or fall arrest system will typically be sufficient to provide safe access to and egress from roof edges, penetrations, lights or any bordering fragile surfaces.

The specific maintenance requirement and the layout of the roof will determine the most appropriate system type. A single point anchorage device may suffice in many cases, however for greater mobility; guided type fall arrest systems may be more suitable. Systems can be designed to suit all movement directions (i.e. vertical, horizontal) and for different numbers of operatives. Whatever type of fall restraint and/or fall arrest systems are installed they should be designed specifically for the appropriate maintenance requirements of the green roof system.

Fire Safety

Many green roof systems will provide a positive contribution to the resistance of penetration by fire due to the non-combustible nature of mineral/brick based growing media.

Green roof systems can also provide a positive contribution to resistance of spread of flame provided they are correctly designed, installed and maintained. However, like any vegetation-covered surface consideration must be given to methods preventing the external spread of flame during prolonged periods of drought.

Extensive roofs are only considered to be fire resistant if:

• the substrate/soil is at least 30mm deep – we propose 75 – 100mm for Maitland Park

• the substrate/soil contains less than 20 per cent organic matter – substrate based system of crushed concrete, aggregate, bricks etc. with appropriate self-vegetating, hydro seeded, wildflower plug mix.

• there is a 1m wide gravel or slab 'fire break' every 40m – gravel/slab access routes to be coordinated to provide appropriate fire breaks at required intervals.

• gravel/shingle strips are provided around all structures penetrating the roof covering. These strips should be at least 300-500mm in width, or 1m in width where they are to act as firebreaks on large roof areas – strips to be provided adjacent to roof access, plant enclosures, access hatches, building services penetrations and around PV support structures (unless Bio-solar option is specified – See option 3).

Extensive green roofs suit restricted access applications such as the roof top areas forming part of the Maitland Park Estate development which are heavily populated with plant equipment and photo-voltaic arrays.

Extensive Green Roofs and Photovoltaic Solar Panels

If correctly implemented, the use of both solar/photovoltaics and green roofs provides dual benefits in terms of energy production and energy savings with the combination of technologies offering multiple benefits.

Solar/Photovoltaic (PV) A-Frame panels at roof level are known to work more efficiently when installed on a green roof rather than on a conventional surface. The green roof element not only saves energy during the summer time but, if correctly designed, can also increase efficiency of PV by reducing fluctuation of temperatures at roof level and by maintaining a more efficient microclimate around the PV Panels. The green roof serves as a natural cooling mechanism, thereby maintaining the panels' efficiency.

In this option, the extensive green/biodiverse roof would occupy the available areas bordering the PV arrays and some of the resultant spaces in between rather than targeting the whole roof area as a green roof. This approach seeks to combine the two technologies whilst mitigating the risks associated with wider spacing of the PV arrays (potentially impacting quantity of solar panels) and more regimented, species critical planting schedules.

Cost Implications

Extensive green/biodiverse roofs are usually cheaper to install than intensive green roofs and are less costly to maintain.

An indicative cost for an extensive green roof will depend on the type of system used. The cost of installing an inverted, substrate based green roof system, including waterproof and insulation will be in the region of 50% higher than a conventional roof construction.

A substrate-based roof can result in other cost savings due to the reduction in the number of drainage outlets and in the amount of storm water amelioration at ground level. Further savings can be factored in when accounting for the reduced energy needs within the building and its positive impacts on whole life costing. It is widely recognised that a green roof is the most cost-effective method of roofing over a 25-year period.

Option 3 – Bio-solar

Biosolar roofs provide an opportunity to combine PVs over a biodiverse green roof to generate free electricity, increase the lifetime of the roof and, with thoughtful planting, provide a vital habitat for urban flora and fauna essential for supporting biodiversity.

Solar/Photovoltaic panels can work more efficiently on a roof when installed over a green roof system. The micro-climate around the panels is important and green roofs can help to regulate the ambient temperatures around the panels at or near 25 degrees C which is the temperature at which solar panels work most efficiently.

A green roof can make the installation of A-frame panels easier providing the ballast to hold the support structure and panels in place with no impact on the waterproofing layer below.

The PV panels can contribute to increasing the diversity of vegetation and fauna using the green roof by creating shaded areas underneath, with rain run-off making damper areas to the front and drier areas behind. This creates a diverse habitat allowing a wider variety of vegetation to flourish, in turn attracting a wider range of butterflies, bees, beetles and other species.

A key feature of the Biosolar system is that it allows the entire roof to qualify as a biodiverse green roof (resulting in increased levels of biodiversity and reduced surface water run-off) although it's interface with the planting and substrate below must be carefully managed. Consideration in design and installation is important to allow liberal growing room for the extensive vegetation without blocking light to the solar cells and reducing the efficiency of the panels. This arrangement must also enable light and moisture to reach beneath the panel to support the plants below.

Although Biosolar systems are often selected to maximise the vegetated area and the PV output, the quantity, proximity and spacing of the PV arrays combined with appropriate plant selection are critical to the success of the biosolar approach. A balance must be struck between the quantity and arrangement of PV units and the planted areas otherwise the system will fail. A green roof requires appropriate levels of daylight, moisture, drainage, aeration to the plant root systems and nutrients in order to flourish and this can make the specification of biosolar solutions more complex than other available green roof/solar panel combinations.

The current arrangement of PV panels on the rooftops of the Maitland Park buildings are extremely congested (in order to maximise energy production) and regular unobstructed access is required to access and maintain the various rooftop features (plant equipment etc.). This may result in an ineffective use of the combined technologies for this application with panels unable to efficiently generate energy or plant species unable to grow in shaded or more trafficked areas. A wholesale redesign of the solar arrays would be required to offer sufficient spacing for planting to flourish and this would likely reduce the number of panels on each roof.

Structural Implications

The exact system weight will vary depending on ballast requirements and system specification but the average BioSolar solution will weigh approximately 175kg/m2*

*weight includes waterproofing membranes, insulation, green roof system and solar modules

The weight of the combined system exceeds the threshold for the Maitland Park structure based on the limit advised by the Structural Engineer as a max load of 150kg/m2.

Safety & Access

As with the extensive green/biodiverse roof some form of fall restraint and/or fall arrest system will be required to provide safe access to and egress from roof edges, penetrations, lights or any bordering fragile surfaces.

As a biosolar system targets maximum vegetated roof area, careful consideration will need to be given to access routes in and around the rooftop plant areas, PV arrays and other features for maintenance purposes and to achieve compliant fire break detailing.

Fire Safety

Biosolar uses biodiverse green roofs systems that can provide a positive contribution to resistance of spread of flame provided they are correctly designed, installed and maintained. However, as the rooftops are intensively vegetated they must be carefully monitored to ensure that vegetation does not dry out during periods of drought resulting in large quantities of dry plant material on the roof surface that could be a fire hazard.

Cost Implications

The indicative cost for a Biosolar system combining solar photovoltaic panels with an inverted, substrate based biodiverse green roof system (including waterproof and insulation) to maximise vegetation across the available roof area will be in the region of 75% higher than a conventional roof construction and 25% higher than the extensive green/biodiverse roof and PV combination described in Option 2 (where planting does not extend beneath the PV arrays).

Option 4 – Retain existing Stage 4 Design

The current Stage 4 design proposes that a total of 458m2 of photovoltaic panels be provided across the buildings within the development in support of our renewable energy strategy.

Aspen Court – approx. 244m2

Aspen Villas – approx. 92m2

Grafton Terrace – approx. 113m2

Grafton House – approx. 9m2

During the design development process, and prior to establishing the extent of plant equipment and other roof top features, the team suggested the removal of the green roof provision which occupied the areas around the borders of the PV arrays as these were deemed negligible in terms of offering any benefit for biodiversity. This also represented a cost saving to the project in our drive to address commercial viability.

Retention of the current scheme has a number of benefits as follows;

- PV quantities specified to maximise energy production in support of a robust renewable energy strategy.
- No additional loads applied to the existing structural frame
- No supplementary maintenance requirements transcending that relating to upkeep of the PV units or plant equipment.
- Clear and unobstructed access to and around the roof top plant areas, PV arrays and other features without the need for additional fire breaks or 'no-go' areas where access is restricted to protect vegetation from footfall.
- Cost effective solution to address budget constraints
- Retention of current Stage 4 design will avoid the need for a potentially costly redesign and protect the delivery programme.

It is worth noting also that, in general, Warranty providers do not encourage the use of planted roofs due to lack of maintenance leading to plants dying with dry vegetation becoming a potential fire hazard.

Mindful that this option does not maximise biodiversity across the development site we would suggest a revisit of the landscaping scheme and review of planting schedules/external features at ground level to target habitat creation and encourage local flora and fauna to populate the site and thrive.

Recommendations based on option appraisal

We acknowledge the importance of promoting biodiversity, renewable energy sourves and sustainable construction and remain committed to working with the relevant London Borough of Camden teams to agree a strategy which maximises the benefits whilst safeguarding the already constrained budget and tight delivery programme.

Based on our appraisal of the options available for the scheme and with sensitivity to striking a balance across all associated factors, we would like to offer our recommendations as set out below;

Recommendations for Maitland Park Estate

IKO Permatec inverted and substrate-based roof system (75 – 100mm crushed concrete, aggregate, bricks etc. – loads not exceeding 150kg/m2) with appropriate waterproof membrane, combined with a self-vegetating/hydro-seeded biodiverse roof installed in the margins bordering the PV arrays and in the areas in between where spacing of solar panels will allow healthy growth via access to daylight and protection from wind.

Ballasted type photovoltaic panels to be installed on paving with trays secured by ballast blocks to avoid penetrations through rooftop waterproofing layer.

Provision of biodiverse roofs should be limited in more trafficked areas such as access to and egress from maintainable assets (plant areas, access hatches, PV arrays) with gravel/shingle or paved borders provided to edges, where appropriate.

Our recommendation of installing a low maintenance, lightweight extensive, substrate-based biodiverse roof is compounded by Table 1 of the Living Roofs and Walls technical guidance which shows that this offers the highest level of biodiversity for this application when compared to other green roof options whilst providing significant benefit in terms of addressing climate change, building energy balance, SUDS and overheating. Please refer to Table 1 below.

Table 1: Matrix of Roof Type vs. Potential Environmental Benefit

Roof Type	Potential Benefit					
	Climate Change	Building Energy Balance	UHIE	SUDS	Biodiversity	Amenity
Intensive	✓✓	✓✓	✓✓✓	✓✓✓	✓	✓✓✓ (visual)
Extensive – mat-based <40mm	✓	✓	✓	✓	✓	✓ (visual)
Extensive – substrate-based >75mm	✓✓	✓✓	✓✓	✓✓	✓✓✓	✓ (visual)

Other benefits include improved thermal insulation, enhanced air quality, noise attenuation, protecting and extending the life of the roof membrane and reducing energy costs in operation. This solution will contribute to reduced surface water run-off from the building, lower risks of flooding, reduced CO2 in the local climate, reduced Urban Heat Island Effect thus reducing air conditioning energy requirements and reduced energy consumption generally whilst safeguarding the commercial viability of the scheme.

Adopting this strategy will provide approximately 682m2 of biodiverse roof (Refer to sketches provided at Appendix 1) coupled with retention of 458m2 of solar photovoltaic panels in accordance with the original consented scheme. This represents a balanced approach to achieving our collective ambitions for the project within the parameters of the scheme at this stage in the design evolution.

[Note: All recommendations based on preliminary option appraisal and subject to detailed review and verification by specialist PV Consultant/ Ecologist]