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Assessment of 3 community led solar PV pilot projects

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Executive Summary

London Borough of Southwark (LBS) Council have engaged BRE to assess the technical and commercial feasibility of three community-led renewable energy projects at Juniper House, Haddonhall Estate and Brenchley Gardens Estate. The energy generated by the projects will be used to offset landlord electricity costs which are currently shared by tenants and leaseholders in each of the estates.

Following a series of site surveys, BRE have assessed the solar PV potential of each of the roof spaces at the three estates. Viable roofs have been presented in this report complete with an estimate of installation capacity, optimised to offset landlords electricity consumption, and maximise financial and carbon benefits. Where appropriate, consideration has also been given to energy efficiency measures, energy storage, and/or other renewable energy options that could provide a reduction in landlord energy costs.

The following high level conclusions have been drawn:

- Juniper House – This has one of the highest electricity consumptions per connection across the three estates. The cost of access equipment (i.e. scaffolding) to install and maintain a solar PV system is the most significant influencing factor on any business case. A 17.3kWp PV array on the east facing roof will provide the most benefit, however an assessment of the suitability of the roof structure and covering for a PV system needs to be undertaken. However, it is currently considered that better cost savings could be realised through an LED rollout across the estate
- Haddonhall – There is significant shading on most roofs due to surrounding trees and buildings. The electrical consumption on this estate is mainly for lighting and, following the recent installation of LEDs, is continuing to reduce. As a result of the low electrical loads, and the separate metering for each block, only small PV systems (<4kW) would be required to cover the electricity consumption. As before, the cost of access equipment will have a big influence on any business case.
- Brenchley Gardens – This presented one of the better business cases for solar PV, particularly on the blocks (due to existing roof access provision). However, it is currently considered that better cost savings could be realised through an LED rollout across the estate. Whilst the communal heating loads have also been assessed the current gas powered heating and hot water are considered more cost effective than renewable alternatives.

A number of financing options for the projects have been explored and a detailed financial analysis of Juniper House has been included in Appendix A. In addition, a clear and objective criteria against which LBS can evaluate the individual proposals has been presented.

Contents

Introduction

London Borough of Southwark (LBS) Council have a commitment to become a greener borough and have set out a number of ambitions, including: becoming carbon neutral by 2050; divesting Council investments away from fossil fuels and into sustainable alternatives; supporting the creation of community led sustainable energy projects on estates to help residents reduce their energy bills; as well as cutting operational costs for the Council.

Three resident communities (some via Tenant Management Organisations (TMOs)) put forward proposals for the installation of solar PV on Council owned estates, namely:

- Juniper House
- Haddonhall Estate
- Brenchley Gardens Estate

All three estates contain different types of properties, with different tenure mixes and different opportunities for the technology.

LBS Council engaged the BRE National Solar Centre (NSC) to provide an independent and impartial study of the technical and financial feasibility of the three community-led renewable energy projects.

This report has been broken down into the following sections to present an estimation of solar PV system size, potential for energy storage, high level assessment of renewable energy generation options and financing options assessment:

1. Solar PV technology options
2. Solar PV financing options for LBS
3. Juniper House solar PV feasibility study
4. Haddonhall Estate feasibility study
5. Brenchley Gardens Estate feasibility study
6. Evaluation criteria for a solar PV project

BRE's expertise

BRE offer:

- Proven knowledge and expertise in the assessment, development and integration of RE technologies into buildings, on land etc.
- A deep knowledge and understanding of historic, existing and projected market/ cost trends including new technology innovations.
- A repository of lessons learned from delivery of research in RE since 1976.
- Ongoing experience supporting RE projects and low carbon innovation for public and private sector clients across the UK.

Owned by a charity (the BRE Trust), BRE is the world's leading building science centre. Our approach is therefore one of independence, technical understanding and diligence, providing our clients with information and support they can rely on. BRE's full range of services and products can be found at www.bregroup.com.

BRE has established and trusted relationships with the wider UK renewables industry and has collaborated with industry leaders to publish best practice guidance on large scale projects. Relevant publications include:

• Multifunctional Solar Car Parks – A good practice guide for owners and developers (2018);
• Battery energy storage systems with grid-connected solar photovoltaics (2017);
• Flexible electrical networks for a low carbon future: Network and built environment opportunities for enabling smarter networks (2017);
• Solar PV on Commercial Buildings – A guide for owners and developers (2016); and
• Renewable energy: A collection of BRE expert guidance on RE systems in the built environment (2016)

Further information on the NSC's activities and services can be found on the website: www.bre.co.uk/nsc.

Methodology

Site surveys

LBS have provided copies of third-party proposals (containing varying level of detail) for the three proposed solar PV projects as well as energy bills for the landlords supplies at the estates. NSC visited each estate between the 21st – 23rd January 2018 to gather data and discuss the plans, aims and objectives of each project with each TMO manager and/or residents leading the projects. The purpose of the site surveys was to assess the potential for solar PV and other renewable energy options on the buildings. The site surveys sought to establish (subject to access) the following information:

- Roof size and suitability for solar PV installation.
- Identify and locate any building features that may impacts upon the PV scheme layout, including shading, location of landlord's supply and electrical connection points, communication considerations, restrictions to cable routes, access, proximity to neighbours, overhead obstructions, etc.
- Potential for other renewable energy generation across the estate (including car parks, building integrated PV, energy storage and heating technologies).
- Assessment of requirements for installation delivery and ongoing maintenance.

Estimation of solar PV system size and potential for energy storage

Based on the information gathered for each estate, and adhering to the IET Code of Practice for Grid-connected Solar PV Systems and current Planning Guidance, a series of solar PV generation scenarios were modelled, where appropriate, as follows:

A. Solar only - maximized for generation potential (i.e. allowed by available roof space and grid connection potential)
B. Solar only - maximized to offset the landlord supply/ TMO electricity consumption
C. Solar and storage – maximized for generation potential (i.e. allowed by available roof space and grid connection potential)
D. Solar and storage – maximized to offset to landlord supply/ TMO electricity consumption

An indicative layout diagram has been produced for each estate, providing the size of solar PV array and optimal location. The output of the models provide an estimation of annual yield (kWh/yr), associated CO_2 reductions, cumulative cashflows (IRR and NPV), potential savings and revenue streams.

Data provided

Estate	Data received
Juniper House	Estate map & electricity survey form completed 2009 Npower reports (July to Sept 2018) – adhoc meter readings and/or estimates
Haddonhall Estate	Estate map & electricity survey form completed 2009 Npower reports (2016/17, 2017/18 and 2018 to Sept 2018) - adhoc meter readings and/or estimates Copies of latest TMO electricity bills (Dec 2018) for all properties <u>except</u> for: 58-63 Rephidim Street 1-6 Thornham House 1-6 Poitier Street 7-12 Poitier Street 269-279 Tabard Street 21-31 Rothsay Street
Brenchley Gardens Estate	Estate map & electricity survey form completed 2009 Npower reports (2016/17, 2017/18 and 2018 to Sept 2018) - adhoc meter readings and/or estimates Copies of latest TMO electricity and gas bills (Dec 2018) for Estate Office and Community Centre

Table 1. Data supplied by LBS

Introduction to RE technologies

Introduction to RE technologies

RE technologies can be crudely split into two categories; heat generating and electricity generating. In addition, there are some cogeneration technologies (such as combined heat and power) that are able to provide both, these technologies require careful specification so that energy generation suitably matches demand. The effectiveness of some RE technologies can be improved with energy storage. Effective system specification, installation, operation, control and maintenance are also vitally important.

Heat generating RE technologies

Biomass – heat generated from burning logs, wood chip, wood pellets (or related bio-products) for space heating and/or hot water.
Solar thermal – solar collectors that generate heat typically to contribute to hot water provision (and potentially space heating).
Heat pumps – uses electricity to extract, and upgrade, low grade heat from air, water or ground sources for space heating / cooling.

Electricity generating RE technologies

Wind turbines – generates electricity from the wind, can be located both on land and offshore.
Solar photovoltaics (PV) – solar modules that generate electricity, can be mounted on buildings or land.
Hydro – generates electricity from moving water.

Electricity and heat generating RE technologies

Combined heat & power (CHP) – produces electricity and heat simultaneously. Typically via a natural gas-fired engine although can also be fueled by bio-gas, biomass, oil, etc.
Deep geothermal – extracts heat from hot rocks deep underground (>2km) generating large amounts for heat that could be used for heating/ district heating (or to produce steam from which electricity can be produced).
Solar photovoltaic-thermal (PV-T) – combines PV technology with a heat generating technology such as solar thermal or heat pump to deliver electricity and low grade heat.

With respect to heating, Haddonhall communal heating is facilitated by the existing communal heating scheme. Juniper House does not have any communal heating requirements. Brenchley Gardens only requires communal heating for the Estate Office and Community Centre which are currently run via gas boilers. However, opportunities for energy efficiency measures to reduce landlord energy bills were identified and are discussed.

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1. Solar PV technology options

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Solar PV technology options

Solar PV is a modular technology that can typically be installed in a whole range of applications, including on existing or new buildings, car parks and ground mounted. It can be specified to fit within a given area, to generate a specific amount of energy, or to offset electricity consumption. Solar PV offers a well proven low-risk solution that can reduce the Council's carbon emissions and deliver cost benefits which can be passed on to tenants and leaseholders.

The uptake of solar PV systems in the UK has seen significant growth since 2010, with capacity increasing from close to zero to more than 12GW (nearly 1 million solar PV systems)[1]. A significant driver for this growth is the feed-in tariff (FIT) scheme, an incentive paid to generators for every unit (kWh) of renewable energy generated which is due to close to new applicants from end of March 2019. A new Smart Export Guarantee is currently in consultation and is due to replace the current export tariff arrangement.

Solar PV is one of the more suitable renewable technologies for urban locations, delivering low carbon electricity from otherwise unused building surfaces that can be directly consumed on-site, stored in batteries for use at times of non-generation, stored as hot water or heat in standard hot water cylinders using an energy diverter, or exported to the grid.

The business case for solar PV works well when the daily on-site electricity demand aligns closely with a typical solar generation curve i.e. the majority of electricity consumption within a building occurs during daylight hours, with an increase in consumption between 10am – 2pm (as illustrated in Fig 1).

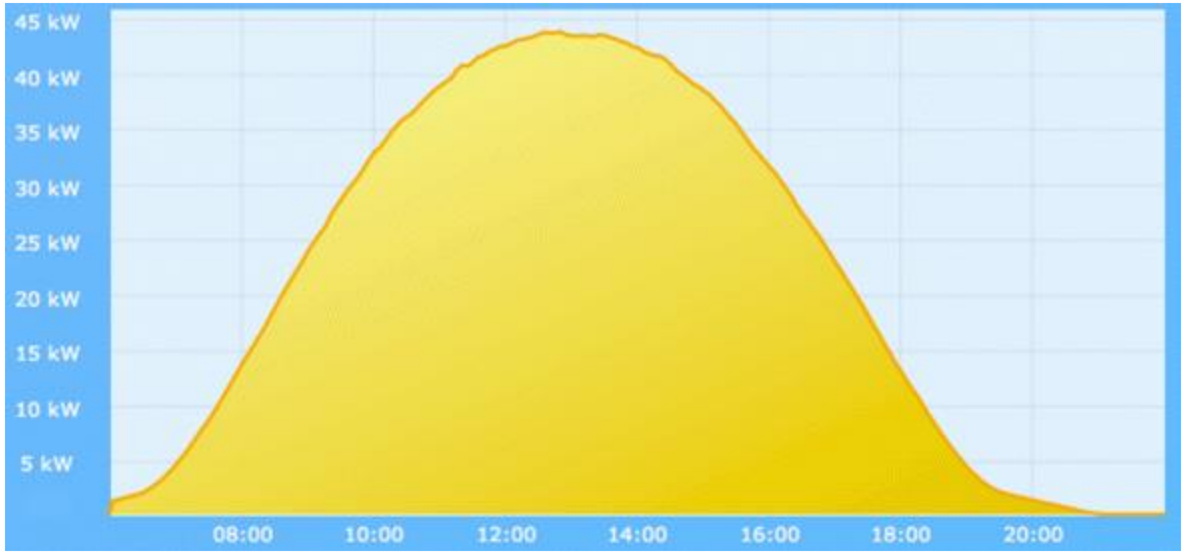

Fig 1. Typical solar PV generation curve

[1] Solar photovoltaics deployment (BEIS, 2019)

Solar PV technology options

Solar Photovoltaic (PV)

Description	Advantages	Disadvantages
Solar PV modules that generate electricity, can be mounted on buildings (roof or façade), carports, or land.	• Well established and proven technology. • Good solar resource available across the UK. • Shorter project timescales. • Scalable technology. • Versatile mounting locations. • Considered a permitted development for rooftop PV <1MW. • Low operational costs. • Large scale solar (1MW+) has a low LCOE (£73/MWh)[1].	• Variability of solar resource (daily and seasonal). • Grid reinforcements may be required for connections of large schemes. • Efficiency affected by shading. • Planning permission required for non-roof mounted PV systems >4kW.

Table 2. Advantages and disadvantages of solar PV

[1] BEIS Electricity Generation Costs (2016) – Levelised cost of energy hurdle rate predictions for 2020 by technology type. <1MW = £109/MWh, 1-5MW building mounted = £73/MWh, 1-5MW ground mounted = £76/MWh, 5MW+ = £67/MWh

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Solar PV technology options

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Table 3. Comparison of installation options for solar PV

Roof mounted	Building integrated	Carport mounted	Ground mounted
			
Price: £	Price: £££	Price: ££	Price: £
Timescales: Quick	Timescales: Moderate	Timescales: Moderate	Timescales: Longer
Advantages: Low visible impact. Installed at point of demand, shorter connection routes.	Advantages: Can offset building material cost. Versatile product offering for all aspects of building.	Advantages: Utilises space that is otherwise unused. Provides cover from rain and sun.	Advantages: Easy to maintain, can be more cost effective than rooftop. Can be sold as a separate asset at a later date.
Disadvantages: Access for maintenance can be an issue. Possible structural reinforcement.	Disadvantages: More complex build & integration. Typically less efficient technology.	Disadvantages: Car park layout may need to be changed. Some loss of parking spaces.	Disadvantages: Security can be an issue. Planning application process can be lengthy.

Solar PV technology options

Solar PV technologies

“Solar PV module” is the industry term for a photovoltaic solar panel. Solar PV modules are constructed from a number of solar cells made up of one or more materials. Crystalline silicon solar PV modules have the main share of the market in the UK and globally. This is in part due to the relative abundance of silicon and their favourable efficiencies in comparison to competing products. Thin film technologies are gradually improving in terms of conversion efficiency and so are increasingly becoming regarded as a credible alternative to crystalline silicon technologies.

Key characteristics of commercially available solar technologies are detailed in Table 4.

Table 4. Characteristics of main solar technologies

	Crystalline silicon (c-Si)	Thin Film
Types of technology	Mono-crystalline silicon (mono-Si) Poly-crystalline silicon (multi-Si)	Amorphous silicon (a-Si) Cadmium telluride (CdTe) Copper indium gallium selenide (CIGS)
Typical module efficiencies	13% - 20% (commercial products are commonly around 15%)	4% - 16% (commercial products are commonly around 13%)
Module power output	230W - 285W (60 cells) 290W – 350W (72 cells)	90W – 170W
Module size	1.6m^2 – 2.0m^2	1.1m^2 – 1.3m^2
Typical module construction	Cells encapsulated between glass front and plastic rear sheet within an anodized aluminium frame.	Same as c-Si or cells encapsulated between two glass sheets without a frame (lower embedded carbon)
Mounting requirements	Industry standard	Industry standard or frameless modules requiring specialised mounting system
DC wiring	Industry standard – pre-fitted polarised plug and socket connectors affixed to UV stable double insulated DC cable.	Same as c-Si, however higher cell voltages mean less modules can be connected in series.
Typical applications	Residential, commercial, utility	Commercial and utility

Solar PV technology options

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Solar PV performance

Solar PV modules perform best under direct sunlight, but continue to generate electricity from reflected sunlight and in reduced light conditions, such as on cloudy days.

The performance of PV modules will be affected by anything that prevents sunlight falling on the solar cells (i.e. shading, dust or snow, etc.), therefore the surface of PV modules need to be kept clean and free of debris and this is an important operation and maintenance consideration if performance is to be maximised.

When assessing the viability of a PV system it is essential to estimate the system yield (generation potential). There are a variety of industry-accepted methods, tools and software for doing this with yield typically being calculated by considering: the efficiencies of key components (PV modules, inverters, cabling); the effect of orientation and inclination (pitch angle) of the PV array (as shown in Fig 2); any shading on the PV modules (both horizon shading and building specific shading, such as ventilation pipes, other buildings, etc.); and the solar irradiance potential for the particular site.

Orientation

Inclination	North -185°	-165°	North West -150°	-135°	-120°	-105°	West -90°	-75°	South West -60°	-45°	-30°	-15°	South 0°	15°	South East 30°	45°	60°	75°	East 90°	105°	North East 120°	135°	150°	165°	North 180°
90°	25	27	32	37	40	44	50	57	60	66	70	70	70	70	70	66	60	57	50	44	40	37	32	27	25
80°	28	29	34	38	45	50	56	61	68	73	78	79	78	79	78	73	68	61	56	50	45	38	34	29	28
70°	32	34	37	42	48	55	66	69	75	80	85	87	87	87	85	80	75	69	66	55	48	42	37	34	32
60°	37	38	41	48	54	62	69	75	80	85	91	92	93	92	91	85	80	75	69	62	54	48	41	38	37
50°	42	45	48	52	59	68	72	78	85	91	95	96	97	96	95	91	85	78	72	68	59	52	48	45	42
45°	46	49	52	56	62	70	74	80	87	92	95	97	98	97	95	92	87	80	74	70	62	56	52	49	46
40°	50	52	55	60	65	73	76	82	88	93	96	98	99	98	96	93	88	82	76	73	65	60	55	52	50
35°	55	57	59	65	67	75	79	85	90	94	97	99	100	99	97	94	90	85	79	75	67	65	59	57	55
30°	60	60	61	67	70	78	80	85	91	94	96	98	98	98	96	94	91	85	80	78	70	67	61	60	60
20°	70	70	71	73	75	72	84	86	91	92	95	96	96	96	95	92	91	86	84	72	75	73	71	70	70
10°	78	78	79	80	82	85	85	88	90	91	92	92	93	92	92	91	90	88	85	85	82	80	79	78	78
0°	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85

Fig 2. Effect of orientation and inclination on PV performance (MCS, 2012)

Solar PV technology options

Inverter options

A solar inverter converts the direct current (DC) generated by a PV module into alternating current (AC). The inverter conditions the power output from the solar array, to ensure it is suitable for electrical distribution. The inverter plays a number of other key roles on both the AC and DC sides to ensure maximum productivity and safety for the solar PV array. Choosing the right configuration of inverter(s) is important for a successful solar installation. There are a number of technological solutions for performing inverter functions and they vary depending on the size and type of system to which they are applied. The main inverter types deemed most likely suitable to the LBS projects are as follow:

- Micro-inverters - small units designed to condition DC into AC, for a single or pair of modules. These offer basic single phase power conditioning. The advantage of these is that they deal with variable shading more effectively, but presently they are not as cost effective as string inverters (see below). Micro-inverters connected to the UK's Distribution Network must be certified to conform to Engineering Recommendation G98. A number of module manufacturers now have partnerships with micro-inverter manufacturers to provide off-the-shelf AC solar PV modules.

- Commercial string inverters – typically range from 5 - 50kW and may be single or three-phase. They are less effective at dealing with shade due to the PV modules being connected in series in a string, limiting efficiency to the worst performing (i.e. shaded) module in the string. Commercial string inverters connected to the UK's Distribution Network must either be certified to conform to Engineering Recommendation G99, or a witness test must be completed (upon commissioning of the installation) by a Distribution Network Operator (DNO) engineer. This is to ensure the system conformance to G99 requirements.

DC optimisers

DC optimisers are electronic devices that can be retro-fitted to the back of any solar PV module, providing module-level maximum power point tracking (MPPT) and, in some case, performance monitoring. These devices still require modules to be connected to an inverter to enable grid connection. Some DC optimisers can work with any inverter, whereas others are manufacturer specific. As with other MPPTs, DC optimisers can improve system performance but are normally only cost effective for sites with complicated shading or multiple orientations. A number of module manufacturers now have partnerships with DC optimiser manufacturers to provide off-the-shelf 'smart solar PV modules'.

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Solar PV technology options

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Energy Storage

Battery storage systems are becoming a popular addition to new and existing solar PV systems in a bid to increase the amount of self-consumption and reduce energy costs. Charging during daylight hours uses ‘free’ solar electricity and, if this energy is then discharged into loads (e.g. at night or at times of low solar generation) this has the potential to offset the cost of grid-supplied electricity. In some scenarios it may be more cost effective to charge a battery at night and use the stored energy to work alongside the solar PV system to offset daytime imported electricity where tariffs can be higher.

There are a range of different battery chemistries available however Lithium Ion (as shown in Fig 3) has had most market success to date due to its energy density, reliability, longevity and scalability. Costs are predicted to reduce by at least 50% in the next 10 years, as the uptake of storage increases[1].

Battery storage systems are considered for all 3 estates, but at present none of the sites are considered viable for the following reasons:

- Juniper House – Solar PV system is already financially unviable due to potential high installation costs, adding energy storage does not sufficiently assist in improving this.
- Haddonhall Estate – Electricity consumption per block is very low making individual batteries per property unviable and the dispersed location of blocks making a communal battery equally unviable.
- Brenchley Gardens – There is limited unshaded roof space for the installation of solar PV and the majority of solar electricity would be consumed when generated, so limited opportunity to store surplus generation.

In addition to battery storage, it is also possible to store surplus generated energy in other forms, such as hot water. Intelligent diverters can increase self-consumption by diverting excess electricity into a resistive load, typically an immersion heater. This can save using more expensive sources of energy and possibly reduce cost. Only Brenchley Gardens Estate presents the opportunity for use of renewable generated heat, however as condensing gas boilers are already fitted it is considered to be unviable at this time.

Fig 3. Example of lithium ion batteries

[1] Li-ion batteries for mobility and stationary storage applications - Scenarios for costs and market growth (JRC, 2018)

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2. Solar PV financing options

Solar PV financing options

There are typically four key stakeholders involved in the delivery of any solar PV project:

- Electricity consumer (Landlord/ TMO)
- Property owner (LBS)
- Solar PV system owner (to be confirmed)
- Engineering Procurement and Construction (EPC) contractor (commissioned by system owner to install the solar PV system)

System ownership

Self-funded projects are traditionally realised through capital reserves, project financing (i.e. borrowed capital) or a debenture model (i.e. capital raising from a collection of investors, such as crowdfunding). The key advantage of this approach is that LBS could retain control of the system and could sell any surplus electricity generated to an electricity supplier. The disadvantages are ensuring a good quality installation, the ongoing liability of the asset (i.e. operation and maintenance of the system) and the potential increase in business rates as a result of consuming self-generated solar electricity.

With a third party ownership model, the third party would build, own and operate the solar PV asset and LBS will enter into an power purchase agreement (PPA) to purchase the generated electricity at a specified rate for a specified term. Typically the PPA rate will be less than the consumers current electricity tariff, making it financially attractive. The key advantage to this approach is realisation of cost and carbon savings without any financial outlay and longer term fixing of energy prices. The disadvantages are that LBS are unlikely to have influence over the procurement and quality of the system installed, or the ongoing operation, maintenance and reliability of power production.

LBS have advised that there is potential for a solar PV array at Juniper House to be funded from the previous Tenant Management Committee reserves as the project could be deemed as being a ‘building improvement’. A community energy organisation, South East London Community Energy (SELCE), has approached LBS to install 6 community funded solar PV arrays on Haddonhall, entering in to a PPA with LBS/ TMO to sell onsite generated electricity to the landlords supply. There are no firm funding plans for Brenchley Gardens Estate.

Some third party business cases may rely on securing Government incentives, so it is worth highlighting that Feed in tariffs, and the current arrangement for export tariff, are both closing to new applicants from the end of March 2019.

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Solar PV financing options

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Self-Funding

Public sector bodies have access to low-cost, long-term infrastructure funding in the form of the Public Works Loans Board (PWLB). This enables an organisation to borrow at Government rates and issue loans for 20 year terms, for circa 2.5% payable on interest only. This is lower than any private sector finance and it can enable the loan to be repaid from the solar PV revenue and savings. The process of application is also relatively straightforward. A business plan is required to illustrate that future revenue streams will fulfil the repayments.

Project Financing

A number of funding bodies and financial institutions provide public sector financing for a wide range of projects, including solar PV.
Salix operate the Salix Energy Efficiency Loans Scheme (SEELS). The Scheme provides an interest free loan to finance up to 50% of the costs of an energy saving project, such as a solar PV installation. The project must be able to demonstrate a payback of 8 years or less at a cost of £200 per tonne of CO_2 over the lifetime of the project.

Third Party Ownership

An alternative to investing directly in a PV scheme is to enter into a Power Purchase Agreement (PPA) with a third party investor. PPAs enable the Council to benefit from solar energy without any upfront capital or ongoing maintenance costs. The business case will be made on a comparison of the PPA tariff versus the anticipated costs of continuing to purchase electricity from a licenced energy supplier. Typically under a PPA, the third party investor will require the Council to agree to purchase all, or a proportion of, the generated solar electricity, at a discounted rate (typically around 10p/kWh). PPAs can be linked to the retail price index (RPI) or the price of retail electricity, or fixed for the entire PPA term (typically between 20 and 25 years).

Third party ownership of PV assets has the potential to fix electricity prices for the landlord's supply and reduce expenditure. It would also realise a reduction in CO_2 without any Council investment.

Solar PV financing options

LBS led 'third party' ownership models
As solar is considered to be a reliable RE technology the market for third party investment is very active and a number of models have been developed over the years to deliver solar PV projects and offer competitive PPAs. Detailed below are models where LBS could be the 'third party' by setting up a new entity to build, own and operate the solar PV asset(s).

Energy Supply Company (ESCO) - a commercial structure created to produce, supply and manage the local delivery of decentralised energy directly to LBS via a private wire agreement. As a supplier of electricity, ESCOs are required to register and meet the standards for quality and performance set out by Ofgem. As illustrated in Fig 4 'Licence Lite' is a simplified method of applying for a licence to supply electricity. It requires licensees to partner with an existing third party licensed supplier to manage the obligation for code compliance (the costlier and more technically challenging parts of a supply licence) as set out by the regulator Ofgem.

Special purpose vehicles (SPVs) – Since 2017, solar PV systems on non-domestic buildings can potentially attract an increase in business rates. As a result it has become common practice for owners of non-domestic systems to set up a SPV as a separate legal entity to take ownership of the installed system. The SPV then acts as a thirty party owner passing on the financial benefit of solar generated electricity through a PPA.

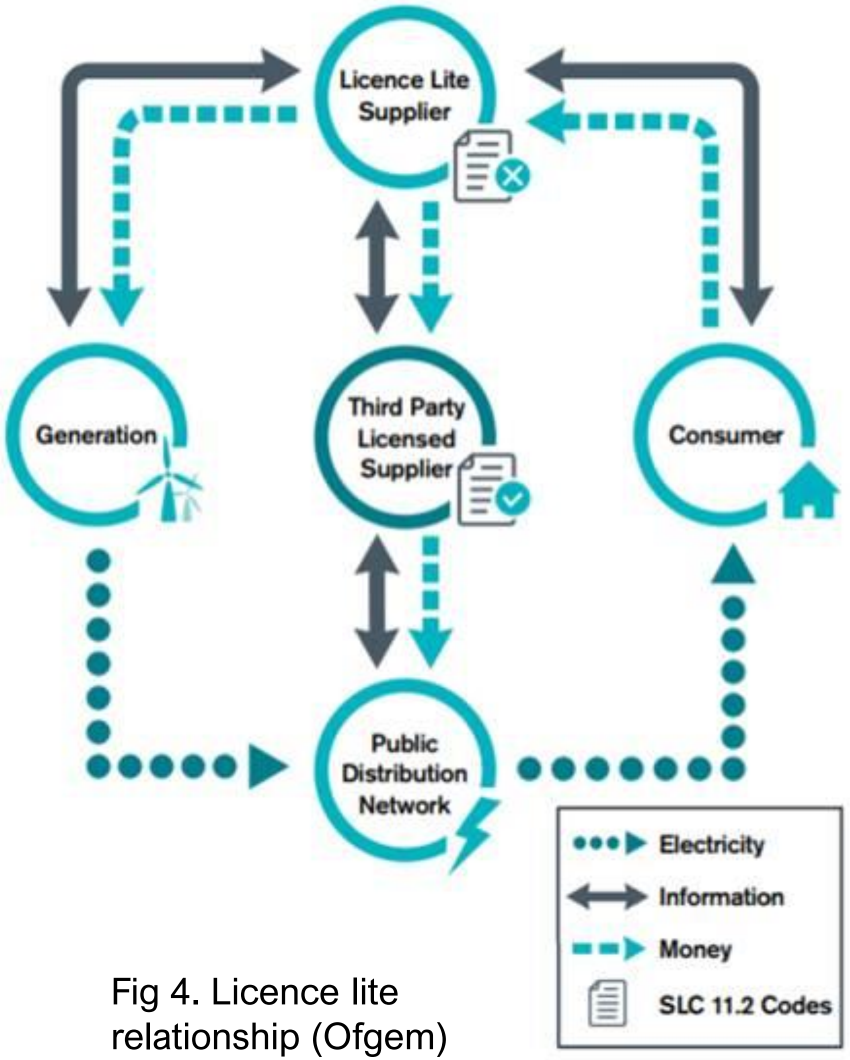

Fig 4. Licence lite relationship (Ofgem)

Solar PV financing options

Other business models

In addition to the traditional third party ownership model offered by many solar developers and investors (i.e. hedge funds etc.), there are also opportunities to engage with other types of investor, some of which be a better 'fit' for LBS. There are also options where LBS can share the financial burden and financial benefit with select investors, or lease the PV array from a supplier.

Community Shared Ownership – As proposed for Haddonhall Estate, LBS could open all, or a proportion of, the investment up to a community share scheme. In addition to providing an above market rate return on investment (when compared to personal savings accounts), a shared ownership scheme can also provide other benefits to the community such as greater engagement and understanding of energy issues such as fuel poverty, energy efficiency and environmental choices.

Community owned RE schemes are generally either set up by third party 'community energy' organisation (a charity or community interest company), or via a community benefit society, or similar (as could be facilitated by a TMO). They also tend to be co-operatives including at least one board member from the beneficiary organization (i.e. LBS or TMO).

Traditionally, a community share offering will be launched providing a set dividend / interest rate for shares (linked to PV performance), although not normally 100% of the profit as most organisations have wider aims & objectives than just community ownership of RE. As a result it is typical for a funding pot to accumulate which can then be spent on specific initiatives, be given out through grant schemes, etc. As with all share/ crowd funding schemes the recipient organisation has to comply with FSA rules as well as being able to deliver a solar PV project. Initial shares could be offered to residents in the first instance and then extended to the wider LBS community.

Solar Lease – A few PV product suppliers now offer lease agreements where they build, own and operate a solar PV system for the full term of the lease (typically 15 years) with a performance guarantee. Instead of a PPA, LBS pay equal monthly repayments which are financed by the savings on electricity costs. The lease is structured to be cash positive in year 1, for the full term. Similar to a Personal Contract Purchase (PCP) agreement there is an option for LBS to purchase the system at the end of the term at it's current value (a small proportion of it's original value) and operate it for the remaining 10+ years of it's life.

Solar PV financing options

SWOT analysis of common PV delivery models

A Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis of the PV delivery models discussed previously (i.e. self-funded, third party ownership and community ownership models) are explored below to allow LBS to consider and compare the varying approaches.

The access and/or availability of project finance, in–house knowledge and expertise, the Council's approach to financial risk / reward, and level of community desire are all likely to be of critical importance in establishing which delivery model is preferred for any individual organisation.

Self-funded

STRENGTHS

- Procurement processes already in place;
- Can set/define quality standards;
- Increased control;
- Appoint one contractor;
- LBS will own all equipment.

WEAKNESSES

- Likelihood of sub-contractors being used to aid delivery;
- Securing funding / repayment terms;
- Complexity of delivering projects / framework.

OPPORTUNITIES

- Offer best financial returns (electricity savings etc.);
- Most flexibility for implementing innovative approaches;
- Can maximise the economies of scale.

THREATS

- Long process / procurement timeline;
- May have limited technical capability in-house?;
- Risk of poor or expensive tenders;
- Risk of poor management of the contract.

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SWOT analysis of third party ownership model

Third party

STRENGTHS

- Least financial burden (but also lower potential reward);
- No / reduced time and money input required by LBS;
- Most simple solution for PV deployment;
- LBS realise additional benefits (perception of being green).

WEAKNESSES

- Establishing legal terms and contracts;
- Overall revenue savings considerably less;
- Less control over quality (equipment/labour);
- Systems will be scaled to suit the third party developer & LBS may lose opportunity to maximise carbon reductions;
- May restrict future PV developments

OPPORTUNITIES

- Can mobilise PV capacity quickly;
- Fixed energy prices for terms of contract;
- Could end up owning PV system / liability at end of contract term.

THREATS

- Quality control measures need to be put in place;
- Need to consider the long term risks of signing a PPA agreement and leasing roof spaces;
- If the utilisation factor reduces there may be contractual penalties;
- Additional considerations / cost when re-roofing, extending or refurbishing buildings.
- Potential increased insurance requirements

Solar PV financing options

SWOT analysis of community ownership model

Community

STRENGTHS Supporting communities; Perceived community benefit; Can lead to other added value e.g. re-investment into community infrastructure (fuel poverty etc.); Potential for good 'rate of return' for community investors.	**WEAKNESSES** Establishing legal terms and contracts; Difficult to get off the ground / hand-holding required; Current (and future) capability / willingness of community group? Long development timescales; Attracting sufficient investors and FSA rules; LBS input required and potentially administratively heavy.
OPPORTUNITIES Positive change; Create local employment? LBS realise additional benefits (perception of being green).	**THREATS** Keeping momentum going; Risk of not raising funds.

Solar PV financing options

Feed-in-Tariff preliminary accreditation

Feed-in-Tariff (FIT) preliminary accreditation (PA) is available to any solar PV systems with an installed capacity of >50kW and up to a 50MW. PA can lock the proposed PV installation into the current FIT for a period of 12 months (for community or school installations only, 6 months for all other applicants[1]) from the date the application is submitted to Ofgem as long as there is available capacity with the deployment band (i.e. PV >50kW). For Q1 2019 (the final quarter when the FIT is available) the deployment cap is 19.4MW plus any surplus capacity from previous quarters (currently estimated to be ~22.6MW). With current rates of deployment it is likely that any successful PA submitted before 1st April 2019 will be eligible and locked into the current applicable FIT rate (detailed in Table 5) and export tariff of 5.24p/kWh.

Description	Total Installed Capacity (kW)	Tariff (p/kWh)
Standard Solar photovoltaic receiving the higher rate	0-10	3.79
	10-50	4.03
	50-250	1.69
Standard solar photovoltaic receiving the middle rate	0-10	3.41
	10-50	3.63
	50-250	1.52
Standard solar photovoltaic receiving the lower rate	0-10	0.15
	10-50	0.15
	50-250	0.15
Standard large solar photovoltaic	250-1000	1.33
	1000-5000	0.15

Table 5. FIT rates 2019 (Ofgem, 2019)

All other terms and conditions relating to the FIT remain the same (i.e. 20-year eligibility period from FIT application, tariffs retail price index (RPI) linked increasing every April).

Typically, PA applications take approximately 12 weeks to be processed by Ofgem. The following information is required as part of the PA:

- Total installed capacity (TIC) and declared net capacity (DNC).
- Installation location.
- Planning permission evidence – typically either a planning decision notice or permitted development notice which can take up to 12 weeks.
- Information about any other PV systems installed on site.
- Details of any grants to be used to purchase or install the PV system.
- Grid connection agreement from the local distribution network operator (DNO) – as the installation is likely to be completed until after the 27th April 2019, a G99 application will need to be submitted to UK Power Networks (UKPN). Typically, UKPN will provide a response to grid connection applications within 2 weeks.
- Schematic of the proposed PV system.

[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/765647/FIT_Closure_Government_Response.pdf

Solar PV financing options

Pre-registration for community energy installations

This is an additional process that verifies the status of a ‘community organisation’ and allows relaxation of the minimum energy efficiency requirement for the FIT as detailed in Table 5, where the higher rate tariff is payable regardless of the Energy Performance Certificate (EPC) rating of non-domestic properties[1]. A ‘community organisation’ is considered to be a charity; a subsidiary, wholly owned by a charity; a community benefit or co-operative society; or a community interest company.

An EPC of D or above is required to obtain the higher rate tariff. All properties with less than an EPC of D will only be eligible for the lower rate tariff. The middle tariff is for owners of more than 25 individual installations. There is potential that the communal areas of the blocks of flats are considered as a) non-domestic and b) EPC exempt, however this is down to the interpretation of the commissioned EPC assessor of the EPC exemption rules.

The pre-registration process requires the following documents:

- Evidence to demonstrate the applicant’s community organisation status
- A non-domestic EPC
- An application letter, containing the following information:
    - Confirmation of what benefit is being applied for and the technology to be used.
    - Type of community organisation.
    - Whether the community organisation employs 50 employees or fewer.
    - Proposed capacity (TIC and DNC) of the installation.
    - Address of the community organisation.
    - Address & MPAN of the building to which the installation is connected.
    - Information regarding the EPC.
    - Declaration of application.

[1] https://www.ofgem.gov.uk/environmental-programmes/fit/applicants/benefits-communities-and-schools

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Solar PV financing options

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Pre-accreditation of community energy (using existing or new TMO-led community energy organisations) projects prior to 31st March 2019 potentially allow access to two guaranteed income streams (namely FIT and export tariff). An example of a community funded business model with PPA has been detailed for Juniper House and presented in Table 9.

It is understood that LBS own all of the estate buildings considered in this study. Consideration should also be given to the following points regardless of the ownership of the solar PV system.

Business rates

In 2017, business rates for non-domestic properties were revised to include rooftop solar PV systems. There are two valuation methods that are defined by whether the electricity generated is intended ‘mainly for export’ or whether it is ‘mainly for self-consumption’. It is possible for owners of rooftop solar to qualify for the considerably lower ‘mainly export’ business rates by changing their legal relationship with their rooftop solar so that, in effect, they ‘mainly export’ their solar power to themselves. In addition, community owned (or part owned) systems can attract up to 100% relief.

Roof leasing structures and terms

In the event that the Council enters in to a contractual arrangement with a third party investor (TMO, community, or other), it is critical that all lease agreements and PPAs provide the Council with the guarantee of providing a well installed, maintained, fit for purpose, high quality system that has the capability to provide the level of generation specified in the PPA for the full term of the agreement and which has the provision to mitigate any risk to the Council’s asset and operation. Independent legal advice should be obtained in all leasing structures and terms.

Insurance

Insurers require notification of the addition of a solar PV system to a building. Generally, insurers will review the building’s sum insured and assess the risk to the building of the PV addition. These considerations could lead to insurers charging additional premiums and/or imposing special terms by way of cover restrictions or exclusions.

Building Standards

All solar PV systems serving a building must comply with the requirements of the Building Regulations 2010, as amended.

Building a better world together

3. Juniper House solar PV feasibility study

Juniper House solar PV feasibility study

Description

Juniper House is made up of a single 5 storey 'L' shaped block, comprising 75 deck accessed flats (as shown in Fig 5). A single room Community Office occupies flat 50A on the ground floor of the north eastern corner of the block. There is a mix of stock in the building, 61 of the flats are leased from the Council, the remaining 14 are privately owned. All tenants and leaseholders pay a service charge of which a portion contributes towards communal energy costs.

Until recently the block was managed by Juniper House Tenant Management Community (TMC) Limited, a community run cooperative. The operation has now been handed back to the Council and is in the process of being setup as a TMO.

The tenants have presented some options for a solar PV system plus battery to LBS with the aim of funding the system(s) with reserves from Juniper House TMC.

There are three key influencing factors to the specification of an appropriate sized PV system for Juniper House, these are:

1. Facilitation and cost of roof access for installation and maintenance – in order to keep costs down, it would be advantageous to install a solar PV system at a time when other maintenance requiring scaffolding is being completed. Consideration also needs to be given to the ongoing access to the PV system for inspection and maintenance.
2. Offsetting on-site consumption - there are three metering points on the ground floor at Juniper House (detailed on Fig ?), the electricity consumption varies across each of the connections.
3. Shading – the chimneys (which are only used for ventilation) on the south and west aspects of the roof cause significant shading and could potentially be removed and replaced with roof level vents to make installation easier.

Fig 5. Location of electricity meters at Juniper House

Juniper House solar PV feasibility study

Description continued

The roofing system at Juniper House is terracotta tiles (as shown in Fig 6) mounted to battens and sarking. Additional cost may be incurred during the installation process from accidental breakage of tiles. The 45° pitched roof is a standard construction timber-framed trussed roof. An assessment will need to be made by a structural surveyor to ensure the suitability of the roof construction to take the loading imposed by a PV system.

Two arrays are considered to provide the most benefit to meet the landlord energy demands, a solar PV array on the south facing roof and/or an array on the east facing roof. Both present installation challenges and compromises on performance.

Fig 6. Terracotta roof tiles at Juniper House

Other energy options for Juniper House

Due to the limited number of communal energy requirements at Juniper House, there is limited opportunities to reduce the landlords energy costs. Replacing the current compact fluorescent lamp (CFL) luminaires for energy efficient LEDs, could significantly reduce the electricity consumption at Juniper House. Motion detectors on communal lighting could also reduce electricity consumption. Reducing energy consumption should be priortised ahead of installation of renewable energy technologies.

Other carbon options for Juniper House

It is understood that LBS are committed to reducing carbon emissions across the Council. Due to the increase in renewable electricity generation connected to the UK distribution network, the carbon emission factors of grid electricity is reducing year after year. Transferring over to a renewable only electricity tariff, will deliver carbon reductions but will not reduce on going landlord costs for tenants and leaseholders.

Headline energy consumption figures

Juniper House only has communal electrical loads, namely lighting and lift operation. Based on the electricity readings taken during the site survey and historical estimated electricity bill data provided by LBS, electricity consumption has been estimated for 2018 and is detailed in Table 6. Two out of the three meters for Juniper House are on day/ night tariffs.

Meter location	Juniper House Intake 1 (1-25)	Juniper House Intake 2 (26-50)	Juniper House Intake 3 (51-75)
Estimated 2018 electricity consumption – TOTAL (kWh)	17,305	9,105	8,244
Estimated 2018 electricity consumption – DAY (kWh)		3,241	4,669
Estimated 2018 electricity consumption – NIGHT (kWh)		5,864	3,574
Current tariff (p/kWh) DAY/ NIGHT	10.582	11.370/ 7.621	9.183/ 7.581
Estimated annual electricity cost* (£)	1,831.22	815.40	699.70

Table 6. Summary of annual electricity consumption and cost at Juniper House
* Excluding any additional charging components (i.e. Climate Change Levy, standing charges etc.)

As it can be seen from Table 6, each of the intakes at Juniper House vary in their electricity consumption, in both scale and split between night and day. It should be noted that the lift at intake 3 has not been operational in 2018 and may be the reason for the lower electricity usage. In addition the lift at intake 1 is the closest to the street entrance and therefore may be utilised more often than the others. Without further metering/ energy monitoring it is not possible to examine the energy usage of loads in more detail. There is variation in the tariffs paid by LBS, so there may be an opportunity to negotiate a more cost effective electricity tariff for the building as a whole.

Juniper House solar PV feasibility study

PV array layout – south facing roof

Advantages of this location include:

- South facing arrays deliver the most efficient PV performance.

Disadvantages of this location include:

- Chimneys will shade some modules.
- Intake 3 has the lowest electricity consumption and connection to other intakes will involve lengthy cable runs.
- Roof access from 5th floor stairwell is on the north aspect of the roof so is not suitable for access.
- Complicated and costly roof access for installation and maintenance.
- Trees will need to be managed to limit shading.

As shown in Fig 7, in order to reduce most of the effects of shading from the chimneys, a 56 module system (~15.4kWp) could be installed.

Chimneys act as a shading sundial with modules to the west of chimneys shaded in the morning and those to the east shaded in the afternoon. Typically, the arrays are not shaded at all from mid-morning to mid-afternoon in this layout i.e. during peak generation times. Using DC optimisers or micro inverters will yield the best results, whereas the use of string inverters may reduce generation by approximately 20% over the year.

If the chimneys were removed the installed capacity could be increased by approximately one third (~23.1kWp).

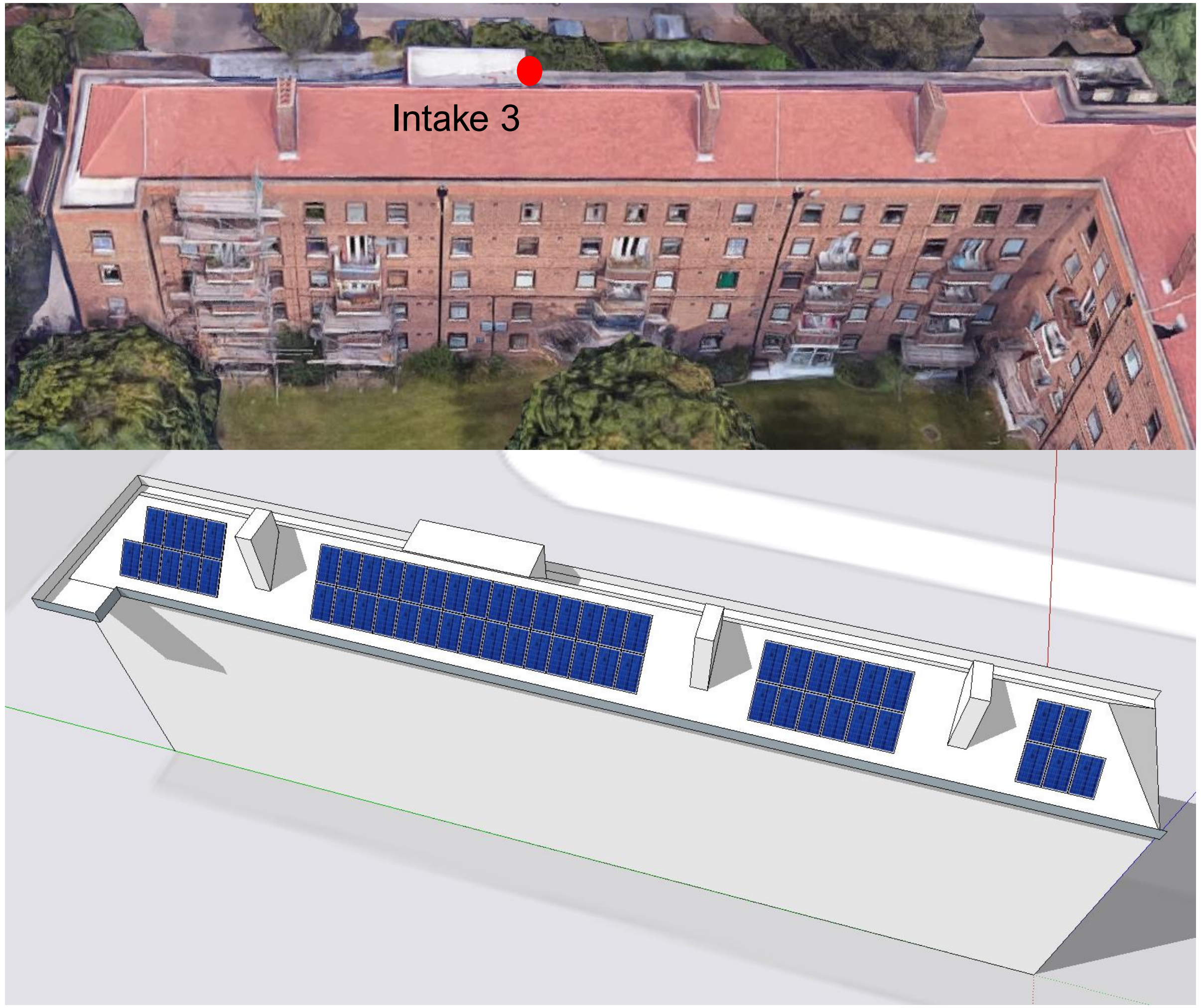

Fig 7. Potential for PV on south facing roof of Juniper House

Juniper House solar PV feasibility study

PV array layout – east facing roof

Advantages of this location include:

- Intake 1 & 2 have the highest electricity consumption, representing shorter cable runs.
- Scaffolding access may be able to be installed on 5th floor balcony reducing costs.
- Shading can mainly be avoided/ managed.
- Roof access is available on the same side of the PV array, although a lanyard system will need to be installed for safe working at heights.

Disadvantages of this location include:

- Typically a non-shaded east facing array performance will be approximately 7% less than a south facing array.

As shown in Fig 8, an 84 module system (~23.1kWp) could be installed on the east facing roof.

The array has been located slightly higher up the roof to avoid shading from the boiler flues and parapet wall situated along the lower edge of the roof. The chimneys on the west side of the roof protrude above the ridge and can cause shade on the PV array in the afternoon. The use of DC optimisers or micro inverters will mitigate any shading issues.

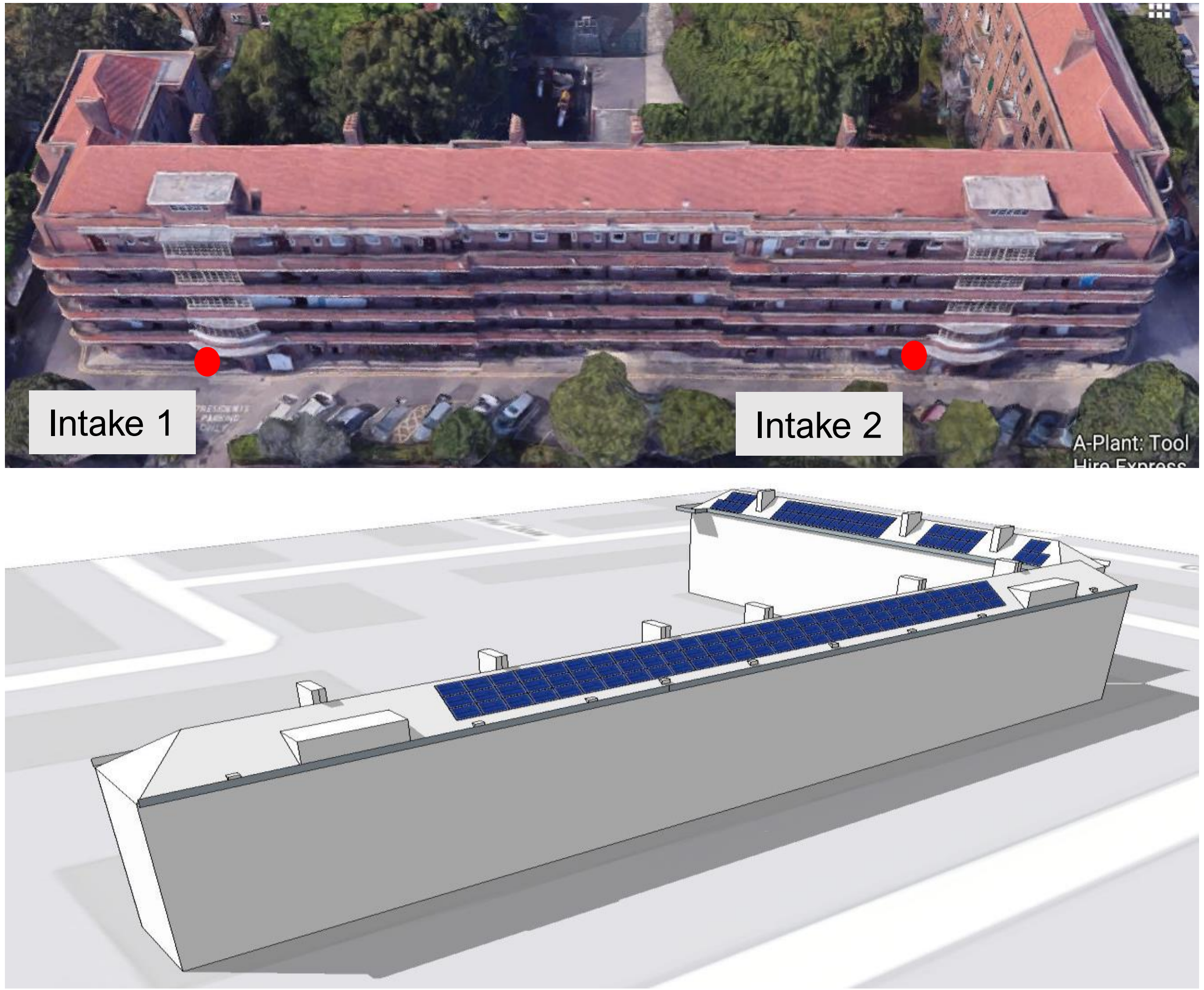

Fig 8. Potential for PV on east facing roof of Juniper House

Juniper House solar PV feasibility study

Comparison of PV only options

In order to assess the viability of the solar PV options presented, the key information from each system has been compared in Table 7.

	Maximum south facing array with chimneys	Optimised self-consumption south facing array	Maximum east facing array	Optimised self-consumption east facing array
No. of modules	56	24	84	63
PV capacity (kWp)	15.4	6.6	23.1	17.3
kWh/kWp yield*	980	980	751	751
Est. annual output (kWh/yr)	15,092	6,648	17,348	13,011
Connection points	Intake 3 and 2	Intake 3 and 2	Intake 1 & 2	Intake 1 & 2
Estimated utilisation factor	47%	100%	75%	99%
Grid electricity offset (kWh/yr)	7,119	6,648	12,976	12,976
Cost savings (£/yr)	733	668	1,428	1,412
Potential added revenue** (£/yr)	419	0	227	7
CO_2 savings*** (tonnes CO_{2e}/yr)	4,272	1,831	4,911	3,678
Est. installation cost**** (£)	31,820	24,780	37,980	33,340
Est. installed £/kWp	2,066	3,754	1,644	1,927

Table 7. Modelled retrofit solar PV systems for Juniper House

* Based on Microgeneration Certification Scheme Standard Estimation Method kWh/kWp tables (MCS, 2012)

** Based on current export tariff rates of 5.24p/kWh (moving to Smart Export Guarantee from March 2019)

*** Based on UK Government GHG Conversion Factors for Company Reporting 2018 UK electricity (1kWh = 0.28307 $kgCO_{2e}$).

**** Based on current market rates of £800/kWp + estimated scaffolding costs based on proposed system costs provided by LBS

Juniper House solar PV feasibility study

Comparison of PV plus storage options

LBS are interested in exploring the benefit that energy storage can bring to any potential PV system. Battery storage systems suitably sized for the landlords electricity consumption (i.e. maximising utilization factor to 95%) have been modelled based on the information included in Table 7 and are presented in Table 8.

	Maximum south facing array with chimneys	Optimised self-consumption south facing array	Maximum east facing array	Optimised self-consumption east facing array
PV capacity (kWp)	15.4	6.6	23.1	17.3
Est. annual output (kWh/yr)	15,092	6,648	17,348	13,011
Battery usable capacity (kWh)	45	20	70	52
Estimated utilisation factor	95%	95%	95%	95%
Grid electricity offset (kWh/yr)	14,337	6,316	16,480	12,360
Cost savings (£/yr)	1,481	635	1,809	1,355
Potential added revenue** (£/yr)	40	17	45	34
CO_2 savings*** (tonnes CO_{2e}/yr)	4,272	1,831	4,911	3,678
Est. installation cost**** (£)	58,820	36,780	86,500	56,300

Table 8. Modelled retrofit solar PV and storage systems for Juniper House

* Based on higher band Feed in Tariff Rates up to 31/3/19, assuming landlords supply will be EPC exempt

** Based on current export tariff rates of 5.24p/kWh (moving to Smart Export Guarantee from March 2019)

*** Based on UK Government GHG Conversion Factors for Company Reporting 2018 UK electricity (1kWh = 0.28307 kgCO_{2e}).

**** Based on current market rates of £800/kWp for solar and £600/kWh for battery + estimated scaffolding costs based on proposed system costs provided by LBS

Comparison of community ownership model

It is considered that in order for a PV project to secure the income stream guaranteed by the existing FIT and Export Tariff than the project will need to be funded by a community energy entity (whether TMO-led or an existing community energy organization) and complete the pre-accreditation and pre-application process discussed in Section 2 before 31st March 2019, with installation being completed before 31st March 2020.

A financial analysis has been completed on the different scenarios presented within this report, including a system cost excluding scaffolding costs to demonstrate the impact of these costs on project viability. The results are detailed in Table 9. The scenarios modelled are as follows:

1. PV only – 15.4kWp south facing solar PV array (with estimated scaffolding costs)
2. PV only – 15.4kWp south facing solar PV array (excluding estimated scaffolding costs)
3. PV + battery – 15.4kWp south facing solar PV array (with estimated scaffolding costs)
4. PV only – 6.6kWp south facing solar PV array (with estimated scaffolding costs)
5. PV only – 6.6kWp south facing solar PV array (excluding estimated scaffolding costs)
6. PV + battery – 6.6kWp south facing solar PV array (with estimated scaffolding costs)
7. PV only – 23.1kWp east facing solar PV array (with estimated scaffolding costs)
8. PV only – 23.1kWp east facing solar PV array (excluding estimated scaffolding costs)
9. PV + battery – 23.1kWp east facing solar PV array (with estimated scaffolding costs)
10. PV only – 17.3kWp east facing solar PV array (with estimated scaffolding costs)
11. PV only – 17.3kWp east facing solar PV array (excluding estimated scaffolding costs)
12. PV + battery – 17.31kWp east facing solar PV array (with estimated scaffolding costs)

A copy of the calculations and assumptions made are provided in Appendix A. A borrowing rate of 3% has been set on the assumption that the community energy group will be looking to repay community investors a dividend. The cost of inverter replacement on PV + battery scenarios also includes the cost of replacement batteries at year 12.

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Juniper House solar PV feasibility study

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	Grid electricity cost savings* (£/yr)	Estimated FIT revenue** (£/yr)	Estimated export tariff revenue*** (£/yr)	Total annual financial benefit (£/yr)	Payback in years	Internal rate of return (%)	Net present value (£)	CO_2 savings**** (tonnes CO_{2e}/yr)
Scenario 1	733	608	419	1,760	19	<0	-4,520	4,272
Scenario 2	733	608	419	1,760	8	7	14,406	4,272
Scenario 3	1,481	608	40	2,129	25+	<0	-42,217	4,272
Scenario 4	668	245	0	913	25+	<0	-9,871	1,831
Scenario 5	668	245	0	913	6	14	9,058	1,831
Scenario 6	635	245	17	897	25+	<0	-29,996	1,831
Scenario 7	1,428	699	227	2,354	17	<0	-1,624	4,911
Scenario 8	1,428	699	227	2,354	8	7	17,305	4,911
Scenario 9	1,809	699	45	2,554	25+	<0	-73,625	4,911
Scenario 10	1,412	524	7	1,924	18	<0	-2,743	3,678
Scenario 11	1,412	524	7	1,924	7	10	16,184	3,678
Scenario 12	1,355	524	34	1,912	25+	<0	-46,850	3,678

Table 9. Estimated total potential benefit of retrofit solar PV and storage system scenarios for Juniper House

* Savings based on average electricity tariffs charged for metered connection points of system.
** Based on higher band Feed in Tariff Rates up to 31/3/19, assuming landlords supply will be EPC exempt
*** Based on current export tariff rates of 5.24p/kWh (moving to Smart Export Guarantee from March 2019)
*** Based on UK Government GHG Conversion Factors for Company Reporting 2018 UK electricity (1kWh = 0.28307 $kgCO_{2e}$).

Juniper House solar PV feasibility study

Conclusion

There is significant variation in loads between the 3 intakes at Juniper House, with intake 1 consuming approximately twice as much as the other intakes. Half hourly metering or further monitoring of loads will help understand the electricity consumption in more detail and will support more accurate PV and battery system modelling. An LED retrofit scheme will deliver instant energy savings for the landlords supply, reducing costs to tenants and leaseholders. Transferring onto a renewable electricity tariff will also deliver carbon savings without any capital expenditure.

The cost of access equipment (i.e. scaffolding) to install and maintain a solar PV system is the biggest influencing factor on a solar PV installation at Juniper House. With the information provided it is estimated that the project costs far outweigh any financial benefit seen from offset electricity costs and (if available) income derived from exporting surplus electricity to the grid. Access equipment costs for the solar PV scenarios have been based on an estimate provided to LBS and should be investigated in more detail. Installing a PV system at a time when access equipment is required for other maintenance will make a significant difference to the business case.

An assessment should be made to check whether the roof structure is capable of withstanding the loads of a PV array. Requirements for structural reinforcements could add additional cost to a solar PV project.

High level modelling has been completed for eight different system options, namely, south and east facing scenarios for both PV only and PV + battery for a maximized system and an optimised system for increasing self-consumption. Based on the information provided, the inclusion of a battery with a PV system that is optimised for daytime electricity consumption does not improve financial performance of the system. Solar on both the south (9.7kW) and west (27.5kW) roof and inclusion of energy storage has the potential to cover all electricity requirements for Juniper House. The cost of battery systems are continually reducing and this option may become more cost effective in the future.

Although an east facing array will deliver approximately 7% less generated electricity than a south facing array, the potential for reduced cost of access equipment, easier access for maintenance and less shading issues, make a solar PV array on the east facing roof a better option for Juniper House. Without a guaranteed export tariff after March 2019 there is no benefit to LBS, or the tenants, to install a PV system that generates more electricity than the daytime consumption of Juniper House.

Building a better world together

4. Haddonhall Estate solar PV feasibility study

Haddonhall Estate solar PV feasibility study

Description

Haddonhall Estate (outlined in Fig 9) is made up of a mixture of 3 storey low rise blocks and houses. The Estate Office occupies a single storey building adjacent to Rephedim Street block and the Community Centre. There is a mix of stock across the buildings;

- 1-12 Thornham House – 9 tenanted, 3 leasehold
- 1-42 Potier Street – 17 tenanted 25 leasehold
- 269-279 Tabard Street – 5 tenanted, 1 leasehold
- 1-24 Prioress St – 14 tenanted, 10 leasehold
- 6-11 Green Walk – 18 tenanted, 3 leasehold
- 2-55 Rothsay St – 11 tenanted, 7 leasehold, 15 freehold houses
- 12-75 Rephidim St – 23 tenanted, 3 leasehold
- 30-34 Wilds Rents – 4 tenanted houses, 1 freehold house

All tenants and leaseholders pay a service charge of which a portion contributes towards communal energy costs. Only the low rise blocks, Community Centre and TMO Office have landlord supplies, therefore the houses in Rothsay Street and Wild Rents have note been included in this study.

A local community energy organization, South East London Community Energy (SELCE), has approached LBS to install 6 community funded solar PV arrays on some of the Haddonhall Estate buildings and enter in to a contract with LBS to sell the electricity to the TMO/ LBS under a power purchase agreement (PPA) at a rate that is a lower rate than is currently being paid. In order for this business case to work SELCE require to apply for pre-accreditation for the systems, in order to secure a feed-in-tariff and export tariff post March 2019.

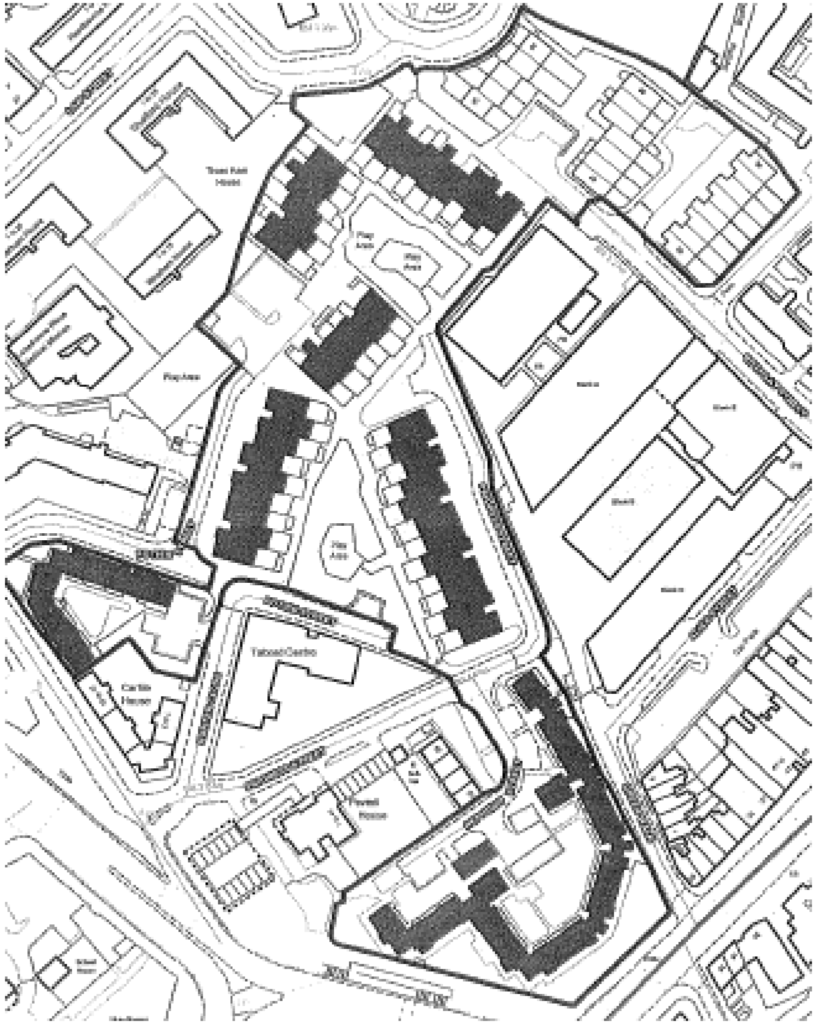

Fig 9. Buildings included in the Haddonhall estate

Haddonhall Estate solar PV feasibility study

Description continued

The 3 storey low rise blocks are of traditional construction with pitched slate roofs. Prioress Street, Rothsay Street, Thornham House and 13-42 Potier Street have communal stairwells that open out to a third floor deck (as shown in Fig 10). The communal areas of the other buildings are all enclosed. Lighting is the only communal energy use on the estate outside the Estate Office and Community Centre.

An assessment will need to be made by a structural surveyor to ensure the suitability of the roofs constructions to take the loading imposed by any proposed PV systems.

There is a significant amount of large trees (some with Tree Preservation Orders) around the Haddonhall estate that have made some of the estate roofs unviable for PV due to shading. A detailed shading analysis has not been completed for the proposed PV arrays.

Other energy options for Haddonhall Estate

Due to the limited communal energy requirements at Haddonhall, there is limited opportunities to reduce the landlord's energy costs. It is understood that the TMO has already started an LED replacement scheme which will significantly reduce the electricity consumption at Haddonhall. Motion detectors on communal lighting may also further reduce electricity consumption. Reducing energy consumption should be priortised ahead of installation of renewable energy technologies, however this may have a significant impact on SELCE's business case.

Access to the district heating boiler was not possible during the site survey, however further investigation should be completed to assess whether there is an option to upgrade the communal heating scheme to incorporate a combined heat and power (CHP) unit. CHP has the potential to deliver both heat to the district heating circuit and generate electricity for the landlords supply and potentially residents as well, however this may not be viable due to low electricity consumption.

Fig 10. Example of low rise block at Haddonhall

Haddonhall Estate solar PV feasibility study

Headline energy consumption figures

Haddonhall has communal electrical and heating loads, however the heating loads are only present in the Estate Office and Community Centre and are directly fed from the existing communal heating system. Based on the electricity readings taken during the site survey and historical estimated electricity bill data provided by LBS and the TMO, electricity consumption has been estimated for 2018 (where data is available) and is detailed in Table 10 (over 2 pages). All properties are currently on day/ night tariffs. Overall electricity consumption is low across the estate.

Meter location	Estimated 2018 electricity consumption – TOTAL (kWh)	Estimated 2018 electricity consumption – DAY (kWh)	Estimated 2018 electricity consumption – NIGHT (kWh)	Current tariff (p/kWh) DAY/ NIGHT	Estimated annual electricity cost (£)
6-11 Green Walk	2,052	1,332	720	24.285/ 10.08	396.05
12-20 Rephidim Street	3,348	2,100	1,248	24.285/ 10.08	635.78
21-26 Rephidim Street	684	552	132	24.285/ 10.08	147.36
50-57 Rephidim Street	2,112	1,212	900	24.285/ 10.08	385.05
58-63 Rephidim Street				24.285/ 10.08	
64-69 Rephidim Street	2,796	1,532	1,264	24.285/ 10.08	499.46
70-75 Rephidim Street	2,580	1,564	1,016	24.285/ 10.08	482.23
1-6 Prioress Street	1,316	496	820	24.285/ 10.08	203.11
7-12 Prioress Street	1,040	692	348	24.285/ 10.08	203.13
13-18 Prioress Street	468	144	324	24.285/ 10.08	67.63
19-24 Prioress Street	1,872	1,656	216	24.285/ 10.08	423.93

Haddonhall Estate solar PV feasibility study

Meter location	Estimated 2018 electricity consumption – TOTAL (kWh)	Estimated 2018 electricity consumption – DAY (kWh)	Estimated 2018 electricity consumption – NIGHT (kWh)	Current tariff (p/kWh) DAY/ NIGHT	Estimated annual electricity cost (£)
1-6 Potier Street				24.285/ 10.08	
7-12 Potier Street				24.285/ 10.08	
13-18 Potier Street	1,084	488	60.08	24.285/ 10.08	178.59
19-24 Potier Street	392	216	17.74	24.285/ 10.08	70.20
25-30 Potier Street	1,496	696	80.64	24.285/ 10.08	249.66
31-36 Potier Street	1,304	708	60.08	24.285/ 10.08	232.01
37-42 Potier Street	1,428	620	81.45	24.285/ 10.08	232.01
Boiler House Potier Street	5,828	5,828	0.00	12.229/ 7.975	712.71
269-279 Tabard Street				24.285/ 10.08	
21-31 Rothsay Street				24.285/ 10.08	
33-43 Rothsay Street	440	200	24.19	24.285/ 10.08	72.76
45-55 Rothsay Street	4,368	1560	283.05	24.285/ 10.08	661.89
1-6 Thornham House				24.285/ 10.08	
7-12 Thornham House	1,304	844	46.37	24.285/ 10.08	251.33

Table 10. Summary of annual communal electricity consumption and cost on the Haddonhall Estate

Haddonhall Estate solar PV feasibility study

Electricity consumption on Haddonhall Estate
As can be seen from Table 10 Haddonhall's electricity consumption varies from building to building. It is estimated that the total landlord's electricity consumption for 2018 is in the region of 45MWh, costing LBS/ TMO in the region of £8,000 plus standing charges etc. per year.

At present LBS only pays directly for the electricity bills for the Boiler House on Potier Street (which has an unusually higher consumption than other blocks). The remainder of the electricity bills are paid for directly by the TMO. The current tariff paid by the TMO is considered to be high and there is potential to renegotiate this tariff, or for LBS to takeover the bills and gain a better price through existing energy procurement channels.

The majority of the electrical load is communal lighting and the effect of the reduced energy consumption of LEDs fitted by the TMO can be seen in the annual electricity usage of some blocks. It is assumed that electrical consumption and expenditure will continue to reduce as LEDs are rolled out across the entire estate.

The low level and distributed electricity consumption across the Estate may make it very difficult for SELCE to develop a reasonable business case for community owned PV.

Other carbon options for Haddonhall Estate
It is understood that LBS are committed to reducing carbon emissions across the Council. Due to the increase in renewable electricity generation connected to the UK distribution network, the carbon emission factors of grid electricity is reducing year after year. Transferring over to a renewable only electricity tariff, will deliver carbon reductions but will not reduce on going landlord costs for tenants and leaseholders.

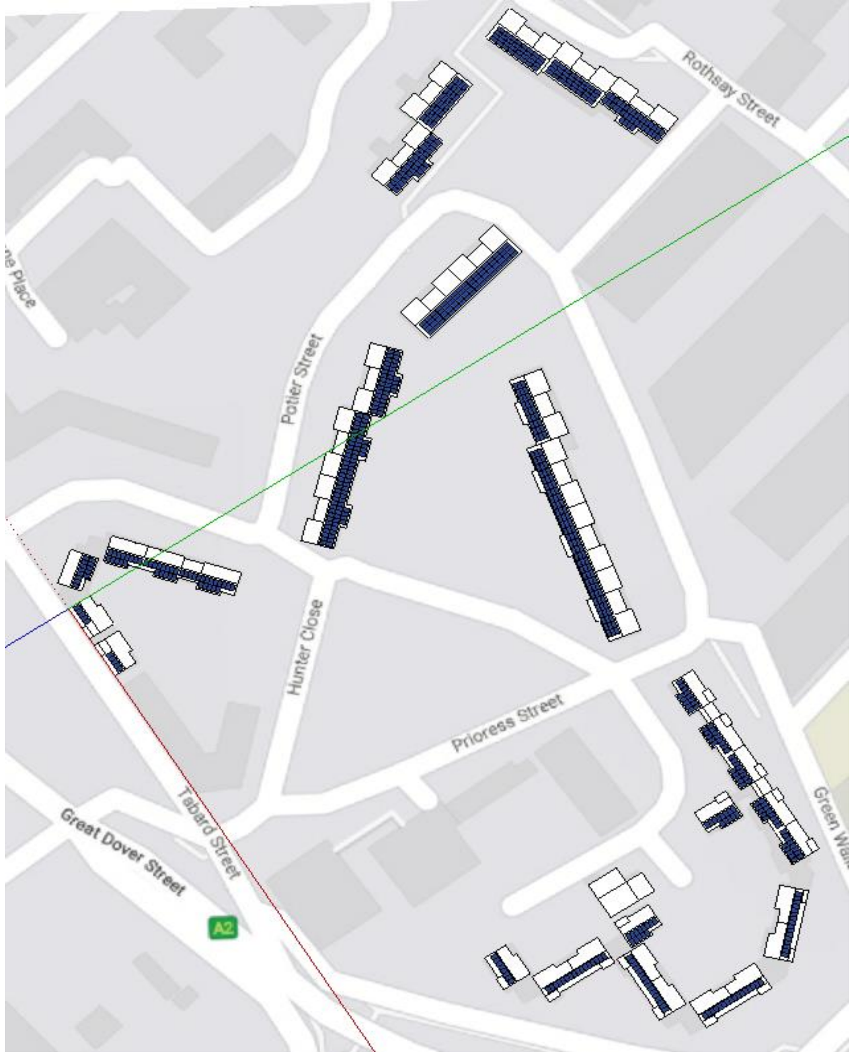

Fig 11. Solar PV layout for Haddonhall Estate

Haddonhall Estate solar PV feasibility study

Maximum potential for Haddonhall Estate

As can be seen from Table 11 there is a significant amount of roof space in the Haddonhall Estate and generation potential. A theoretical 190kWp could be installed on one aspect of each roof as shown in Fig 10, delivering nearly 3 times more energy than is required by the landlord's loads, if the arrays were unshaded.

The estate currently consumes slightly more electricity during the day than it does at night. This would lend itself well to the inclusion of energy storage. Unfortunately due to the scale of electricity consumption at each building, individual storage systems would be unviable, in addition due to the dispersed loads across the site, communal battery storage would equally not be viable at this scale.

The shading issues caused by the large amounts of trees in and around the estate would seriously impact on the majority of the arrays.

SELCE have proposed six separate arrays that are on predominantly unshaded roofs. Low requirements for on-site electricity means optimal system sizes are typically smaller than those proposed. Each system has been assessed and is discussed.

Meter location	Maximum array size (kWp)	Meter location	Maximum array size (kWp)
6-11 Green Walk	7.15	1-6 Potier Street	3.58
12-20 Rephidim Street	10.73	7-12 Potier Street	4.95
21-26 Rephidim Street	7.15	13-18 Potier Street	12.1
50-57 Rephidim Street	7.98	19-24 Potier Street	11.55
58-63 Rephidim Street	4.4	25-30 Potier Street	11.55
64-69 Rephidim Street	4.4	31-36 Potier Street	9.35
70-75 Rephidim Street	4.4	37-42 Potier Street	9.35
1-6 Prioress Street	7.43	Boiler House Potier Street	3.58
7-12 Prioress Street	7.43	269-279 Tabard Street	2.75
13-18 Prioress Street	7.43	21-31 Rothsay Street	8.8
19-24 Prioress Street	7.43	33-43 Rothsay Street	8.8
1-6 Thornham House	9.9	45-55 Rothsay Street	8.8
7-12 Thornham House	8.8	**TOTAL**	**189.79**

Table 11. Theoretical maximum rooftop solar PV at Haddonhall Estate

Haddonhall Estate solar PV feasibility study

6-11 Green Walk & 12/15/18 Rephidim Street solar PV arrays (Table 12)

The west facing aspects of these 25° pitch roofs will provide the best yield (as shown in Fig 12). Shading from the adjacent tree is considered to be minimal at present, but may require active management over time so as to not negatively impact performance.

	Maximum array	Optimised array
No. of modules	39	12
PV capacity (kWp)	10.7	3.3
kWh/kWp yield*	874	874
Est. annual output** (kWh)	9,374	2,884
Connection points	6-11 Green Walk & 12-20 Rephidim Street	
Estimated utilisation factor	29%	95%
Grid electricity offset (kWh)	2,746	2,746
Cost savings to LBS/TMO (£)	666.78	666.78
CO_2 savings*** (tonnes CO_{2e})	0.777	0.777
Est. installation cost**** (£)	11,560	5,000

Table 12. Modelled retrofit solar PV systems for Green Walk & Rephidim Street

* Based on Microgeneration Certification Scheme Standard Estimation Method kWh/kWp tables (MCS, 2012)

** Including simple shading analysis

*** Based on UK Government GHG Conversion Factors for Company Reporting 2018 UK electricity (1kWh = 0.28307 $kgCO_{2e}$).

**** Based on current market rates of £800/kWp + estimated scaffolding costs at £1,000 per block, minimum £5,000

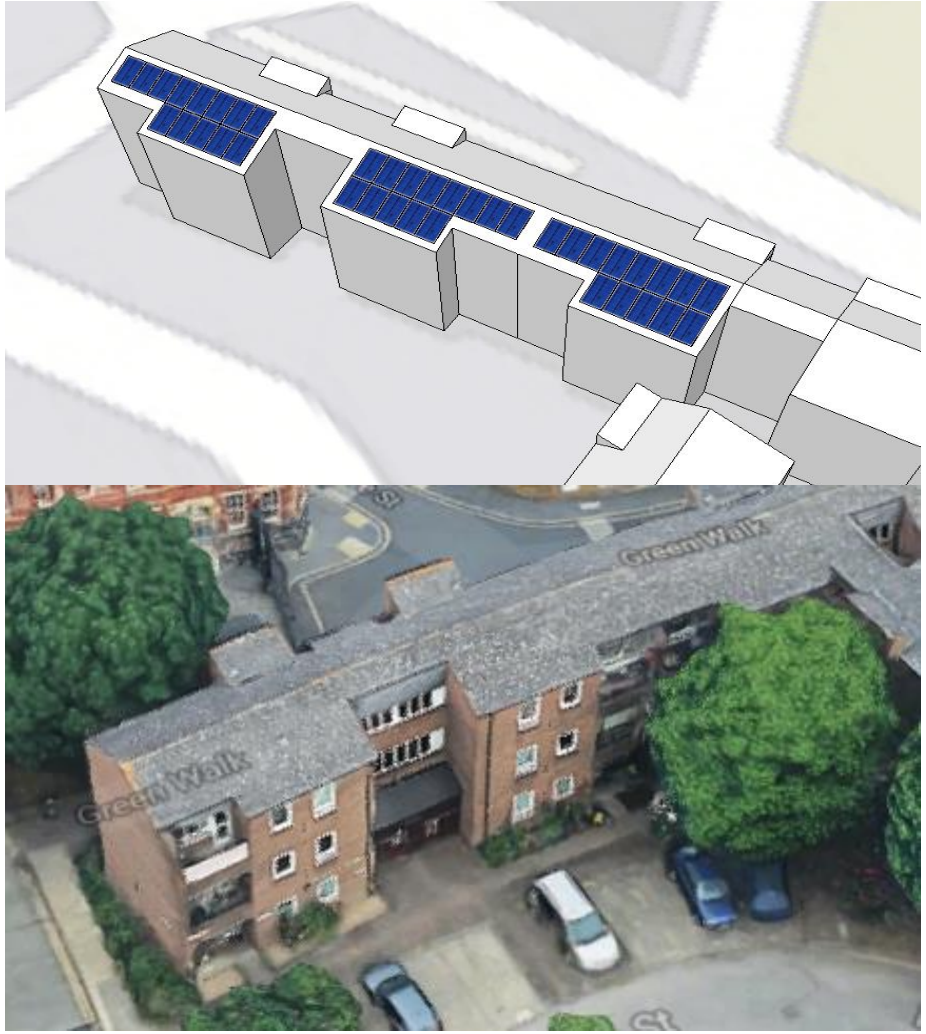

Fig 12. Solar PV layout on Green Walk/ Rephidim Street

Haddonhall Estate solar PV feasibility study

13/16/19 Rephidim Street solar PV array (Table 13)

The south-east facing aspect of this 25° pitch roof (as shown in Fig 13) receives minimal shading from the adjacent roofs, however, shading from the adjacent tree is considered to impact system performance in the afternoon.

	Maximum array	Optimised array
No. of modules	13	9
PV capacity (kWp)	3.8	2.5
kWh/kWp yield*	950	950
Est. annual output** (kWh)	3,396	2,351
Connection points	12-20 & 21-26 Rephidim Street	
Estimated utilisation factor	63%	90%
Grid electricity offset (kWh)	2,122	2,122
Cost savings to LBS/TMO (£)	515	515
CO_2 savings*** (tonnes CO_{2e})	0.601	0.601
Est. installation cost**** (£)	5,000	5,000

Table 13. Modelled retrofit solar PV systems for 13-19 Rephidim Street

* Based on Microgeneration Certification Scheme Standard Estimation Method kWh/kWp tables (MCS, 2012)

** Including simple shading analysis

*** Based on UK Government GHG Conversion Factors for Company Reporting 2018 UK electricity (1kWh = 0.28307 $kgCO_{2e}$).

**** Based on current market rates of £800/kWp + estimated scaffolding costs at £1,000 per block, minimum £5,000

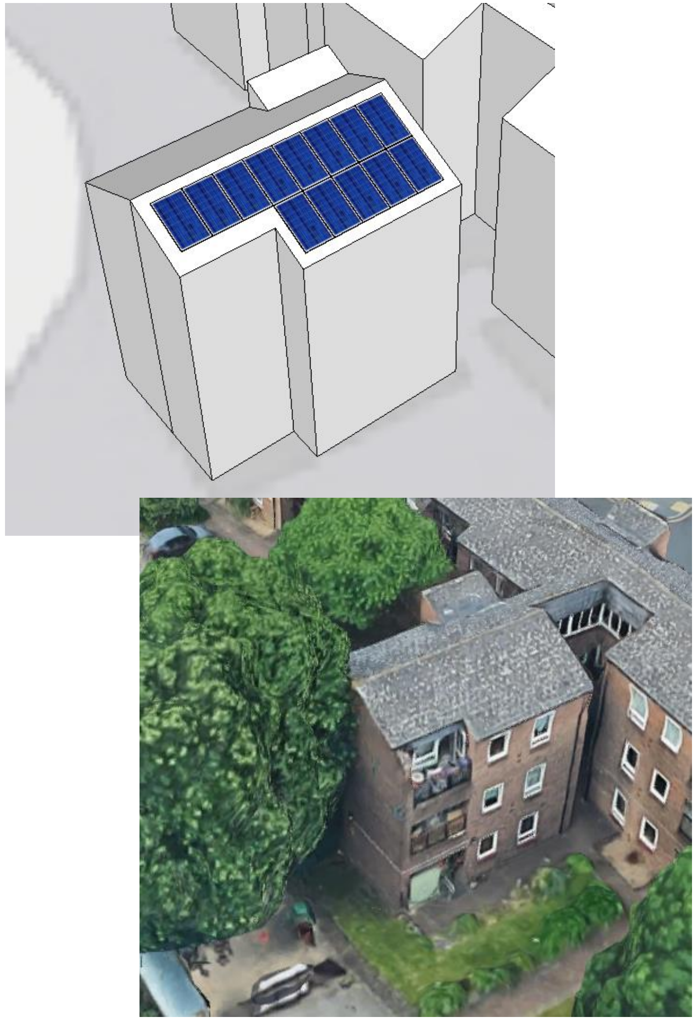

Fig 13. Solar PV layout on 13-19 Rephidim Street

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Haddonhall Estate solar PV feasibility study

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14-25 Rephidim Street solar PV array (Table 14)

The west facing aspect of this 25° pitch roof will provide the best yield (as shown in Fig 14). Shading from the adjacent tree is considered to be minimal at present, but may require active management over time so as to not negatively impact performance.

	Maximum array	Optimised array
No. of modules	26	9
PV capacity (kWp)	7.2	2.5
kWh/kWp yield*	874	874
Est. annual output** (kWh)	6,499	2,351
Connection points	12-20 & 21-26 Rephidim Street	
Estimated utilisation factor	33%	90%
Grid electricity offset (kWh)	2,122	2,122
Cost savings to LBS/TMO (£)	515	515
CO_2 savings*** (tonnes CO_{2e})	0.601	0.601
Est. installation cost**** (£)	7,760	5,000

Table 14. Modelled retrofit solar PV systems for 14-25 Rephidim Street

* Based on Microgeneration Certification Scheme Standard Estimation Method kWh/kWp tables (MCS, 2012)

** Including simple shading analysis

*** Based on UK Government GHG Conversion Factors for Company Reporting 2018 UK electricity (1kWh = 0.28307 $kgCO_{2e}$).

**** Based on current market rates of £800/kWp + estimated scaffolding costs at £1,000 per block, minimum £5,000

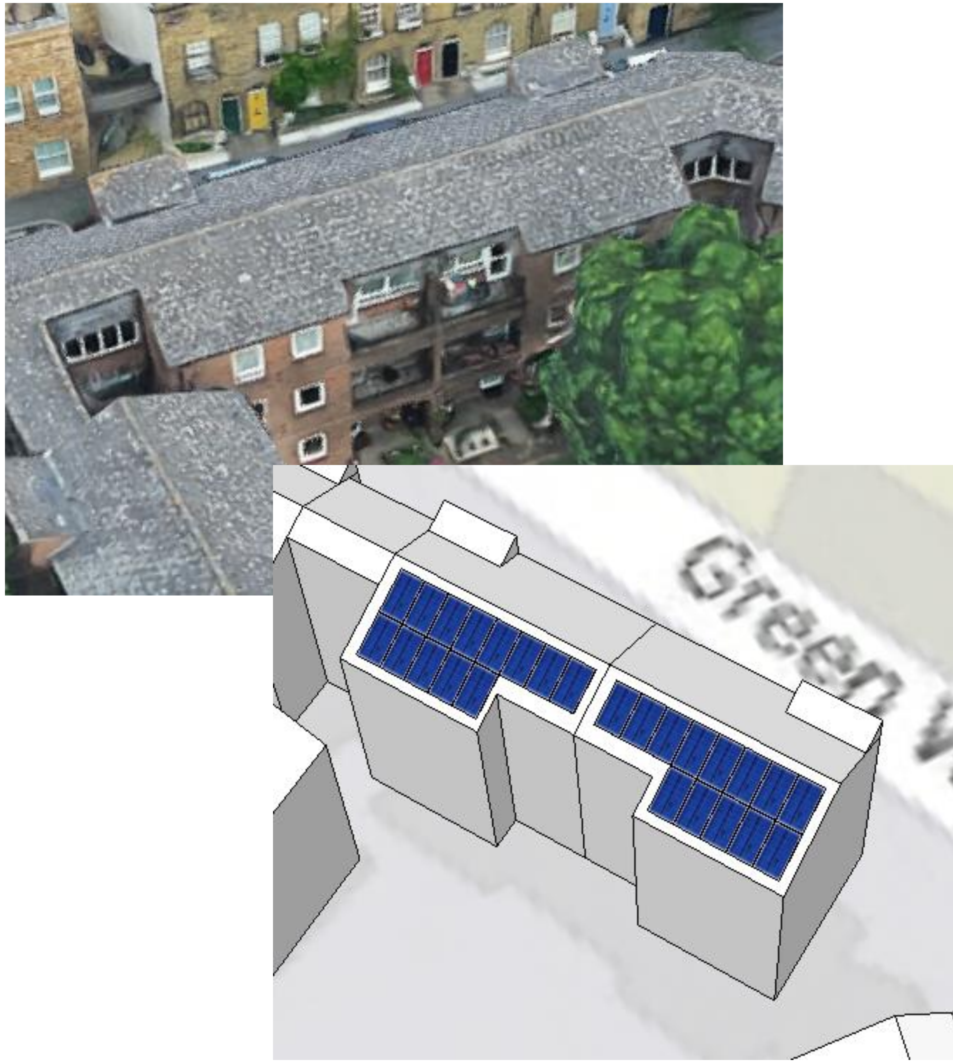

Fig 14. Solar PV layout on 14-25 Rephidim Street

Haddonhall Estate solar PV feasibility study

7-18 Prioress Street solar PV array (Table 15)

The south-west facing aspect of this 25° pitch roof will provide the best yield (as shown in Fig 15). Shading from the adjacent tree is considered to be minimal at present, but may require active management over time so as to not negatively impact performance.

	Maximum array	Optimised array
No. of modules	43	11
PV capacity (kWp)	11.8	3.0
kWh/kWp yield*	861	861
Est. annual output** (kWh)	10,181	2,605
Connection points	1-6, 7-12, 13-18 & 19-24 Prioress Street	
Estimated utilisation factor	24%	92%
Grid electricity offset (kWh)	2,390	2,390
Cost savings to LBS/TMO (£)	580	580
CO_2 savings*** (tonnes CO_{2e})	0.677	0.677
Est. installation cost**** (£)	11,400	5,000

Table 15. Modelled retrofit solar PV systems for 7-18 Prioress Street

* Based on Microgeneration Certification Scheme Standard Estimation Method kWh/kWp tables (MCS, 2012)

** Including simple shading analysis

*** Based on UK Government GHG Conversion Factors for Company Reporting 2018 UK electricity (1kWh = 0.28307 $kgCO_{2e}$).

**** Based on current market rates of £800/kWp + estimated scaffolding costs at £1,000 per block, minimum £5,000.

Fig 15. Solar PV layout on 7-18 Prioress Street

Haddonhall Estate solar PV feasibility study

13-24 Potier Street solar PV array (Table 16)

The south-east facing aspect of this 25° pitch roof will provide the best yield (as shown in Fig 16). Shading from the adjacent tree is considered to be minimal at present, but may require active management over time so as to not negatively impact performance.

	Maximum array	Optimised array
No. of modules	70	8
PV capacity (kWp)	19.3	2.2
kWh/kWp yield*	861	861
Est. annual output** (kWh)	16,571	1,894
Connection points	13-18, 19-24 & 25-30 Potier Street	
Estimated utilisation factor	7%	60%
Grid electricity offset (kWh)	1,120	1,120
Cost savings to LBS/TMO (£)	272	272
CO_2 savings*** (tonnes CO_{2e})	0.317	0.317
Est. installation cost**** (£)	17,440	5,000

Table 16. Modelled retrofit solar PV systems for 13-24 Potier Street

* Based on Microgeneration Certification Scheme Standard Estimation Method kWh/kWp tables (MCS, 2012)

** Including simple shading analysis

*** Based on UK Government GHG Conversion Factors for Company Reporting 2018 UK electricity (1kWh = 0.28307 $kgCO_{2e}$).

**** Based on current market rates of £800/kWp + estimated scaffolding costs at £1,000 per block, minimum £5,000

Fig 16. Solar PV layout on 13-24 Potier Street

37-42 Potier Street solar PV array (Table 17)

The south-east facing aspect of this 25° pitch roof will provide the best yield (as shown in Fig 17). Shading from the adjacent tree is considered to be minimal at present, but may require active management over time so as to not negatively impact performance. The building to the east will cause some shading in the winter months.

	Maximum array	Optimised array
No. of modules	20	8
PV capacity (kWp)	5.5	2.2
kWh/kWp yield*	919	919
Est. annual output** (kWh)	5,055	1,894
Connection points	31-36 & 37-42 Potier Street	
Estimated utilisation factor	24%	60%
Grid electricity offset (kWh)	1,204	1,120
Cost savings to LBS/TMO (£)	292	272
CO_2 savings*** (tonnes CO_{2e})	341	0.317
Est. installation cost**** (£)	5,400	5,000

Table 17. Modelled retrofit solar PV systems for 13-24 Potier Street

* Based on Microgeneration Certification Scheme Standard Estimation Method kWh/kWp tables (MCS, 2012)

** Including simple shading analysis

*** Based on UK Government GHG Conversion Factors for Company Reporting 2018 UK electricity (1kWh = 0.28307 $kgCO_{2e}$).

**** Based on current market rates of £800/kWp + estimated scaffolding costs at £1,000 per block, minimum £5,000

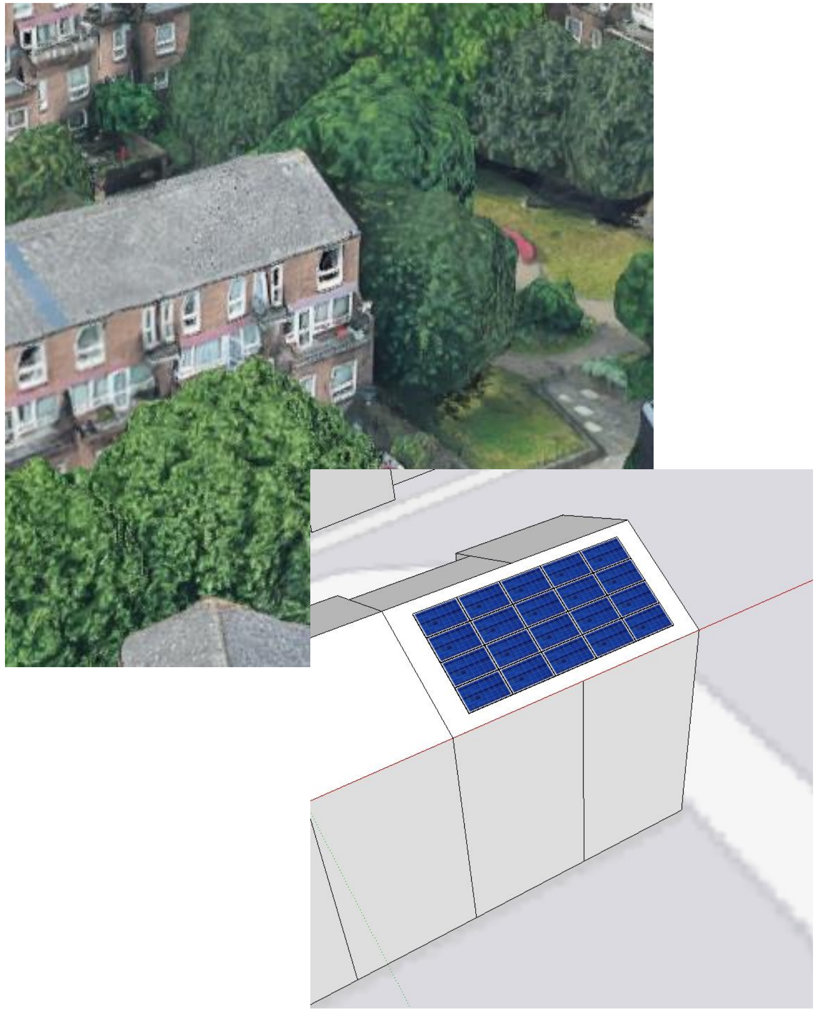

Fig 17. Solar PV layout on 37-42 Potier Street

Haddonhall Estate solar PV feasibility study

Conclusion

The majority of Haddonhall's energy requirements is for lighting in communal areas in the low rise blocks. The TMO has already started an LED retrofit scheme and energy savings for the landlords supply are being realised. Expanding the rollout of LEDs to other blocks will further reduce costs to tenants and leaseholders. Transferring onto a renewable electricity tariff will deliver carbon savings without any capital expenditure but may increase energy costs. Consideration should also be given to renegotiating electrical tariffs as those paid by the TMO are considered to be high.

In general the energy requirements for all communal areas of the estate are low and the dispersed nature of the loads across multiple buildings makes it hard to realise the benefits of aggregating consumption, generation and storage.

A high level appraisal has been completed of the PV arrays outlined by SELCE. The appraisal concludes that the roofs chosen are the most favourable for solar PV generation, as a result of being those that are least effected by shade. However, the buildings to which they are connected generally have low electricity requirements and therefore optimal system sizes to meet onsite demand are typically small. The proposed PV arrays could off-set an estimated £2,840 electricity costs, a reduction of approximately a third, if the arrays were owned outright by LBS/TMO.

It is considered that SELCE will struggle to offer a cost competitive PPA rate and make a business case with these low levels of onsite consumption. LBS will need to carefully consider the implications of any long term supply contract with a third party, lease arrangements for the roof, how the residents can directly benefit from the cost reductions, and agreement on system and tree maintenance to ensure ongoing performance.

For any projects going forward, an assessment should be made to check whether the roof structure is capable of withstanding the loads of a PV array. Requirements for structural reinforcements could add additional cost to a solar PV project.

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5. Brenchley Gardens Estate solar PV feasibility study

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Brenchley Gardens Estate solar PV feasibility study

Description

The Brenchley Gardens Estate is made up of 4 blocks of 4 storey flats (16 flats per block), 4 terraces (4 houses per terrace), 4 garage blocks and the Don McCoan Community Centre as shown in Fig 18. The Estate Office occupies flat 163 in Block 4. There is a mix of stock on the estate and 43 of the 95 properties are leased by the Council (13 houses and 30 flats). The remaining 52 are privately owned. The blocks are approximately 50/50 split between tenants and leaseholders. It is estimated that 21 of the leasehold flats are owner-occupied with the remaining 12 being sublet.

All tenants and the majority of leaseholders pay a service charge of which a portion contributes towards communal energy costs. It is thought that some early right-to-buy leaseholders do not pay service charges. The Estate Office and Community Centre energy bills are paid directly by the TMO. The communal lighting in the blocks and the external column lighting electricity bills are paid for by LBS.

The blocks have insulated deck roofs that have been reroofed in the last 10 years. Access is available via an internal hatch and edge protection is provided all round, therefore scaffolding is not required for the installation however the PV modules may need to be lifted externally. There are other on-roof obstacles, such as chimneys, vents and satellite dishes that have the potential to cast shadows. All blocks have a similar roof layout.

The garages are single storey with asphalt covered roofs. Due to the raised position of the blocks to the south-east these are significantly shaded for most of the day. Their low profile also means they could be prone to vandalism. The Community Centre is a relatively new single storey building with a concrete tiled hip roof.

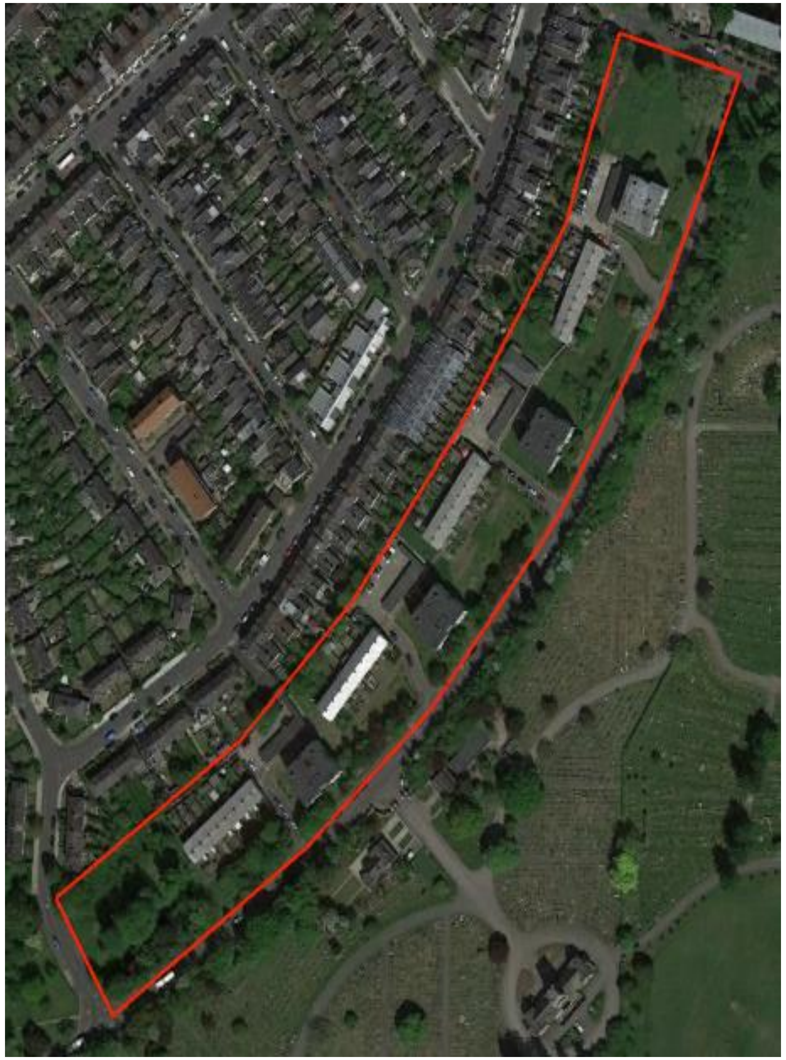

Fig 18. Aerial view of Brenchley Gardens Estate

Other energy options for Brenchley Gardens Estate

Both the Community Centre and Estate Office have both heating and hot water loads that are paid for directly by the TMO. Both buildings are served by gas boiler systems and although not renewable, it is currently one of the most cost effective systems to operate.

Replacing the current CFL luminaires for energy efficient LED, could significantly reduce the electricity consumption across the estate (internal and external luminaires). Motion detectors on communal lighting was installed but was not always operational, so addressing this could help reduce electricity consumption. Reducing energy consumption should be priortised ahead of installation of renewable energy technologies.

Electric vehicle (EV) charging was discussed with the residents and there was interest of having an EV charging point installed in one or more of the estate car parks. At present there are a few residents with hybrid vehicles, but it was thought that EV charging would encourage EV take up on the estate and be of benefit in the future. EV chargers could be connected to the landlord supply via the estate lighting connections.

It was identified that external wall insulation on the blocks and houses is likely to make a significant difference in reducing the cost of heating the properties, but it may be prohibitively expensive (i.e. the cost will far out weigh the potential reduction in residents heating bills in the short-medium term) and will only provide direct benefit to the residents receiving it.

Other carbon options for Brenchley Gardens Estate

It is understood that LBS are committed to reducing carbon emissions across the Council. Due to the increase in renewable electricity generation connected to the UK distribution network, the carbon emission factors of grid electricity is reducing year after year. Transferring over to a renewable only electricity tariff, will deliver carbon reductions but will not reduce on going landlord costs for tenants and leaseholders.

Headline energy consumption figures

Brenchley Gardens has communal electrical and heating loads, however the heating loads are only present at the Estate Office and Community Centre. It is estimated that the Community Centre and Estate Office utilise approximately 6,048kWh and 7,683kWh of heating respectively.

Based on the electricity readings taken during the site survey and historical estimated electricity bill data provided by LBS and the TMO, electricity consumption has been estimated for 2018 and is detailed in Table 18. All of the blocks are on day/ night tariffs.
It should be noted that there appears to be an error with the estate lighting meter '(49-63)' (*), which is currently being investigated.

Meter location	Estimated 2018 electricity consumption – TOTAL (kWh)	Estimated 2018 electricity consumption – DAY (kWh)	Estimated 2018 electricity consumption – NIGHT (kWh)	Current tariff (p/kWh) DAY/ NIGHT	Estimated annual electricity cost (£)
Estate lighting (1-15)	4,735			12.1	572.94
Estate lighting (49-63)	717,916*			11.218	80,535.82*
Estate lighting (97-111 & 145-159)	6,706			11.218	752.28
Block 1 (17-47)	7,892	4,030	3,862	12.229/ 7.975	800.82
Block 2 (65-95)	9,639	6,784	2,855	13.091/ 8.738	1,137.56
Block 3 (113-143)	6,772	5,686	1,086	12.593/ 8.703	810.55
Block 4 (161-191)	13,875	8,247	5,628	13.06/ 8.730	1,568.38
Estate Office	3,234			13.88	448.88
Community Centre	2,414			12.773	307.37

Table 18. Summary of annual communal electricity consumption and cost on the Brenchley Gardens Estate

Brenchley Gardens solar PV feasibility study

Blocks and garages solar PV array (Table 19)

Both of the block and garage roof are flat (as shown in Fig 19). A ballasted east/west mounting system with a 10° pitch will provide the optimum generation whilst maximising areas of minimal shade. Although the layout is optimised to avoid all year round shade, some shading on both the blocks and the garage roofs is likely until mid-morning and it is therefore recommended that the system is fitted with DC optimisers or micro inverters to reduce the impact on system performance.

	Block array	Garage array
No. of modules	32	8
PV capacity (kWp)	8.8	2.2
kWh/kWp yield*	741	659
Est. annual output** (kWh)	6,518	1,449
Connection points	Block 4	Estate Office
Estimated utilisation factor	100%	100%
Grid electricity offset (kWh)	6,518	1,449
Cost savings to LBS/TMO (£)	851	201
CO_2 savings*** (tonnes CO_{2e})	1.845	410
Est. installation cost**** (£)	8,800	2,200

Table 19. Modelled retrofit solar PV systems for block 4 and garage at Brenchley Gardens

* Based on Microgeneration Certification Scheme Standard Estimation Method kWh/kWp tables (MCS, 2012)

** Including simple shading analysis

*** Based on UK Government GHG Conversion Factors for Company Reporting 2018 UK electricity (1kWh = 0.28307 $kgCO_{2e}$).

**** Based on current market rates of £1,000/kWp assuming both arrays (garage and block) are installed as one system with optimisers.

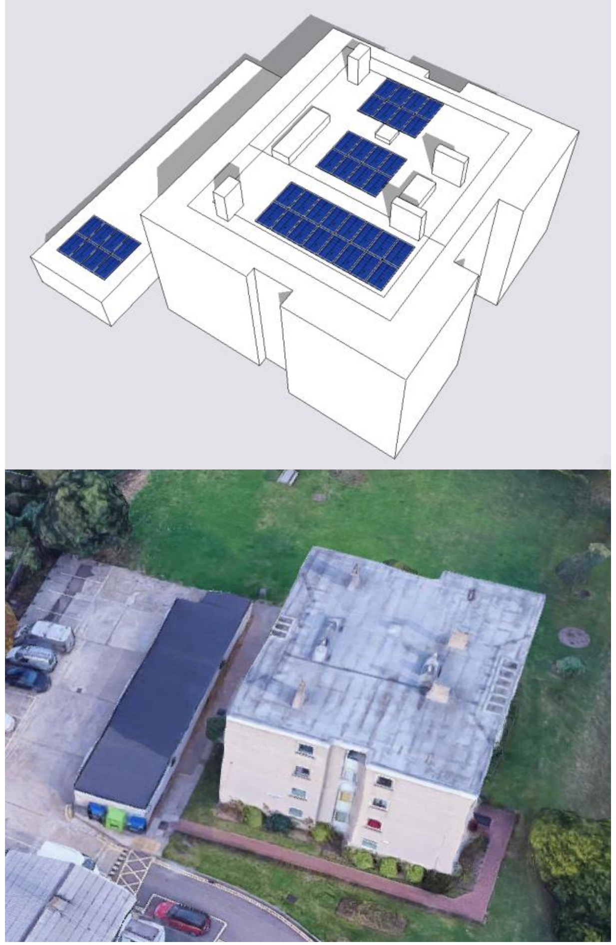

Fig 19. Solar PV layout on Block 4

Brenchley Gardens solar PV feasibility study

Community Centre solar PV array (Table 20)

The Community Centre has a good south facing 30° pitch roof (as shown in Fig 20) but due to the close proximity and elevated position of Block 3, it receives significant shading from September to March and the roof will also tend to remain shaded till midday in the shorter winter days. In order to make this system viable DC optimisers or micro inverters are recommended.

	Maximum array	Optimised array
No. of modules	18	7
PV capacity (kWp)	4.95	1.93
kWh/kWp yield*	756	756
Est. annual output** (kWh)	3,742	1,455
Connection points	Community Centre	
Estimated utilisation factor	39%	99%
Grid electricity offset (kWh)	1,448	1,448
Cost savings to LBS/TMO (£)	185	185
CO_2 savings*** (tonnes CO_{2e})	0.41	0.41
Est. installation cost**** (£)	5,000	5,000

Table 20. Modelled retrofit solar PV systems for Brenchley Gardens Community Centre

* Based on Microgeneration Certification Scheme Standard Estimation Method kWh/kWp tables (MCS, 2012)

** Including simple shading analysis

*** Based on UK Government GHG Conversion Factors for Company Reporting 2018 UK electricity (1kWh = 0.28307 $kgCO_{2e}$).

**** Based on current market rates of £1,000/kWp assuming the system is installed with optimisers, minimum £5,000.

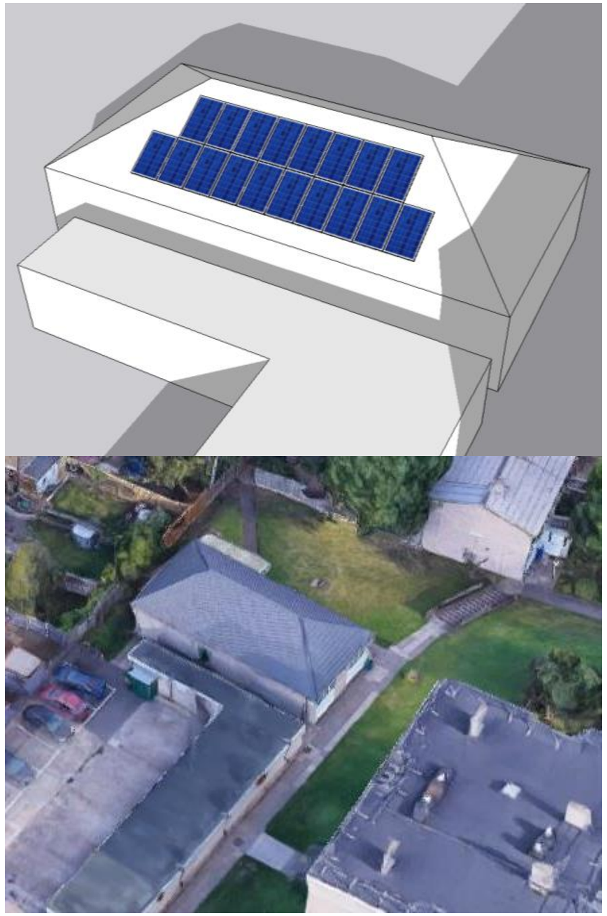

Fig 20. Solar PV layout on Community Centre

Conclusion

The Brenchley Gardens Estate is made up of low rise blocks, houses, an Estate Office and Community Centre. There are heating and hot water loads at both the Estate Office and Community Centre but these are currently served by condensing gas boilers and therefore replacement with renewable heat alternatives is currently unlikely to provide financial benefit to residents.

The lighting loads at the Estate are the most significant and a LED replacement scheme should be priortised ahead of investment in renewable technology. LEDs in the blocks and for the estate lighting will significantly reduce electricity consumption and running costs. Other energy schemes have also been discussed.

There are opportunities for solar PV on the blocks and Community Centre however due to shading from on-roof obstacles and other estate buildings, these would need to be fitted with DC optimisers or micro inverters to make these systems viable. Due to the existing edge protection on the blocks and the single storey buildings, access equipment costs are going to be significantly less than at the other estates. This, and the fact that future maintenance will also be made easier, makes the solar PV arrays at Brenchley Gardens more financially attractive. However, it should be noted that any significant reduction in electricity consumption as a result of a LED retrofit scheme, may significantly impact the viability of a PV system.

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6. Evaluation criteria for a solar PV project

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Evaluation criteria for a solar PV project

In order to gain maximum value from any solar project it is necessary to objectively evaluate the technical and financial performance. Establishing the aims and objectives for installing a solar PV system is a useful first step. Different aims and objectives will require different solutions. Different energy efficiency and renewable energy system solutions could also be compared in relationship to the investment made e.g. on the basis of: kWh saving/yr per £ investment, kg CO_2 reduction per £ invested or £ saved for residents per £ invested, etc.

For the purpose of this evaluation criteria the following aims and objectives for LBS have been used;

- Offsetting communal energy costs*
- Reducing cost to residents
- Reducing carbon
- Raising energy awareness in residents
- Utilising unused roof space

The technical and financial criteria will change depending on the ownership model, however for the purpose of this report we have assumed that the minimum criteria used would be if LBS were investing their own/ TMO funds to ensure a good quality, fit for purpose system that is able to deliver the required performance for the lifetime of the system (defined as 25 years).

BRE can provide further support regarding technical specification, preparation of tender documents, review of tenders, etc.

Raising energy awareness in residents is hard to quantify and a wider approach to assessing estate energy spend could be led by the TMO to see the impact of any solar PV projects. The initial work completed by SELCE with the Haddonhall residents looking at energy reduction should be continued and similar approaches encouraged at all estates.

* At present the electricity consumption at all 3 estates is not monitored and consumption data is based on periodic readings that do not provide any granularity of data. It is recommended that LBS investigate upgrading to half hourly metering to inform more detailed analysis.

Evaluation criteria for a solar PV project

Financial evaluation criteria

The key financial criteria to ensure successful project delivery are;

Criteria	Evaluation	Method of assessment
Solar performance	The proposed system should be capable of delivering the kWh/kWp for the specific installation location.	Confirmed by modelling estimated PV generation or guaranteed performance ratio.
Installation costs	Should be in line with current market rates and reflect all installation costs likely to be incurred (i.e. meeting H&S requirements, equipment supply, installation, commissioning, building control compliance etc.).	Competitive tender.
Utilisation factor	The proposed PV system should make a significant contribution to onsite loads (>70% of PV generated is consumed onsite).	Confirmed by modelling estimated PV generation against electricity consumption data.
Term	The financial model shall be completed over 25 years and be reviewed periodically to monitor long term performance.	Utilising generation meter readings or performance data from PV system.
PPA	If applicable, the PPA should provide a financial advantage to LBS for the full term of the agreement in comparison to the best electricity rate available.	Investigation into renegotiation of electricity prices to obtain the best rate available.
Maintenance costs	Clear definition of maintenance responsibilities and should cover scheduled maintenance, periodic verification, fault resolution and include the cost of an inverter replacement at year 10.	Competitive tender.
Inflation	Any business model should factor in relevant inflation rates for the full term (i.e. RPI, electricity price inflation etc.)	Referenced inflation indices.
Value for the money	The PV proposal should be able to demonstrate a higher reduction in energy costs to LBS and tenants than other energy efficiency measures.	Comparison of business cases to other energy efficiency proposals (£/kWh saved)

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Evaluation criteria for a solar PV project

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Technical evaluation criteria

Key technical criteria to ensure successful project delivery include:

Criteria	Evaluation	Method of assessment
Structural	The building and roofing system must be capable of, or adapted to be capable of, supporting the loads imposed by the proposed solar PV array and installation process.	Structural engineer assessment
Grid connection	Distributed generation connection consent must be obtained from UK Power Networks prior to installation for all systems >16A per phase.	Follow ENA's Engineering Recommendation G99 and obtain written consent from UKPN.
Electricity yield	Systems installed should make a significant contribution to onsite loads (>70% of PV generated is consumed onsite i.e. utilisation factor is >70%).	Comparison of modelled PV generation and electricity consumption data.
Long term performance	The proposed system must be capable of delivering the estimated electricity yield for 25 years with <1% degradation per year.	All systems installed must meet technical specification and have an automated method of monitoring performance.
Orientation	Priority should be given to roofs that are orientated near south without any shading. If shading reduces electrical yield by 10% per year, consideration should be given to installing DC optimisers or micro-inverters.	Onsite assessment and/or use of 3D PV modelling software.
Installation location	There must be sufficient accessible space with adequate ventilation to install and maintain all system components.	Onsite assessment. Any components installed externally must have an adequate IP rating.
Standards	All systems must meet current standards, building regulations, planning guidance and industry best practice (i.e. IET Code of Practice for Solar PV).	Building control certificate, electrical commissioning certificate etc.
Building maintenance	Consideration should be given to any future building maintenance work or change of building use that may affect PV performance or energy consumption.	Understanding of future plans for buildings.

Evaluation criteria for a solar PV project

Solar PV module technical specifications

Best practice specification for solar PV modules typically include:

- Have a verified module efficiency of at least 16.5%
- Be a MCS accredited product, providing independent verification that the technology has been tested in accordance with IEC 61215 or IEC 61646
- Be a 'Class A' and 'Tier 1' module
- Carry a CE mark
- Be double-insulated (safety class II) by construction
- Be supplied with pre-fitted double-insulated, UV protected flying leads
- Be supplied with purpose-designed, weather-proof and touch-proof polarised plug and socket connectors
- Have an appropriate arrangement of bypass diodes for the selected mounting position of the module
- Have a power warranty of at least 80% after 20 years
- Have a positive rated power output tolerance of 0/+5%, or better
- Have a product warranty of at least 10 years
- Be supplied with a traceable serial number affixed to the module
- Be capable of connecting in strings with a maximum system voltage rating of at least $1000V_{dc}$
- Be suitable for a grid-connected system
- Be supplied with a module datasheet that meets the requirements of IEC 61730-1

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Evaluation criteria for a solar PV project

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Inverter technical specifications

Best practice specification for inverters typically include:

- Be capable of providing a single-phase or three-phase AC output, as appropriate for the existing electrical installation.
- Be pre-configured for connection to the UK grid and be either G98 (<16A per phase) or G99 (>16A per phase) type tested.
- Have operational parameters further refined to local requirements, if required by the DNO.
- Have a European efficiency of at least 95%.
- Be supplied with on-site and remote monitoring capabilities, showing all key system performance information.
- Be installed in a location accessible by maintenance personnel, with the system status displays clearly visible.
- Be installed in a location with adequate ventilation or cooling where required according to the manufacturers recommendations.
- Incorporate MPPTs capable of operation with the solar PV modules throughout all expected temperature and irradiance ranges.
- Have a rated power ratio between 0.8 - 1.1 x PV array kWp for each array.
- Be capable of accepting the maximum open circuit voltage and maximum short circuit current of the specified PV modules (strings configured for optimal generation, as appropriate) without damage or malfunction.
- Have a method of protecting against DC reverse polarity, AC short-circuit currents, ground faults and DC overcurrent and insulation faults.
- Have an ingress protection rating of at least IP44 if mounted indoors, IP55 for outdoor mounting.
- Have a product guarantee of at least 5 years.
- Have a manufacturer’s serial number displayed on the inverter in an accessible location.

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Evaluation criteria for a solar PV project

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DC system component technical specifications

Best practice specification for DC components typically include:

- Be designed, specified and installed to the requirements of BS 7671.
- Be designed with all DC components rated for continuous operation at DC and for the maximum voltage and current likely to be encountered, multiplied by a safety margin.
- Be installed with appropriately sized fusing according to industry good practice. In all cases fuses must be in accordance with the manufacturer's instructions and maximum fuse rating for the module. The fuse type must be 'gPV', as defined within IEC 60269-6.
- Have appropriate switching and isolation provisions specifically designed for the array architecture according to BS 7671. Purpose-designed DC isolators, conforming to BS EN 60947-3, and in line with BRE's 'DC isolators for photovoltaic systems: A good practice guide'.
- Have appropriate provisions for lightning and surge protection in accordance with BS EN 62305, where a lightning risk assessment has determined that lightning protection is advisable.
- Be suitably earthed according to BS 7671.
- Be designed, specified and installed to keep DC losses to a minimum.

AC system component technical specifications

Best practice specification for AC components typically include:

- Be designed, specified and installed to the requirements of BS 7671.
- Have appropriately rated AC isolators that are selected and conform to BS EN 60947.
- Have adequate G98 or G99 provisions either built into the inverter(s) or as an additional component and in compliance with ENA Engineering Recommendations.
- Have an Ofgem or MID approved generation meter preferably with provisions for remote access of generation data.
- Have effective performance monitoring provisions which allow for remote performance and analysis of the system.
- Have appropriate provisions for lightning and surge protection in accordance with BS EN 62305, where a lightning risk assessment has determined that lightning protection is advisable.
- Be suitably earthed according to BS 7671.
- Be designed, specified and installed to keep AC losses to a minimum.

Evaluation criteria for a solar PV project

Cabling and connectors technical specifications

Best practice specification for cabling and connectors typically include:

- DC cables should be appropriately sized to optimise string voltage, reducing resistive losses and minimising cable size, whilst minimising the risk of earth faults and short circuits in accordance with the BS 7671.
- Solar PV string cables, array cables and DC main cables shall be selected and erected so as to minimize the risk of earth faults and short-circuits.
- Armoured cable should be used where cables are buried or may be subject to mechanical strain or abrasion.
- All cable management components should be installed in accordance with BS EN 62275.
- Wiring systems shall be selected and erected to withstand the expected external influences such as wind, ice formation, temperature and solar radiation.
- DC connectors should be purpose-designed, weather-proof, locking type polarised plug and socket connectors, class II rated and certified to BS EN 50521.
- Where required manufacturers tools should be used for the assembly of plug and socket connectors, and plugs should only be connected to sockets of the same manufacturer, type and rating.

Mounting system technical specifications

Best practice specification for mounting systems typically include:

- Compliance with any structural assessment completed on the PV modules, mounting system and any ballast (if appropriate), considering wind loading (in accordance with BRE Digest 489) and snow loads (in accordance with BS EN 1991 Eurocode 1).
- Be selected to allow adequate access to the PV array for maintenance purposes.
- Be installed so that there is provision for disassembly and removal of the system(s) at the end of its operational life.
- Module fixing shall be carried out in accordance with module manufacturer’s specifications.
- Thermal expansion must be properly accounted for via the provision of adequate thermal brakes and expansion gaps.
- All material selection should be made on the basis of the environmental conditions likely to be experienced on the site and take into account potential galvanic effects.
- Be capable of accommodating array earthing/ equipotential bonding (if required).

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