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BRE National Solar Centre

Multifunctional Solar Car Parks

A good practice guide for owners and developers

BRE NATIONAL SOLAR CENTRE

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Contents

Scope

In this document a solar carport means a shelter for one or more cars that incorporates solar photovoltaic (PV) modules. A solar car park means a parking facility consisting of multiple solar carports.

This document will be of particular interest to investors and developers of solar car parks and multifunctional solar carport systems. It provides an outline of the key factors to be considered when developing a business case for site selection, the design and development of a multifunctional car park, and is intended to provide an awareness of what needs to be considered to realise a project from planning to delivery.

Solar carports are a relatively new form of solar electricity deployment, and there is little published data on costs. In this document solar carport installation costs are expressed in both £/Wp or £/bay in order to aid communication between solar and construction industries. Revenue streams are expressed in £/kWh or £/bay.

Introduction

There are over 17,000 parking facilities in the UK and the sector generates £1.5 billion per annum (BPA, 2015).

Installing PV systems on surface and multi-storey car parks to generate renewable energy is becoming increasingly popular as the area above a car park is an otherwise unexploited brownfield site.

Multifunctional solar carports can add value to car parks by improving economic and environmental performance, especially where the car park is not suitable for building mounted PV. Such added value is derived from:

- Generation of renewable energy
- Availability of covered parking spaces
- Availability of electric vehicle (EV) charging facilities
- Provision of renewable energy to adjacent developments
- Onsite energy storage

Solar car park business case formation

As the UK Government seeks to include more renewable energy in the energy mix, solving problems associated with intermittent renewable generation will become more imperative due to the capacity issues in our electricity distribution network[1]. Low carbon solutions which balance electricity supply and demand are required to achieve this, and multifunctional solar car parks can be part of this solution.

Multifunctional solar car parks can provide a number of revenue streams in addition to power sales and other benefits offered by a renewable energy source. However, when preparing a business case, consideration should also be given to operation, maintenance and security requirements, especially in areas susceptible to vandalism.

Modelling solar revenue streams

Standard solar carports generally offer a PV system with a capacity of 2kWp per 12m2 parking bay, with costs varying widely depending on scale, design and layout. The cost of installing solar carports at the most favourable locations is comparable with more challenging commercial rooftop projects.

The simple financial model for a solar car park is similar to that of any PV system, which means it may include benefits from the Feed-in-Tariff (FIT), Renewable Obligations Certificates (ROCs) or Contracts for Differences (CfDs). These are not discussed in detail in this guide.

Whilst incentives are still potentially available, accessing them is becoming increasingly challenging, as a result developers will increasingly look to see if economics allow their project to be built subsidy free thus lowering administrative burden. In any event, as the cost of PV continues to fall and energy prices rise, incentives are no longer the main stimulus to deployment. It is therefore advisable to consider the business case on the basis of unsubsidised generation, with the potential for an additional income should an incentive prove to be available.

Good site selection and car park layout can help optimise solar energy generation for a specific energy requirement. If the owner of the car park has an onsite electricity demand, then using onsite generated power for self-consumption is likely to bring greater benefit to the business case than the income from selling the power to an electricity supply company.

Other arrangements, such as power sales to adjacent developments or connection to a new or existing private wire network, require careful consideration, not least in order to ensure compliance with relevant regulations on electricity trading. These regulations are likely to be reviewed within the lifetime of this guide, and up to date advice should be sought on the current position.

Integrating transport and energy infrastructure

The shift from conventional vehicles towards EV's creates a need for additional charging points and upgrades to the electricity distribution infrastructure. This will lead to opportunities for car park owners and

1 The Clean Growth Strategy (BEIS, 2017)

operators to develop their business by offering enhanced services, such as EV charging, whilst making a statement about climate change and clean air ambitions in the area.

Having relevant and current data about your car park users, local EV ownership, existing and planned EV infrastructure, is important to help inform the business case.

EV charging

There is clearly a synergy between solar carports and EV charging. As of December 2017, there were approximately 125,000 EVs in the UK[2]. National Grid estimates that there could be over 1 million EVs on the road by 2020 and 9 million by 2030[3]. Providing more EV charging points will enhance consumer awareness of both the availability and pace of development of EV infrastructure thereby encouraging EV use and easing range anxiety[4]. Multifunctional solar carports can provide a more welcoming EV charging experience for users, offering accessible and well-lit spaces protected from the weather and supplying clean, renewable energy for their EV.

Revenue generation from EV charge-points is a fast-moving and developing market. There are a variety of EV charging models in practice, from simple £/kWh, £/min and variations in pricing structure on speed of charge (i.e. rapid, fast and slow). Capital costs for EV charge-points range from less than £1,000 fully installed, to over £20,000 per unit.

EV charge-points can be purchased outright, leased, or rented to third parties. Several companies specialise in providing free and chargeable EV infrastructure. Current industry prices are up to £0.35/kWh for rapid charging and £0.25/kWh for fast charging[5] (plus connection charges), resulting in an estimated revenue of £4,800/unit/year for a fast EV charge-point (based on dispensing two charges per day) and up to £33,000/unit/year for each rapid EV charge-point (for prime locations and a high customer turnaround of 10 charges per day). The number of EV charge-points and the frequency of use are important factors in the choice of charging speed. The number and type of EV charge-points should be specified depending on site requirements.

The rate at which EVs and plug-in hybrid electric vehicles (PHEVs) can recharge on 'fast' charge-points (up to 22kW) can be varied dynamically, allowing optimal self-consumption of solar generated energy when using networked, intelligent charge-points. This may be particularly beneficial to car park owners with private vehicle fleets, where the number, type of vehicle(s) and the energy (kWh) required - and over what period - is known in advance. Emerging EV charge-point technology can now determine the available and aggregated capacity in connected vehicles' batteries, allowing optimised charging of the fleet over the course of the day based on solar yield predictions.

Car park owners may wish to provide discounted EV charging to their staff, members, or customers. Additional income can be generated through offering overnight charging to local companies with EV fleets. Local authorities may wish to provide free charging in locations where they are keen to promote EV take up, such as areas with poor air quality.

The self-consumption of solar electricity through EV charging of fleet vehicles can also provide operational savings. In this respect a study has shown how self-consumption could save organisations with a fleet of 10 EVs up to £14,000 per year[6]. The Go Ultra Low campaign has been set up to provide information about EVs and support organisations to convert 5% of their vehicle fleet to electric by 2020.

Multifunctional solar carports are typically more cost effective than installing the three technologies (i.e. PV, energy storage and EV charge-points) separately, as they share infrastructure and project delivery costs. In addition, solar car parks can reduce operational costs of EV charge-point and increase electricity supply security[7].

Currently the Office for Low Emission Vehicles (OLEV) are operating a voucher based grant scheme for the installation of EV charge-points for businesses, charities and public sector organisations. The scheme may contribute £300 per charging socket for use by staff and/or fleet vehicles (up to a maximum of 20 per application)[8].

Energy storage

Onsite new build car parks are not likely to receive FIT or ROCs for onsite PV generation and so developers may wish to examine the use of energy storage to increase self-consumption and so improve the business case. Developers considering electrical energy storage as part of a multifunctional solar carport will typically consider batteries in the first instance. Other electrical energy storage technologies, which are not covered in this Guide, but might be considered are; flywheels, liquid air or hydrogen systems. Another multifunctional option, not covered by this Guide, are solar thermal and thermal energy storage systems for integration with district heating schemes.

Apart from EV charging, most onsite electrical consumption for a car park is likely to be lighting. Multi-storey car parks may need lighting during daylight hours, but most lighting requirement will be at night. The addition of electrical energy storage (e.g. batteries) to a solar car park will help to match onsite energy demands by time shifting surplus generated solar electricity to times when solar generation is unavailable (i.e. night time). This is particularly useful for car parks with night time operations.

Energy storage can be installed 'behind the meter' in parallel with PV and electrical loads, or connected directly to the network with its own separate meter. Usually, greater financial benefit arises from behind the meter operation. Rapidly reducing costs of battery technology are further supporting these business cases (ESN, 2018).

Storage installed behind the meter can also have a role in the energy supply of the car park, even when there is no PV electricity being generated. In such cases the storage system can be charged when low cost electricity is available (e.g. during 'off-peak' periods) and then discharged at times of peak electricity prices, which would normally coincide with the evening peak, especially in winter.

Provided the car park operator enters into an appropriate contract with an energy supplier, and the system is intelligently managed, behind the meter energy storage can offer cost avoidance benefits through peak demand shifting. Activities include reducing both bulk energy costs associated with short term fluctuations in electricity markets and electricity network charging costs, such as the national transmission system (TNUoS) charges (by reducing consumption of grid supplied electricity in 'triad' periods) and local distribution system (DUoS) charges (by reducing consumption of grid supplied electricity in the DUoS red and amber time bands).

Energy storage can also generate revenue through supporting national network balancing. The commercial arrangements[9] can be complex and specialist advice is recommended. The revenue from both energy sales, sales of ancillary services and avoided costs by reducing use of system charges are variable and have fallen substantially in recent years (ESN, 2018).

Alternatively energy storage can be installed on the distribution network side of a car park's electricity meter ('in front of the meter'),

2 http://www.nextgreencar.com/electric-cars/statistics/ 3 Future Energy Scenarios (National Grid, 2017) 4 Sun driven electric future (Solisco, 2017) 5 confirmed by ecodrive (January 2018)
6 https://www.goultralow.com/company-cars-and-fleet-vehicles/electric-car-whole-life-costs/
7 Optimized Operational Cost Reduction for an EV Charging Station Integrated with Battery Energy Storage and PV generation (Yan et al., 2018)
8 https://www.gov.uk/Government/collections/Government-grants-for-low-emission-vehicles

in doing so it will be treated as an independent facility, subject to its own metering and commercial arrangements, and not part of a multifunctional solar car park system.

Energy storage can be retrofitted to an existing solar car park, however the installation will probably be deemed as a material change to the registered PV system. As a result, the addition of storage will need to be completed in such a manner that the PV system remains eligible for any incentive payments that are being received (i.e. FITs and ROCs). Guidance notes on this subject are under preparation by Ofgem.

Premium parking

A surface car park is usually uncovered and open to the elements. The construction of a solar carport allows vehicles and users to be sheltered from the weather. Surface car park revenue varies between £5,540-£9,000/bay/year with actual revenue depending on many factors such as location, frequency and duration of usage. Covered parking can demand a premium of up to £720/bay/year (BPA, 2015).

LED lighting

Many car park owners are converting their car park lighting to LED technology in order to benefit from lower power consumption. Carport under-lighting and LED technology is effective at reducing energy costs, while also reducing light pollution. The use of LED lighting saves energy and reduces electricity costs for lighting by up to 80%[10].

Replacement of lighting in a car park is an opportunity to consider wider redevelopment of the facilities and to include solar carports. Additional value added systems such as light sensors, motion sensors and empty/ reserved bay signalling systems are available, but are not discussed in this Guide.

Solar carports and business rates

The approach to the valuation of solar carports for business rates is similar to other solar installations. Existing legislation requires a distinction is made between who owns the equipment and whether the majority of generated energy is consumed onsite ('Mainly Self Consumption') or exported ('Mainly Export'). Following the business rates revaluations in April 2017[11], solar and energy storage is valued using two methods:

- 'Mainly Self Consumption' – where the direct owner of the installation uses the electricity for self-consumption. For system owners that use more than half of the generated electricity onsite, the value of the solar carport[12] is reflected in the valuation of the car park itself.
- 'Mainly Export' - where generated energy is exported to a customer or a third-party via a power purchase agreement (PPA). Examples include solar farms, third-party rooftop installs, or installs set up within a special purpose vehicle (SPV). These rates were agreed in a Memorandum of Agreement[13] with the Solar Trade Association and the Valuation Office Agency (VoA).

In addition, solar car parks with an installed generation capacity of less than 50kW are classed as 'microgeneration' and therefore have a temporary exemption from business rates until the next business rate revaluation (expected April 2022). Such systems registered in Scotland are permanently exempt.

Environmental taxes

A number of environmental tax schemes are in place to encourage UK business to reduce energy consumption and carbon emissions. The schemes apply to certain types and sizes of organisation. The level of these taxes can be reduced through self-consumption of onsite generated electrical energy (such as solar).

As detailed in the UK Government's Clean Growth Strategy[14], a new Streamlined Energy and Carbon Reporting Framework is due to be introduced in 2019. It is proposed that this framework replaces some of the existing schemes, including the CRC Energy Efficiency Scheme, aligning the mandatory annual greenhouse gas reporting of UK companies.

CRC Energy Efficiency Scheme

The CRC Energy Efficiency Scheme is a mandatory carbon emissions reduction scheme. It currently applies to organisations in the public and private sectors consuming over 6,000MWh per year[15]. Scheme participants account for over 10% of the UK's carbon emissions and include large retail chains, manufacturers and many Government bodies.

In order to encourage energy efficiency measures, annual allowances for missed energy reduction targets must be purchased. These allowances are forecast to cost £17.20 per tonne of carbon in 2018/2019 - equivalent to £0.0066/kWh[16]. Allowances can be purchased from the UK Government or from the secondary market. Trading CRC allowances[17] can represent an extra revenue stream for solar car parks. It should be noted that this revenue cannot be claimed if the solar system is receiving a FIT.

Climate Change Levy (CCL)

The Climate Change Levy applies to the majority of organisations in the industrial, commercial, agricultural and public services sectors. CCL is applied to energy bills, calculated as an additional £/kWh cost. The UK Government set the rates in advance. For 2018/2019 the CCL rate for electricity will be £0.00583/kWh, this is set to increase by over 30% in 2019/2020[18]. Electricity supplied from renewable sources is no longer exempt from CCL[19], however the treatment of electricity storage is currently under review. Advice should be taken on what impact a multifunctional solar car park may have on CCL on a site by site basis.

Enhanced Capital Allowance (ECA) Scheme

The ECA Scheme encourages investment in energy-saving technologies, allowing businesses to write off the whole cost of equipment against taxable profits. Since 2012 solar modules have qualified for a 'special' ECA rate of 8%[20]. They are not eligible for accelerated tax relief in the UK, unlike in Ireland and other energy generation technologies in the UK.

Local planning policy & developments strategies

A number of local authorities have recognised the importance of reducing greenhouse gas emissions through improving the energy efficiency of all new construction projects and maximising the opportunities for onsite renewable generation, such as solar.

An example is the draft London Plan (released at the end of 2017),

9 https://www.nationalgrid.com/uk/electricity/balancing-services 10 Green Parking (Phillips, 2017) 11 https://www.gov.uk/introduction-to-business-rates/revaluation
12 The VOA take an assumption about the capital cost of installing solar in 2015 and apply a decapitalisation rate of 4.4%. 13 http://www.solar-trade.org.uk/business-rates-memorandum-agreement/
14 The Clean Growth Strategy (BEIS, 2017) 15 https://www.gov.uk/guidance/crc-energy-efficiency-scheme-qualification-and-registration
16 Based on a conversion factor of 0.381460 kg/CO2/kWh - CRC Energy Efficiency Scheme Order: Table of Conversion Factors v7 (BEIS, 2017).
17 https://www.gov.uk/guidance/crc-energy-efficiency-scheme-qualification-and-registration 18 https://www.gov.uk/Government/publications/rates-and-allowances-climate-change-levy/climate-change-levy-rates
19 https://www.gov.uk/Government/publications/excise-notice-ccl13-climate-change-levy-reliefs-and-special-treatments-for-taxable-commodities/excise-notice-ccl13-climate-change-levy-reliefs-and-special-treatments-for-taxable-commodities 20 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/192109/capital_allowances_fits.pdf

which maintains the commitment for London to become a zero-carbon city by 2050. The plan sets out a requirement for all new major non-residential developments to achieve annual net zero-carbon emissions and all developments to maximise opportunities for onsite electricity and heat production from solar technologies[21]. The inclusion of a solar car park can contribute to meeting these requirements. Greater London Authority (GLA) reported that during 2016 more than 85% of new developments referred to the Mayor for a final decision[22] included renewable energy, with solar being the dominant technology choice[23].

In addition, Cambridgeshire County Council is working alongside the UK Government and UK Power Networks to develop a deployment model for multifunctional solar car parks[24].

Advertising

Advertising in car parks forms part of the Out of Home (OOH) advertising segment. A multifunctional solar carport offers a range of advertising opportunities; from advertising panels attached to the vertical sections of the mounting frame, to advertising space or branding on EV charge-points.

The revenue from an advertising space will depend largely on car park footfall and location. Hence, when building advertising into a business case this information should be at hand. An OOH advertising agency should then be able to assist in proposing a suitable solution.

Brand value

The Department of Business Energy & Industrial Strategy (BEIS) regularly carries out surveys on public attitudes towards different sources of power generation. The results consistently show PV to enjoy the most support. Over 80% per cent of the population supports the technology[25], and a solar car park provides a strong statement of an organisation's commitment to carbon reduction. Estimating the effect on brand value is beyond the scope of this Guide.

Funding models

Public sector

The public sector has access to low-cost, long-term infrastructure funding in the form of the Public Works Loans Board[26]. This organisation is able to borrow at Government rates, which are typically lower than any private sector lenders. Long loan terms would enable repayments to be made direct from the solar car park revenue. The process of application is relatively straight forward. A business plan is required to illustrate that future revenue streams will fulfil the repayments. Other loan and lease-finance options are also available.

The national RE:FIT programme[27] supports the public sector to retrofit their buildings with carbon and energy reduction measures. In London, where RE:FIT originated, the programme addresses the lack of technical expertise and (increasingly) capacity by providing free of charge expert support to public sector bodies (including London Boroughs, NHS bodies, schools, universities, colleges, central Government departments, cultural and heritage organisations). The scope has recently been extended to offer support to more organisations, bringing a greater focus on solar energy, and expanding its scope to include the retrofit of non-building assets, such as LED street lighting and EV charging infrastructure. RE:FIT can undertake feasibility assessments for solar car parks free of charge to public sector organisations.

Over the next two years London's Decentralised Energy Enabling Project (DEEP) will help implement large-scale decentralised energy projects, which the market is currently failing to develop. DEEP will provide technical, commercial, financial and other support services to assist public and private sectors to develop, procure and bring into operation these large scale projects in London. This could include PV projects (typically 250 KWp or greater) such as solar car parks.

Private sector

Private sector lending rates will vary depending on base rate, credit ratings and project size, however, finance providers are now very comfortable with PV projects and funds would expect to be repaid through energy savings and other revenue streams. Commercial mortgages represent the lowest cost of borrowing for the private sector, with lending rates currently in the range of 3-5%.

Several Local Enterprise Partnerships (LEPs) and other local authority led funding (for example the London Mayor's Energy Efficiency Fund) can be used for private financing of renewable energy technologies, such as solar car parks. A number of the funds have been set up to enable community ownership of energy assets, to generate capital to be re-invested locally in renewable energy and to nurture the spread of community-owned renewable energy generation.

In 2016 the Carbon Trust launched the 'Green Business Fund'. This £7m fund helps provide SMEs (including charities) with energy efficiency support, energy assessments and funding for energy saving equipment, including solar. The funding offered is a capital contribution of up to 15% of the total project cost, up to a maximum of £5,000[28].

Third-party ownership

An alternative to self-funding is to enter into a PPA with a third-party who funds the multifunctional solar car park scheme. PPAs enable asset owners to benefit from solar electricity without any CAPEX or ongoing operation and maintenance costs. PPA projects are generally sized to cover onsite base-loads, with zero or minimal export, and are therefore best suited for sites with high energy consumption. 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 - 25 years). The third-party would claim any available incentives, including generation and export tariffs. PPAs are well-established in the solar sector and limit the risk of asset owners financing their own projects.

Due to the nature of the technologies incorporated in to a multifunctional car park, there are also options for a third-party to own some (rather than all) of the system. Leasing of EV charge-points and/or batteries is common and can help support the business case for a solar car park.

21 The London Plan - The Spatial Development Strategy for Greater London Draft for public consultation (GLA, 2017)
22 https://www.london.gov.uk/what-we-do/planning/planning-applications-and-decisions/what-powers-does-mayor-have-planning
23 Energy Monitoring Report – Monitoring the implementation of London Plan energy policies in 2016 (GLA, 2018)
24 www.solarpowerportal.co.uk/news/uks_largest_solar_carport_with_additional_storage_planned_for_st_ives_park
25 Energy and Climate Change Public Attitudes Tracker: Wave 23 (BEIS, 2017)
26 http://dmo.gov.uk/responsibilities/local-authority-lending-pwlb/
27 https://www.london.gov.uk/what-we-do/environment/energy/energy-buildings/refit/refit-framework
28 https://www.carbontrust.com/client-services/programmes/green-business-fund/

Site selection

Surface car park sites

Surface car parks represent the most common deployment of solar car parks. The advantages of working at ground level removes many of the costs associated with roof mounted systems, such as access equipment and structural reinforcements. A large factor in the cost of surface solar car park systems are the foundations. Good site selection is the most effective way of reducing deployment costs. More information on solar car park design options can be found in Table 3.

Image courtesy of Schletter (www.schletter-group.com)

Multi-storey car park sites

The top decks of multi-storey car parks are a common site for solar carports, but pose more engineering challenges than surface car parks. Solar carports designed for the top decks of multi-storey car parks are higher in cost due to a number of factors; costs of access for materials, the necessary edge protection to ensure safe working at heights, and more complex structural considerations and constraints. The construction and structural capacity of a multi-storey car park are the main factors in determining the design and specification of the carport frames. The frames and the fixings need to be able to withstand significantly higher wind loading and, in some cases, the top deck may not be structurally suitable for the installation. Fixings should be suitably waterproofed if they penetrate the roof deck of a multi-storey car park, to avoid water ingress etc.

Multi-storey car parks are usually located near other high energy users that may also have requirements for energy storage services. Higher onsite usage of electricity often maximises the financial returns of PV systems through self-consumption. Additionally, being significantly higher than ground level car parks they can also potentially suffer less shading related issues, although this is not always the case. Finally, some shelter from wind and rain may also be more beneficial for users of a top deck multi-storey car park than a surface car park.

Image courtesy of Autonomous Energy (www.autonomousenergy.com)

Car park layouts

Organisations can significantly increase the financial performance of multifunctional solar carports by choosing appropriate sites for their installation. There can be a trade-off between maximising financial performance and maximising renewable energy generation. It is therefore important that the customer chooses early-on which strategy is most consistent with its values.

The car park layout that lends itself most favourably to low-cost solar carport installation is long, double rows of flat surface parking adjacent to high energy users. Hospitals, airports, retail parks and large commercial premises often present such layouts.

For maximum financial performance, the developer is advised to select locations which fulfil the greatest number of criteria in Table 1, which shows how several site selection and design factors will impact on Internal Rate of Return (IRR). The factors are grouped into three levels; high, medium and low, depending upon their relative impact on the financial viability of a multifunctional solar car park project. Developers should focus their attention on satisfying the criteria for the higher and medium levels if they wish to maximise the financial performance of the project.

Table 1 Site selection and design factors impact on project financial viability

Impact	Site selection and design factors
HIGH	**Distribution network capacity** The distribution network connection capacity at the location of the solar carport is an important design factor that can limit the capacity of the system. The Distribution Network Operator (DNO) can advise on the cost of connection. If there is little capacity available, the cost of distribution network connection can increase dramatically. Onsite management of energy flows through energy storage and/or use of export limiting devices can be used to mitigate against this issue.
HIGH	**Onsite energy usage** Onsite energy usage (i.e. self-consumption) of the electricity generated typically gives the greatest returns. With retail electricity costing between 9-13p/kWh[29], it makes financial sense to consume as much of the generated solar electricity onsite and/or selling it to nearby energy consumers - including EV users.
HIGH	**Car park type** There are some significant differences between installing solar carports on surface car parks and on the top deck of multi-storey car parks. These should be considered at an early stage of the site selection process. A structural assessment must be completed to determine the loading capabilities of a multi-storey car park. Costs are usually lower for surface car parks than for top decks of multi-storey car parks.
MEDIUM	**Grants and incentives** There are a number of grants and incentives available for multifunctional carports. The installed system may need to meet certain criteria to be eligible for specific incentives and deadlines may need to be met to qualify.
MEDIUM	**Shading** Care should be taken to avoid current and future shading of the solar carports as this negatively impacts performance. Consideration should be given to the proximity to trees, avoiding areas with Tree Preservation Orders and any future plans for construction or extending adjacent properties. Unavoidable shading can be mitigated through good system design.
LOW	**Annual solar potential** Annual solar potential is the amount of sunlight falling on a given location in the UK. The UK receives between 800-1200 kWh/m2 per year of horizontal solar irradiation, with the South receiving more than the North. Local weather conditions and soiling of PV modules can have a significant impact on solar generation and system performance.
LOW	**PV array orientation** Aligning PV arrays to the optimal south-facing orientation is often not possible due to existing car park layouts. Depending on the onsite energy requirements, it may be more beneficial to orientate the carports on an east-west alignment to provide a longer generation day. Car park redevelopments and resurfacing may present opportunities to optimise a solar car park layout. The performance of monopitch carport systems are more effected by orientation than duopitch systems (see Table 3).
LOW	**Carport frame** V-frames are the most cost-effective design, with T-frames being approximately 10% more expensive due to the additional steel used. Portal-frames can also be a cost effective design as they can support larger solar arrays compared to other designs (see Table 3).
LOW	**Carport rows** Foundation costs vary in accordance with site ground conditions and typically there is little difference in the foundation costs for both single and double row structures. The most cost-effective structures to install are long rows of double row carports.
LOW	**Surface inclination** Car parks with an inclined surface need to consider the effects of water run-off. Guttering is required to manage drainage onsite which can increase the cost of a solar carport depending on design orientation and expected run-off.

Other considerations

In addition to the solar carport structures, consideration needs to be given to the location of key system components such as the inverters, batteries, EV charge-points and point of connection to energy consumers/ distribution network.

Certain components will need to be protected from direct sunlight and/ or water ingress. In addition in order to reduce system losses, distances between key components should be kept to a minimum. Please refer to the BRE Technical Guide to Solar Car Parks for more information.

At present there is no National Planning Guidance requirement for the number of EV charge-points to be installed for new non-domestic developments. A number of Local Authorities have developed local strategies for EVs, requiring 1 EV charge-point per 10 unallocated parking spaces. Table 2 details the recommendations made by the Low Emission Partnership for new planning applications of different development types.

29 Prices of fuels purchased by non-domestic consumers in the UK (BEIS, 2017)

Table 2 Recommended number of EV charge-points for new developments[30].

Development Type	Basic	Standard	Advanced
Leisure and Retail	1 point per $200m^2$	2 points per $200m^2$	3+ points per $200m^2$
Business, Higher Education and Hospitals	1 point per $200m^2$	2 points per $200m^2$	3+ points per $200m^2$
Hotels and Residential Institutes	1 point per 30 rooms or per 10 parking spaces	2 points per 30 rooms or per 10 parking spaces	3+ points per 30 rooms or per 10 parking spaces

Park Mark – The Safer Parking Scheme

The Safer Parking Scheme is managed by the British Parking Association (BPA). It is a voluntary standard for UK car parks that helps to ensure the safety of people and vehicles, and crime reduction, through good lighting design, safe pedestrian and vehicular access, surveillance, signage and management. Over 5,000 carparks have been awarded the Park Mark. More information can be found at www.britishparking.co.uk

PARK MARK SAFER PARKING

Image courtesy of Schletter (www.schletter-group.com)

30 Low Emission Topic Note 1 - Provision of EV charging points via planning agreements (Low Emission Partnership, 2013)

Carport design

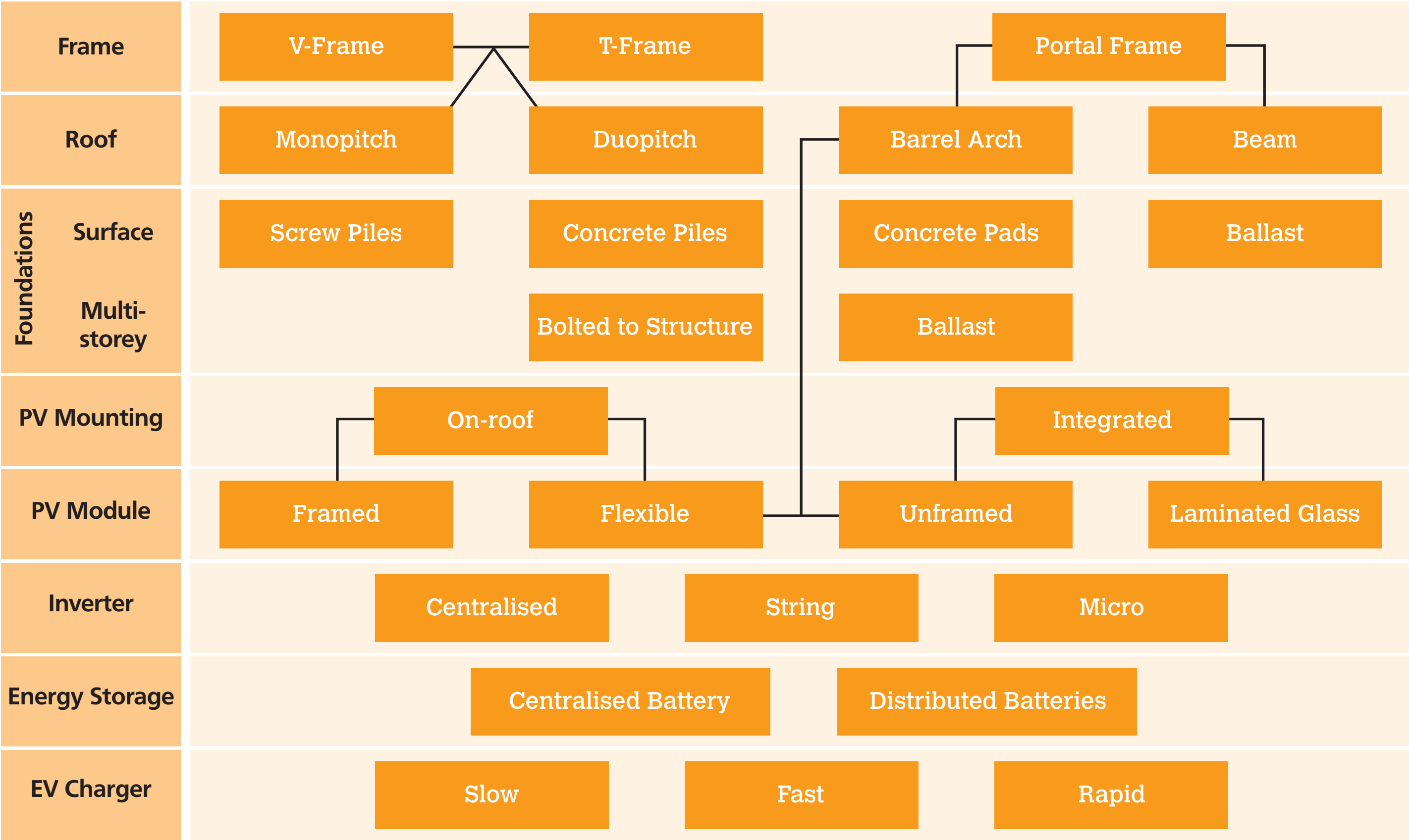
In this section we will discuss the principal components of carports: frames, roofs, foundations, PV systems (i.e. PV module, PV mounting system and inverter), energy storage and EV charge-points.

Solar carports range from basic, modular structures aimed to maximise financial performance, to bespoke designs which aim to make an architectural statement. Bespoke designs typically feature lower PV capacity and higher installation costs.

Design options

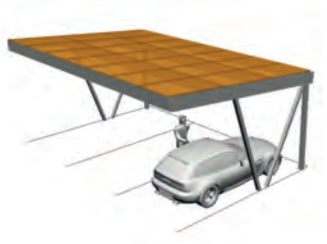
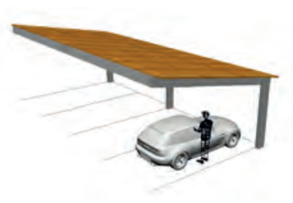
Multifunctional carports present a wide range of design options and technology choices, these have been mapped out in Figure 1.

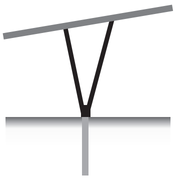
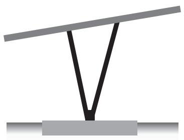
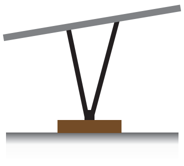
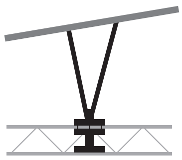
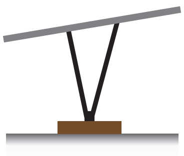
Figure 1 Common multifunctional solar carport design options



Each option has its own relative advantage and disadvantage depending on the site and required functionality of the system. The most common options are presented in Table 3.

Table 3 Advantages and disadvantages of common carport design options

	Carport design option	Advantages	Disadvantages
FRAME	 V-Frame	• Safe space for electrical equipment to be mounted inside the V frame. • Diagonal struts can be positioned to not obstruct vehicle access. • Reduced cantilever frame reduces costs of structure.	• Diagonal struts can obstruct vehicle access on single row arrangement. • Design and installation of guttering system is more complicated.
FRAME	 T-Frame	• Fewer roof supports. • Carport span can be longer, providing more parking spaces per carport. • Electrical equipment can be accommodated within the carport structure.	• Increased cost due to extra steel required for cantilever. • Increased cost of installation due to weight of structure.
FRAME	 Portal-Frame	• Provide full shelter to carpark users. • Largest generation surface. • Diagonal struts do not obstruct vehicle access. • Steeper pitch may generate more electricity.	• Increased cost due to extra steel required for full coverage. • Electrical equipment may need to be located outside carport structure to protect it from accidental damage. • Requires parking bays to be orientated between south-east and south-west. • Extra steel (cost) required for accommodating taller vehicles. • Self-shading of PV modules may occur. • Barrel arch may require flexible modules which can be more expensive.
ROOF	 Duopitch	• Parking bays can be orientated in any direction and still achieve good performance.	• Extra steel (cost) required for accommodating taller vehicles.
ROOF	 Monopitch	• Can accommodate different height vehicles. • Available in double row structures which are the most cost effective frame option.	• Requires parking bays to be orientated between south-east and south-west. • Design and installation of guttering system can be more complicated.

	Carport design option	Advantages	Disadvantages
FOUNDATIONS (SURFACE)	 Screw Piles	• Normally the most cost effective option. • Quick to install. • Good for un-level sites. • Can be removed and recycled at end of life. • Only a small area of carpark surface needs to be removed for each pile.	• Not suitable for all sites. • Size and type of screw piles is site specific and dependent on ground conditions. • Requires specialist equipment.
	 Concrete Piles	• Suitable for a wide variety of ground conditions & variations in level. • Typically come pre-cast and quick to install. • Requires less concrete than a concrete pad.	• Requires more carpark surface to be removed than screw piles. • Can be difficult to remove the concrete pile at end of life. • Requires specialist and noisy equipment. • Concrete is 'CO_2 expensive'
	 Concrete Pads	• Does not require specialist equipment.	• Requires significant amount of concrete which then needs to be removed at the end of life. • Additional time required for pads to cure.
	 Ballast	• Typically surface penetration is not required. • A good option for rocky ground conditions or when sites are sensitive to ground penetration (i.e. because of archaeology or underground infrastructure). • Can be removed and reused at end of life.	• Can be an expensive. • Not suitable for un-level sites. • Takes up valuable car parking space
FOUNDATIONS (MULTI-STOREY)	 Bolted to structure	• Normally the most cost effective option. • Provides the best method of transferring loads to the structure. • Fixing points can be included in new multi-storey carpark designs.	• Not suitable for all sites, suitable structure may not be available in required locations. • Restricts solar carport layout.
	 Ballast	• Typically surface penetration is not required. • Can be removed and reused at end of life. • Simpler to retrofit to an existing multi-storey carpark.	• Not suitable for all sites, ballast required can exceeded the loading capabilities of the structure. • Exposed areas will require significant amounts of ballast. • Can be an expensive. • Takes up valuable vehicle space.

	Carport design option	Advantages	Disadvantages
PV MOUNTING	On-roof (see Figure 2)	• Can simplify design. • Uses commonly available components from solar industry (i.e. for roof mounted PV).	• Additional cost for installing a double roof covering (i.e. sheet roofing and PV modules). • Frame and foundations need to support additional weight.
	Integrated (see Figure 3)	• Provides a single watertight roof structure. • Considered to be more aesthetically pleasing. • Mounting designs can provide additional protection to electrical components. • Can provide natural lighting into parking bays.	• Can require specialist PV modules and mounting systems
PV MODULE	Framed (see Figure 2)	• Commonly available and most cost effective option. • Structural integrity comes from aluminium frame. • Available with all solar cell types including high efficiency.	• Some PV module manufacturers will not allow use in non-standard mounting systems (i.e. not on-roof). • Frames can trap dirt on shallow pitches.
	Unframed (see Figure 3)	• Lighter than framed and glass laminate modules, therefore can reduce steel required for structure. • Available with all solar cell types including high efficiency. • Less embedded carbon.	• PV module manufacture will need to sign-off mounting system design.
	Glass-laminated (see figure 4)	• Solar cells are encapsulated between two sheets of strengthened glass allowing natural light to pass in to parking bays. • Underneath of module is stronger than single sheet modules.	• Additional glass layer makes module heavier than standard modules and more expensive. • Tend to only be available with monocrystalline cells which are more expensive.
	Flexible (see Figure 5)	• Good for covering curved roofs or roofs with weight restrictions. • Can be adhered to a wide range of roof coverings. • Usually non-reflective so a good solution for areas sensitive to glint and glare.	• Tend to only be available as a thin-film technology. • Can be an expensive option.

Figure 2 Example of on-roof mounting of framed PV modules.
Image courtesy of Evoenergy (www.evoenergy.co.uk)

Figure 3 Example of in-roof mounting of unframed PV modules.
Image courtesy of Sunpreme (www.sunpreme.com)

	Carport design option	Advantages	Disadvantages
INVERTER	Centralised	• Commonly used for large solar carparks or where centralised energy storage is to be incorporated. • A cost effective solution for installs >500kW. • Quick installation. • Less susceptible to accidental damage or vandalism due to being installed within a container or purpose built building. • Inverter housing can also accommodate other operational equipment (i.e. monitoring and metering).	• Requires additional space (typically two facing parking bays per 1MW). • Larger number of PV modules are connected together therefore system downtime can cause greater losses in generation. • Larger cables and additional circuit protection is required. • Not recommended for multi-storey carparks.
	String	• These are usually accommodated within the carports (1 every 20 parking bays). • Easily configured for dual orientation layouts. • Fewer PV modules are connected and therefore downtime has less impact than central inverters.	• Can be more susceptible to accidental damage or vandalism. • Not always possible to get a like-for-like replacement as string inverter models are often discontinued.
	Micro	• One micro inverter is required every one or two PV modules. • Maximises performance on systems with multiple orientations, shading and potential for soiling (i.e. near the coast). • Provides module level monitoring. • Converts DC to AC at the module, reducing risk and improving system efficiencies.	• Can be an expensive option for systems that will not realise the performance enhancement of individual module power management. • More components to install and maintain. • Can be more susceptible to accidental damage or vandalism.

Figure 4 Example of in-roof mounting of glass-laminated PV modules.
Image courtesy of Si-Module (www.si-module.com)

Figure 5 Example of in-roof mounting of flexible PV modules.
Image courtesy of Solar Constructions (www.solar-constructions.com)

	Carport design option	Advantages	Disadvantages
ENERGY STORAGE	Centralised battery	• Typically containerised fully packaged system with integrated temperature control, fire detection systems etc. • Prefabricated, fast delivery and installation • More cost effective (£/kWh). • More capacity equals better management of power flows (i.e. EV charging & solar generation). • Potential to provide additional services to third parties when storage is not required onsite. • Less susceptible to accidental damage or vandalism due to being installed within a container. • Can be retrofitted to a solar carpark system at any time. • Wide variety of technologies available. • Leasing options are available.	• Requires additional space for installation and access (typically two facing parking bays per 800kWh). • Modular system with fixed increments limiting bespoke system sizing. • Less flexibility to retrofit additional capacity in containerised system.
ENERGY STORAGE	Distributed batteries	• Typically a packaged battery system. • These are usually accommodated within the carports alongside the string inverter (1 every 20 parking bays). • Less space required. • Can be retrofitted to a solar carpark system at any time. • Typically Lithium Ion batteries are specified – good efficiency and cycling. • Can be specified to suit particular site requirements.	• More expensive due to multiple components. • Connection of smaller batteries to EV charge-points will reduce battery life (due to high cycling). • Batteries need to be protected from direct sunlight and water ingress.
EV CHARGE-POINTS	Slow (Up to 3kW)	• Can be used for long stay and overnight parking (i.e. airports and hotels). • Multiple EV charge-points can be installed without necessarily requiring a distribution network upgrade.	• Slow EV charge-points are being phased out in public locations due to long charging rates (around 6-12 hours for EVs and 2-4 hours for PHEVs). • EV charge-points tends to only serve one vehicle.
EV CHARGE-POINTS	Fast (7-22kW)	• EVs can fully recharge in 2-5 hours. • The most common type of EV charge-point found in carparks. • Almost all EVs and PHEVs can use a fast EV charge-point. • Leasing options are available.	• Costly distribution network upgrades may be required for multiple EV charge-points. • Load balancing may be employed to limit the overall consumption of multiple EV charge-points
EV CHARGE-POINTS	Rapid (43-150kW, up to 350kW)	• Able to provide an 80% charge in around 30 minutes. • Good for short stay parking (<1 hour). • Leasing options are available.	• Costly distribution network upgrades are usually required. • Not all EVs and PHEVs are rapid charge enabled.

Performance

In order to get the most benefit from a multifunctional system it is important to understand what functions can be provided. Standard PV systems provides the most benefit through delivery of 'free' electricity and reducing the amount of grid electricity purchased. Matching generation with demand therefore provide the most benefit. A duopitch roof with an east-west orientation will provide a longer generation period throughout the day providing a good match for daytime loads.

Sites that require energy during the night (i.e. for lighting) or have spikes in their daytime consumption (i.e. as a result of EV charging), may benefit from the incorporation of energy storage. Energy storage can bridge the energy gaps between supply and demand, storing any surplus solar generation for use at night or when daytime loads exceed generation levels.

Energy storage can also help avoid consuming electricity at high tariff prices by charging the battery at times when electricity is cheaper/free and consuming it when prices are high. Understanding the energy usage profile (daily, weekly and seasonally), electricity charging structure and sizing a system accordingly is important for maximising system performance.

The incorporation of energy storage may also bring additional financial benefits through providing network services or supporting a third-party consumers.

Monitoring and metering

System monitoring is important for the management and operation of a multifunctional solar carport. Energy storage devices have battery management systems (BMS) that work alongside solar inverters to manage the energy flows of generation, consumption, import and export, to optimise performance of the required operation.

EV charge-points also have their own inbuilt control systems that can be networked together to manage the charging of multiple vehicles under different prescribed charging regimes. Smart EV charge-point solutions are now being developed with load management that can adapt operation depending on demand and supply limitations.

Typically control systems are set up and managed remotely by an off-site operations and maintenance (O&M) contractor, therefore availability of a mobile network signal or hardwired internet connection is an important consideration.

Additional metering will be required on a multifunctional system to record the amount of solar energy generated and any energy exported to the distribution network or a third-party. There will also be additional metering for any components that are leased, such as the battery and/or EV charge-points. Usually these are GSM meters that send data direct to a meter operator over a mobile data network.

BREEAM implications on multifunctional solar carports

BREEAM (Building Research Establishment Environmental Assessment Method) is the world's leading sustainability assessment method for infrastructure and buildings. The BREEAM assessment process evaluates the procurement, design, construction and operation of a development on a scale of Pass, Good, Very Good, Excellent and Outstanding. When connected to a building, a multifunctional solar carport can contribute towards the BREEAM rating of the building in a number of its categories.

BREEAM criteria are designed to avoid setting prescriptive requirements; instead they are intended to be outcome-focussed. For example, in terms of energy, BREEAM will typically reward the total reduction in carbon emissions, rather than being prescriptive about how the carbon emissions savings should be achieved. At present, a multifunctional solar carport can contribute to achieving BREEAM credits in the energy category through reduction of energy use and carbon emissions and low carbon design. From 2018, additional BREEAM credits will be available under the transport category for the provision of EV charge-points (capability to provide charging for at least 3% of total car parking capacity) and for a demonstration that vehicles using EV charge-points have lower carbon emissions than their petrol or diesel counterparts.

These general provisions cover a number of BREEAM certification schemes including New Construction, In-Use and Refurbishment and Fit-Out.

BREEAM®
delivered by bre

Planning permissions

Planning permission is generally required for solar carports. However, if a Local Development Order (LDO) exists which includes provision for solar carports then planning permission may not be required. The use and application of LDOs by Local Authorities varies widely, so you should always check if planning permission is required even if an LDO is in place.

Solar carports are classified as 'erection/alterations/replacement of plant and machinery', incurring a fee of £385/0.1 hectare (or part thereof up to 5 hectares)[31].

Planning application

It is advisable to seek pre-application planning advice early during the project, for confirmation of fees and required documents. Obligatory documents that need to be submitted for a full planning application are: site plan, location plan, the planning application form, and design and access statement[32].

The planning application process usually takes 8 weeks, although Local Authorities can use LDOs to streamline the planning application process for specific types of development within a defined area. LDOs create certainty and save time and money for those involved in the planning process.

In addition to the above documents, additional information may be required by your planning case officer. Solar carport designers should be able to provide the following:

- Specification of the proposed key multifunctional carport components (e.g. PV modules, inverters, storage and EV charge-points).
- Structural and foundation details.
- Drainage and surface-water management plans.
- Distribution network connection details.
- Glint and glare impacting the surrounding environment .
- Details of construction and decommissioning, including associated construction traffic management plans and compounds for material storage and contractor parking.

Distribution network connection

Applications to connect a power generating source to the electricity distribution networks are covered by the Energy Network Associations (ENA) Distributed Generation Connection Guides G83, G59, and/or G100[33] depending on the installed capacity of the system (PV and storage) and whether it has an export limitation device.

Distribution network connection applications should be made to the local DNO at an early stage, to ascertain the network connection capacity. DNOs will need to be notified about any planned increase in energy generation (i.e. PV and storage) and any changes in energy consumption (i.e. installation of EV charge-points)[34]. Combining all the planned elements as one multifunctional system may reduce the need for costly network reinforcements. More information about the distribution network connection process can be found in the BRE Technical Guide to Solar Car Parks.

Image courtesy of Autonomous Energy (www.autonomousenergy.com)

31 https://ecab.planningportal.co.uk/uploads/english_application_fees.pdf
32 www.planningportal.co.uk
33 http://www.energynetworks.org/electricity/engineering/distributed-generation/dg-connection-guides.htm
34 http://www.energynetworks.org/electricity/futures/electric-vehicle-infrastructure.html

Regulations

There is a wide range of regulations and standards that relate to the design, installation and operation of a multifunctional solar car parks and their interactions with users. The BRE Technical Guide to Solar Car Parks provides information on how to comply with relevant guidelines and standards. The most important guidelines that need to be considered are detailed below.

PV system standards

Recommended good practice is to design, install and operate solar installations to meet the requirements of the 'IET Code of Practice for Grid Connected Solar photovoltaic Systems'[35]. It is aimed at ensuring safe, effective and competently installed PV systems (including battery storage) up to 50MW that comply with relevant UK and international standards.

Energy storage standards

There are numerous codes, standards and other sources of information on the installation and operation of energy storage systems[36]. A battery installation will need to comply with standards specific to its battery type (such as lead acid, lithium ion, flow batteries etc.), as well as compliance with electrical installation standards[37]. Standards for overall system planning and performance are currently being developed[38].

The 'IET Code of Practice for Electrical Energy Storage Systems'[39] presents the safe, effective and competent application of low voltage electrical energy storage systems. Aligned with existing standards, regulations and guidance it provides information on design, installation and safety considerations.

EV charge-point standards

The 3rd version of the 'IET Code of Practice for Electric Vehicle Charging Equipment Installation' is expected to be released in 2018. This covers the installation, physical and electrical installation requirements and specific requirements for installing EV charge-points in locations such as commercial and industrial premises.

Building Regulations

Carports are classified as buildings and must comply with the Building Regulations[40], in particular the following sections from Schedule 1; Part A: Structure, Part B: Fire Safety, Part C: Resistance to contaminants and moisture, Part H: Drainage and waste disposal, Part K: Protection from falling, collision and impact and Part P: Electrical safety. The land owner is ultimately responsible for complying with the relevant planning permissions and Building Regulations and will be liable for any remedial action.

Wind loadings

This is particularly important for multi-storey carpark installations as wind loading increases the higher the structure is off the ground. Full wind loading calculations should be completed in line with 'BS EN 1991-1 Eurocode 1: Actions on structures', defining the wind loadings specific to the UK, to ensure the solar carport frame, foundations and the structure it is attached to can withstand the potential wind and, where relevant, snow loads. For further considerations of wind loading specifically for variations of roof-mounted PV, reference can also be made to BRE Digest 489[41].

Impact from vehicles

Solar carports should be designed to withstand vehicles impacting the structure at speeds of up to 20mph as described in 'BS EN 1991-1-7: General Actions. Accidental Actions'.

Overhead glazing regulations

Carports should only be accessed from underneath the roof structure as the PV glazing is classified as a fragile roof. Consideration should be given to both the potential risk of the PV glazing being broken from above and underneath the carport. 'C632 Guidance on glazing at height' provides guidance on assessing and mitigating the risk through good design and product selection.

Lighting regulations

Car park lighting levels are specified in 'BS 5489-1:2013 Lighting of roads and public amenity areas'. Adequate lighting promotes a sense of security for car park users and also protects against legal liability for claims resulting from vehicle collisions at low light levels. Good lighting design can save energy and avoid light pollution.

Car park layout regulations

'The Manual for Streets', published by the Department of Transport, provides standardised dimensions of parking bays depending upon the car park function. The Environment Agency has also published 'pollution prevention guidelines' on control of surface water-runoff in car parks.

3D rendition of Smart Energy Grid demonstrator project, courtesy of Bouygues Energies & Services (http://www.bouygues-es.com/)

35 Code of Practice for Grid Connected Solar Photovoltaic Systems (IET, 2015)
36 BS EN 61427-2:2015 Secondary cells and batteries for renewable energy storage. General requirements and methods of test. On-grid applications (BSI, 2015)
37 BS 7671:2008+A3:2015 Requirements for Electrical Installations. IET Wiring Regulations (IET/BSI, 2015)
38 IEC TS 62933-3-1 Electrical Energy Storage (EES) systems - Part 3-1: Planning and performance assessment of electrical energy storage systems - General specifications
39 Code of Practice for Electrical Energy Storage Systems (IET, 2017)
40 http://www.legislation.gov.uk/uksi/2010/2214/schedule/1/made
41 Wind Loads on roof-mounted p vand solar thermal systems (P Blackmore, 2014)

Procurement

Public sector

At present the public sector must use tendering processes compliant with the Official Journal of the European Union (OJEU) for projects exceeding a specific threshold, which is published each year[42]. Completing an OJEU tender takes time, money and resource. Several procurement organisations operate OJEU-compliant frameworks that reduce the administrative requirement of tendering by offering a list of pre-accredited suppliers. Public sector organisations not operating under any existing framework and with sufficient internal expertise may wish to procure a carport developer directly. Some examples of existing procurement routes are detailed below.

ESPO framework 636 Vehicle Charging Infrastructure

Eastern Shires Purchasing Organisation (ESPO) is a public sector purchasing consortium which is dedicated to providing all parts of the public sector with procurement solutions to cut costs, reduce tendering times and offer quality products and services. ESPO's framework (reference 636) for 'Vehicle Charging Infrastructure' is a national framework offering public sector customers with low emission vehicles a comprehensive range of charging solutions from the leading providers in the market[43]. It includes the purchase and lease of the latest EV charge-points, installation, maintenance, and back office services. It also has specific provision for emerging technologies, which includes the supply of solar carport charge-points. Standard products can be purchased directly at given prices or quotations can be sought for bespoke solar car park projects[44].

RE:FIT framework

RE:FIT provides a commercial model for public bodies wishing to achieve substantial financial cost savings, improve the energy performance of their buildings and reduce their carbon footprint. Energy Service Companies (ESCos) implement the energy efficiency measures and guarantee the level of energy savings over an agreed payback period, thus offering a secure financial saving over the term of the agreement. In order to benefit from the RE:FIT scheme a public sector body should identify a solar carport project as an Energy Saving Measure (ESM) and bring it to the attention of the local RE:FIT Programme Delivery Unit (PDU).

Private sector

Private sector organisations often have delivery partners for facilities management, construction and more specifically for PV installations.

There are many companies that offer commercial PV systems, however, one should ensure that such companies' experience includes the complex project management skills required in solar carport installation. Even large nationwide contractors tend to subcontract much of their solar carport design and delivery to specialists.

Through running a tendering process, private sector organisations can attract competitive offers from multiple engineering, procurement, and construction (EPC) contractors. Getting the technical specification of a tender right is key to a successful tendering process. Too little information may result in a wide range of offers that are incomparable, too much information may stifle innovation and restrict component choice, resulting in uncompetitive bids.

Typical project timescales

Before breaking ground several months of preparatory work is required. Figure 6 details the main stages of the project and the key tasks to be completed. Timescales for project completion are site specific and will vary considerably depending on the complexity of a site and its restrictions.

Figure 6 Typical project timescales

Feasibility 2-4 weeks

- Feasibility study - initial system layout
- Preliminary network and planning enquiries
- Business case formation

Development 6-12 weeks

- Distribution network connection application
- Planning permission application
- Surveys - structural, ground condition etc.
- Procurement

Delivery 2-8 weeks

- Installation
- Commissioning
- Accreditation

More information

Multifunctional solar car parks can provide flexible onsite renewable electricity generation contributing to the operational energy requirements of the car park (including lighting and EV charging) and any associated buildings. Through the inclusion of other complimentary technologies such as storage, energy can be managed more effectively onsite, making solar car parks a viable investment proposition leading to the provision of better parking facilities for customers and employees.

This guide has presented an overview of how to develop the business case for multifunctional solar car parks on either a surface or multi-storey site, either as a new car park or retrofitted to an existing car park. More detailed information on solar car parks is presented in the BRE Technical Guide to Solar Car Parks. For project support please contact BRE National Solar Centre at nsc@bre.co.uk

42 https://www.ojeu.eu/thresholds.aspx
43 https://www.espo.org/Frameworks/Fleet-Highways/636-Vehicle-Charging-Infrastructure
44 For more information email place@espo.org

Case studies

These case studies describe a selection of multifunctional solar car park projects. Examples from a range of countries have been chosen to indicate the diversity of international regions and site end uses that multifunctional solar car parks are now operating in.

United Kingdom

Location	England
Site use	Manufacturing
Client	Large Manufacturing site
Solar capacity	2.7MWp
Parking bays	1,350

Set to become the UK's largest solar carport system to date, the bespoke structures designed and manufactured by FlexiSolar, will shelter approximately 1,350 car parking spaces. The manufacturing site already demonstrates a strong commitment to PV as an onsite generation technology. Over a 30 year period, substantial energy cost savings are predicted from the project.

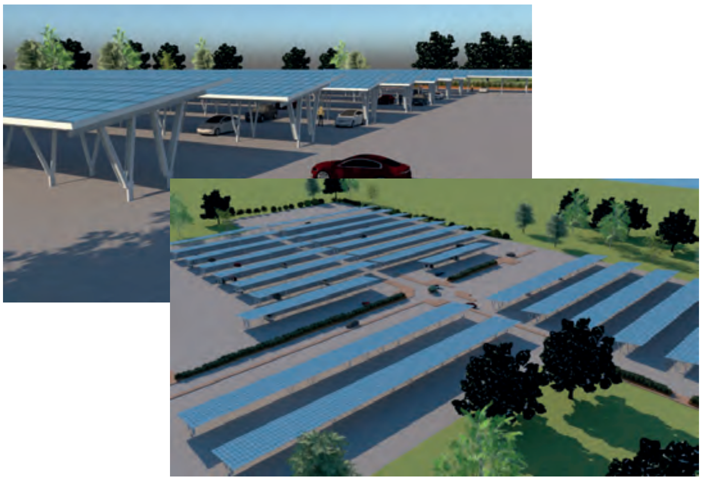


Image courtesy of FlexiSolar (www.flexi-solar.com)

Location	Sutton
Site use	Town Centre Parking
Client	Sutton Council
Solar capacity	133KW

Installed in early 2018 to the top 2 levels of a multi-storey car park, the bespoke solar carport structure from FlexiSolar was part of the car park refurbishment plans, to allow already existing EV charge-points to be more energy efficient. The project came with access limitations and height restrictions which had to be overcome for the successful installation. It is estimated that the 480 module array will generate 116MWh per year, enough to power around 417,000 electric vehicle miles.

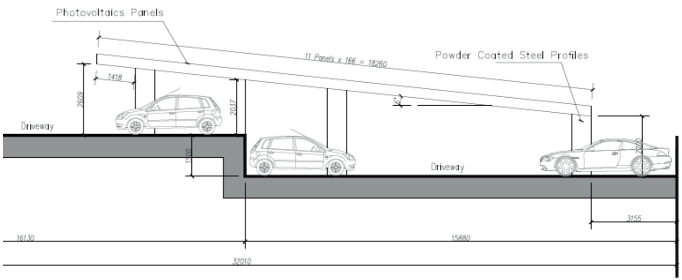


Image courtesy of FlexiSolar (www.flexi-solar.com)

Location	Barnsley
Site use	Town Centre Parking
Client	Barnsley Council
Solar capacity	24KWp
Parking bays	9

As part of the ambitious Better Barnsley town centre redevelopment scheme, Barnsley Council commissioned a bespoke solar carport solution for its new Market Gate Car Park, to generate sufficient electricity to make the carpark lighting energy neutral. The solar carport is based on the FlexiSolar V-Frame construction but was manufactured with modifications to the legs as requested by Barnsley Council to allow for better disabled access. The glass on glass PV modules integrated into this design allows some daylight to pass through the roof without any reduction in electrical efficiency. This configuration improves ambient light levels and provides an attractive finish too.

Image courtesy of FlexiSolar (www.flexi-solar.com)

Australia

Location	Queensland
Site use	University campus
Client	University of Southern Queensland
Solar capacity	1.1MWp
Parking bays	500

Beginning its initial phase of operation in 2017, Autonomous Energy, in partnership with the University of Queensland, developed a multifunctional solar car park to provide electricity to the university campus as well as energy storage capacity. The Toowoomba campus has also benefited through being able generate research data on the effect of solar car park systems on electricity generation, savings and carbon abatement. The installation won the Australian Clean Energy Councils solar design and installation award for solar systems (>240kW capacity). Since its inception the project has resulted in energy savings worth the equivalent of over £0.5 million[45].

Image courtesy of Autonomous Energy (www.autonomousenergy.com)

Brazil

Location	Paranmirim, Rio Grande do Norte
Site use	Industrial factory
Client	SterBom
Solar capacity	310kWp
Parking bays	150

The largest solar car park currently in operation in Brazil, with a total of 1,134 PV modules covering a roofing area 1,884m^2 providing shade and ancillary car park services for approximately 150 vehicles. Electricity generated from the solar car park is consumed onsite due to the high energy uses during solar generating hours. Beginning operation in 2015, this solar car park system represents the majority of the 500kWp of installed PV capacity across the site of the SterBom factory.

Image courtesy of Energia Zero (www.energiazero.eco.br)

France

Location	Rivesaltes
Site use	Logistics centre
Client	La Compagnie du Vent
Solar capacity	13.5MWp

Installed in 2016, 48,378 solar modules are part of the solar carport canopies across the extensive car park at Walon France's logistics centre. 3 of the 64 carports have been set up as a demonstrator for multi-storey car parks, providing solar electricity to co-located EV charge-points and a lithium-ion battery storage system[46].

Image courtesy of Engie Green/ La Compagnie du Vent (www.engie-green.fr)

45 https://www.savingwithsolar.com.au/tag/carpark-solar/
46 https://www.usinenouvelle.com/article/la-compagnie-du-vent-inaugure-une-centrale-solaire-de-13-5-mwc-sur-les-aires-de-stockage-du-logisticien-walon-a-rivesaltes.N448572

Germany

Location	North Rhine-Westphalia
Site use	Airport
Client	Weeze Airport
Solar capacity	4MWp
Parking bays	1,350

This system consists of 66 carports supporting 15,296 PV modules. The airport now welcomes 1.8 million passengers a year and was looking to increase parking facilities whilst providing better weather protection to customers. The 4MW installation was completed within 6 weeks and now supplies solar electricity to the airport and the local electricity network.

Image courtesy of Trina Solar (www.trinasolar.com)

Kenya

Location	Nairobi
Site use	Mixed-use development
Client	Actis
Solar capacity	858kWp
Parking bays	540

Commissioned in late 2015, the Garden City mixed use development in Nairobi incorporates Africa's largest multifunctional solar car park system. Installed on the top floor of a multi-storey carpark, the system supplies electricity to the Garden City development as well as exporting energy to the local distribution network. The system helps to provide security from unpredictable power outages, reducing the requirement and cost of operating back-up diesel generators[47]. The 3,300 solar array is predicted to generate 1,256MWh of electricity per year[48]. In addition, car park users benefit from shading provided by the solar carports[49]. This project was realised through a 12 year financing initiative by NVI Energy Solar Africa.

Image courtesy of Thomson Reuter Foundation (www.trust.org)

UAE

Location	Dubai
Site use	Retail park
Client	Majid Al Futtaim Properties
Solar capacity	128kWp
Parking bays	131

Enerwhere developed a customised solar car park system to support the thriving local shopping centre in the Al Barsha South district of Dubai. Deployed in 2016, the system is connected to the distribution network under DEWA's Shams Dubai Programme[50]. The system is estimated to produce 211MWh of solar electricity per year, saving approximately 114.26 tons of carbon per year.

Image courtesy of Enerwhere Sustainable Energy DMCC (www.enerwhere.com)

47 https://www.pv-tech.org/news/africas_largest_carport_pv_installation_launched_at_kenyas_new_half_billion
48 http://cleanleap.com/kenya%E2%80%99s-solar-clean-leap-africa%E2%80%99s-largest-solar-car-park-garden-city-mall
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