BAUDER

PV DESIGN CONSIDERATIONS

NEW BUILD FLAT ROOFS

1 INTRODUCTION

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The Climate Change Act established a target for the UK to reduce its emissions by at least 80% from 1990 levels by 2050.

"As rooftop solar PV arrays become a consistent element of both new build and refurbishment commercial building specifications it is vital that these schemes have a cohesive design approach that embraces all elements of the project at the planning stage. Understanding the building's energy profile, the impact of the array on the building's fabric and using the highest quality equipment throughout are all vital for success".

In the UK, solar photovoltaic (PV) is the most popular renewable energy and its deployment is rising rapidly across the globe, particularly because climate change and resource scarcity are on the agenda of every government and major corporation in the world. Despite recent UK Government policy changes, the number of large, flat roof installations should still rise as local authorities and businesses look to reduce their carbon footprint and gain energy security for the future.

All too often within the construction industry, photovoltaic specifications focus on energy efficiencies and outputs of the solar panels, omitting to give the same focus to ensuring the rooftop array is installed with methods that have as little impact on the building and its waterproofing as possible and that the array works to its maximum potential for its entire lifespan rather than just becoming a 'tick box' exercise to achieve sustainability credits.

This design guide is aimed at designers considering the inclusion of a PV array on new build flat roof construction projects and outlines the key elements to be mindful of to ensure the design is sustainable, protects the building and meets lifespan expectations.

Contents

Drivers for New Build Applications

Incorporating photovoltaic panels into a design brings all the benefits of low maintenance renewable energy generation to a project. Below are just some of the key drivers for choosing a PV scheme in a new build application:

- BREEAM requirements for buildings often call for site sourced renewables. Minimum of 30% CO_2 reduction from site based renewables is required to achieve maximum credits.
- Satisfying local planning guidelines such as the London Plan, for example the Scottish government has tightened requirements calling for a minimum 1.5kWp per plot for new homes.
- Provide energy security for the future and save money.
- Solar PV is a simple and cost effective method for builders and developers to meet their SAP and SBEM targets, as well as assistance in achieving Part L.

Sizing of PV Systems

The sizing of a PV array can be determined by a number of elements that are often driven by the overall aim of the scheme. In new build applications, common motivating factors are meeting BREEAM, to save money and provide energy security. In these instances the system size will be determined by the following considerations:

Meeting Planning or Part L Requirements

For new build projects, the principal factor that will determine the size of an array will be meeting the buildings energy performance or Part L requirements. The size of the array will be determined by the SBEM/SAP or building energy model.

Usable, Non-Shaded Roof Space

Available roof space will often be the clients biggest limiting factor, particularly for new build applications where the solar array is competing for roof space with other M&E equipment.

Client's Budget

Often a project's financial plan can initially allow for the inclusion of a PV system and capital budget may determine scheme size rather than optimal return on investment or roof size.

Building Energy Consumption

Although often an afterthought on new build schemes, the optimal return on investment will occur if the system is sized to match the building's energy profile. The goal is to provide a solution where all the energy produced is consumed by the building. Buildings that are used predominantly during the day such as; offices, schools and factories are perfectly suited to the energy profile produced by a solar array.

WHY USE PV ON FLAT ROOFS?

A flat roof is often a wasted resource and unlikely to be shaded which makes it the ideal location for a PV array.

A PV array is safe and easy to install and delivers energy close to the point of consumption.

The vast majority of flat roofs are not at eye level and so the PV array is generally hidden from view at street level.

Large commercial or public buildings often have flat roofs as well as the most suitable energy profile to benefit from a PV array.

3 ROOF DESIGN CONSIDERATIONS

HAVE YOU CONSIDERED?

Durability of the waterproofing system is key and its life span should, at a minimum, match that of the PV scheme, as well as be able to withstand any additional access requirements for maintenance.

In new build flat roof construction, the availability of roof space should be considered at concept stage to meet any planning conditions or BREEAM requirements, with other rooftop elements and safe access systems designed and incorporated appropriately.

Meeting BREEAM, Planning, 'Merton Rule' and LZC Technologies

In new build applications, the sizing of the solar PV array will usually be influenced by low or zero carbon (LZC) technology targets either driven by BREEAM or local planning conditions. The array size will be determined by efficiencies of other elements of the building design and so it is important to establish available roofspace and what can be achieved from this area. The maximum outputs from the array can therefore be established as early as possible and help drive decisions on other building elements.

Combining Solar PV and Green Roofs

In urban areas the inclusion of both a green roof and a photovoltaic system can be a prerequisite for the building, which can bring challenges to the designer on how to locate both within the roof area. Where roof space is restricted the two technologies can compete for position and so layering the green roof and PV array so that they can co-habit the same area is a feasible solution.
Ideally, the PV panels should be raised above the substrate and vegetation, allowing the plants to also grow beneath the panels with sufficient light and moisture levels.

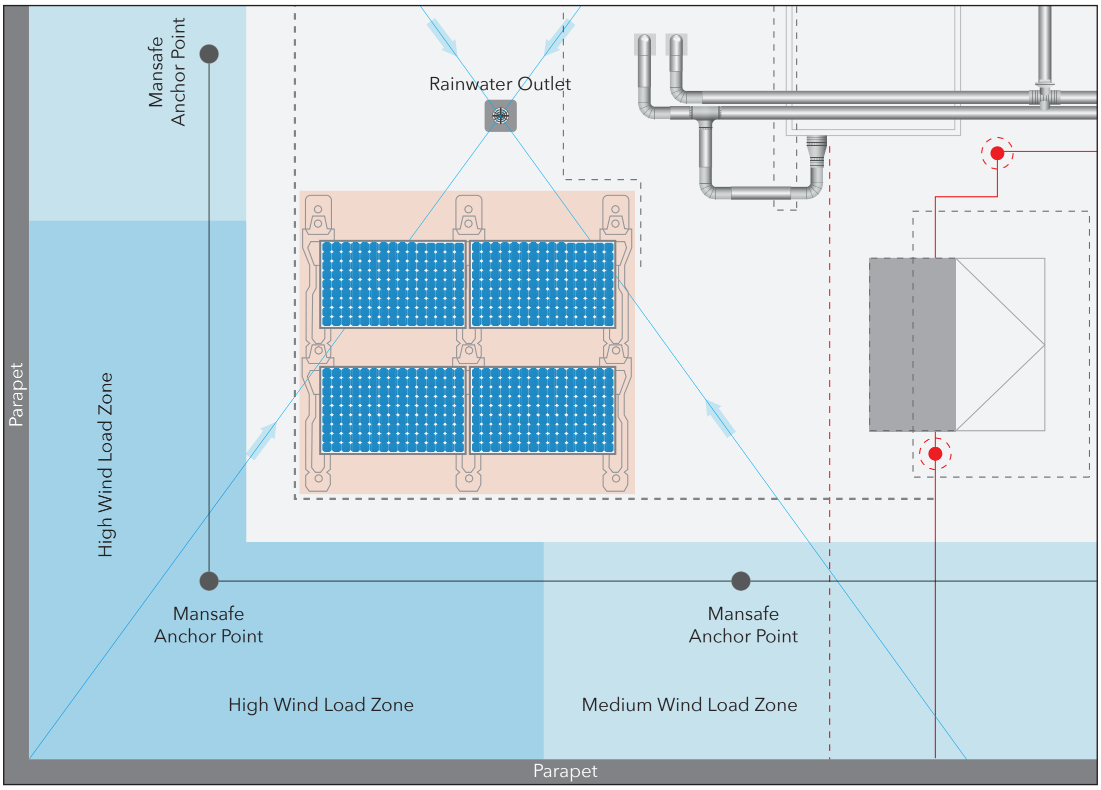
The selection of vegetation and growth height is important so that the plants do not create areas of shading on the panels.

Design Impacts

The weight loading of different systems and their installation methods can be impactful on the construction where a ballasted PV system on a building in an exposed location can impose loads as high as 160Kg/m² compared to other methods of PV installation which could impose as low as 9Kg/m².

The selection and design of a mansafe system or the parapet height required for safe maintenance access can have an influence as they too can create areas of permanent or fluctuating shade that would impact on the output of the PV panels.

The location of the solar array will be determined by a number of factors including wind load zones, other plant and equipment and maintenance access to roof elements such as rainwater outlets.



ARRAY DESIGN AND SHADING 4

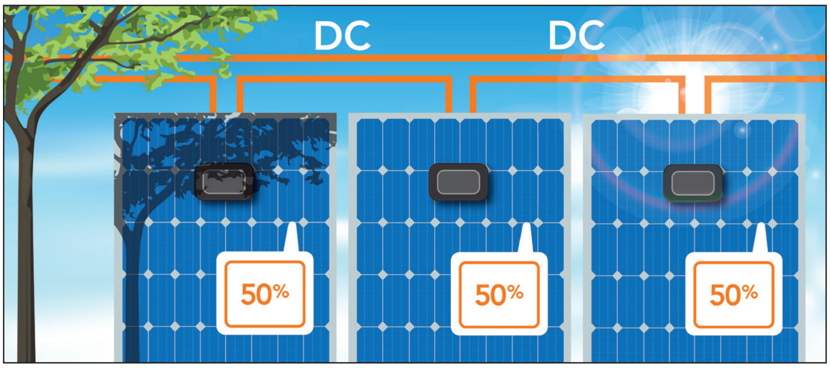
Shading will adversely affect the output of any solar array whether this is from other buildings, rooftop plant, balustrades or tall trees and all efforts must be made to avoid this. The risk of shading should be limited through design of the array and its location, but some shading could be unavoidable, particularly on congested roofs.

Power Optimisation

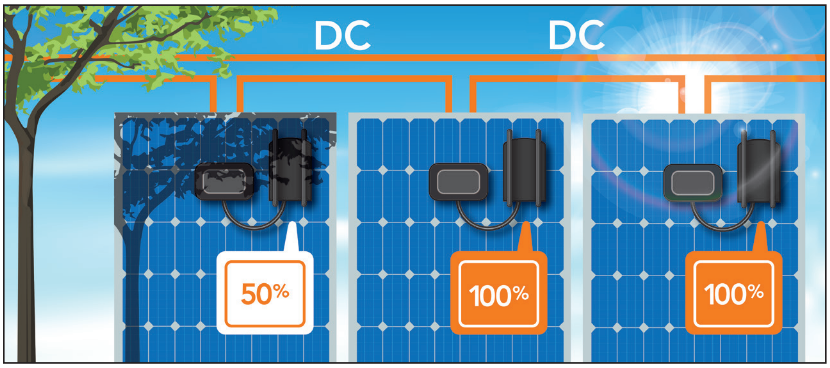
If partial shading of some panels is inevitable the entire string will underperform. Installing power optimisers will mitigate this reduction in efficiency and enable each individual panel in the string to be tracked so that the maximum energy is produced.

A power optimisation system, such as SolarEdge, will track each module's performance individually and provides enhanced capabilities so that full visibility of the system's performance can be scrutinised by the client once the system goes live.

Traditional Inverter



SolarEdge Inverter with Power Optimisation

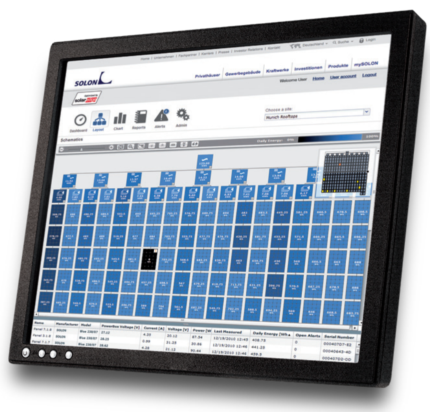


Monitoring the System

A complete monitoring solution increases the reliability by ensuring that issues can be immediately identified and dealt with quickly, providing the most productive performance on a permanent basis.

Most systems will be web-based to give easy access to real time data.

Optimized by solaredge



5 FIXING AND INSTALLATION METHODS

TWO KEY OPTIONS FOR INSTALLATION

There are two fundamental options for fixing a PV system to a flat roof, ballasted or mechanical. A ballasted system adds additional weight to anchor the array to the roof whereas mechanical methods cover two key practises, either they penetrate the roof covering and are fixed to the deck or they do not and leave the waterproofing system intact.

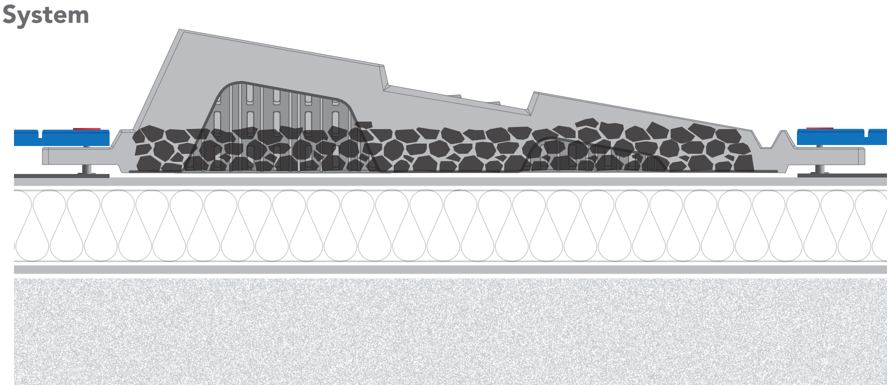
Ballasted Systems

Installing a ballasted PV system requires confirmation from a structural engineer that the additional weight and wind load can be accepted into the design. The ballast itself can take different formats and it is important to confirm that the static load created by the designed ballast will be appropriate and sufficient in accordance with the wind load calculation report.

Where possible, the ballast should allow for a spread of load across the roof rather than any point or line loading.

In all ballasted applications a suitable protection layer must be allowed for and this should be agreed with the waterproofing warranty supplier.

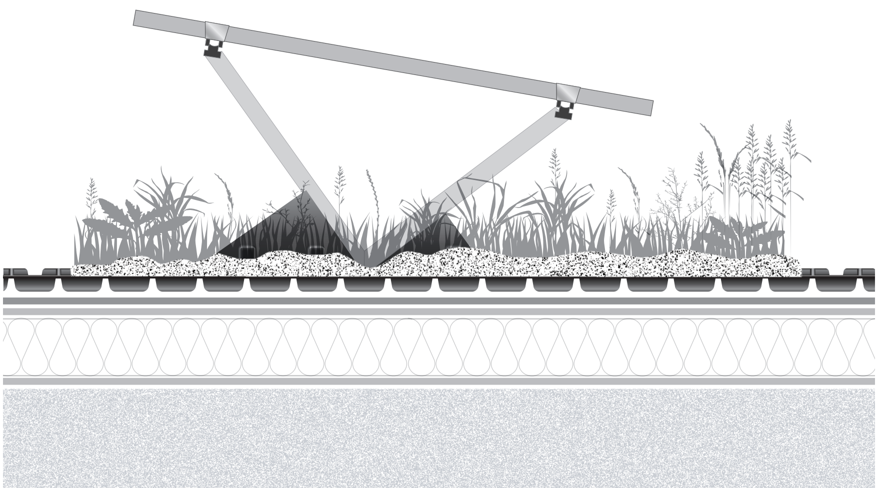
Generic Ballasted System



Bauder BioSOLAR for Green Roofs

The substrate and vegetation provide the ballast to secure the array on the roof.

The entire roof area qualifies as a green roof and if a biodiversity finish is specified this can further enhance the BREEAM credit rating for the roof element.



Mechanically Fixed Systems

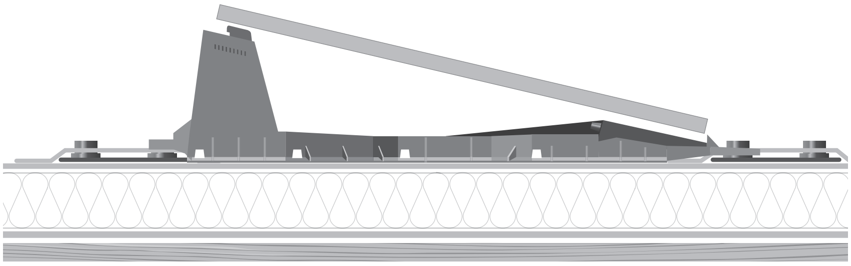
Mechanically fixed solutions are used where ballasted systems are not suitable due to the additional imposed load.

Non-Penetrative Mechanical Fixing

This method is where the mounting system sits completely separate atop the waterproofing via substructures, that are held onto the roof through mounting plates and welding overlying membrane sleeves to the uppermost layer of the waterproof covering.

These systems typically have large and stable attachment footprints with fixing tolerances that allow for levels of movement to occur without detriment to the entire stability of the array.

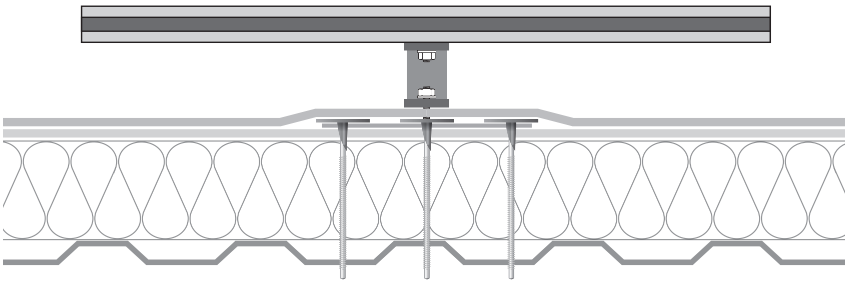
BauderSOLAR for Flat Roofs

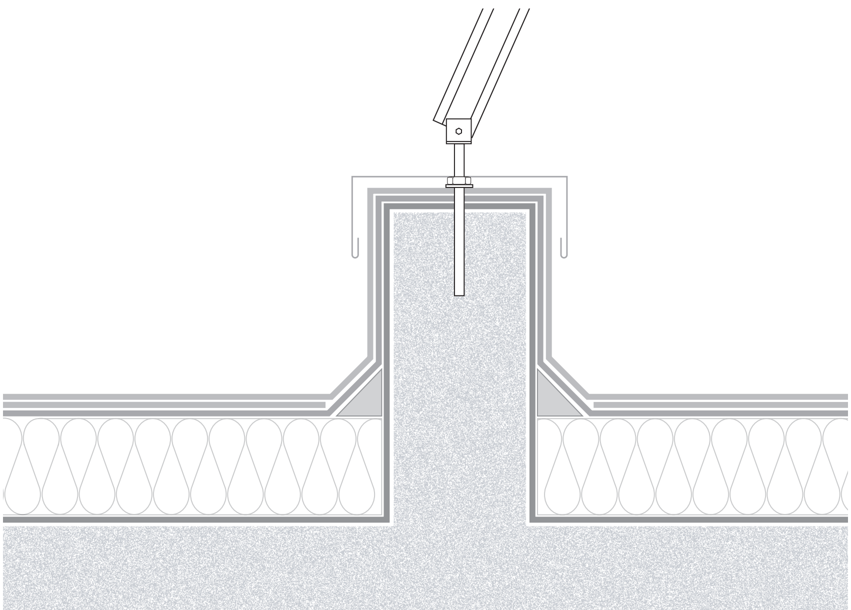


Penetrative Mechanical Fixings

These also have two generic forms where the array is installed either via the creation of a plinth or a proprietary fixing post, the size and shape of which can have an impact on the safe waterproofing and thermal continuity of the roof. These forms of attachment can be the only option in pitched membrane applications or where wind loads are particularly high.

These illustrations show typical detail designs for penetrative mechanical fixings.





PAUSE FOR THOUGHT

Any penetration of the roof structure and its waterproofing increases risk and could invalidate the manufacturer’s guarantee.

Does a penetrative mechanically fixed system really need to be specified or is another installation method possible?

6 SIX STEPS TO DELIVER A PV SYSTEM

PRESTART CHECKLIST

1: ROOF LAYOUT

- [ ] Any obstructions?
- [ ] Any shading items?
- [ ] Cable penetration location & type?
- [ ] Fixing method?

2: INVERTER / SOLAR CABLE / ENGINEERING

- [ ] Inverter location?
- [ ] Solar cabling location?
- [ ] Meter type?
- [ ] Remote supervision & monitoring system required?

3: START DATES

- [ ] Estimated project start date
- [ ] Delivery lead time required

4: SCOPE OF WORK

- [ ] Site inspection
- [ ] Network connection G83 or G59?
- [ ] AC side works required?
- [ ] Lightning & surge protection

Full print version available on our website:

bauder.co.uk/technical-centre

STEP 1: Delivering the Brief

Be clear about the key factors to be achieved when meeting with your preferred selection of manufacturer/suppliers to cover:

- Why PV is to be included in the building design?
- What is the scheme to achieve? Including the size/output required from the array.
- Site locations that need to be taken into consideration such as shading by overhanging trees or nearby buildings and rooftop plant and equipment etc.

STEP 2: Design and Specification

Ensure all the parties from within the project delivery team understand the brief and work together so that a cohesive process is presented by the architect, principle contractor and M&E or sustainability consultant.

A roof layout should be produced as early as possible as this will enable all parties to identify any conflicts with other plant equipment and walkways.

Take into account how the different specification elements can get fragmented and consider a solution where the NBS specs under J41, V14 and Q37 (if a green roof is to be included as well) are delivered from a single company. This prevents miscommunication and delivers a single point of contact for responsibility.

Confirm that the proposed waterproofing and attachment method of PV mounting system are fully compatible and that the integrity of the roof finish is uncompromised. Durability of the roofing system should match and exceed the life span of the PV array.

As a minimum specification should outline:

- Output of system
- Module specification
- Mounting solution
- Inverter specification
- Monitoring requirement
- Maintenance requirement

Ensure design liability including wind load calculations are accounted for and included within the guarantee cover proposed.

When connecting a solar power system to the grid, the application process involves the submission of a form to the relevant Distribution Network Operator (DNO) prior to installation.

Different sized systems require different applications with the correct process dependent on the output thresholds:

- G83 Application – can be submitted post installation if the system is deemed to be fewer than 16A per phase (3.68kW).
- G59 Application – needs to be submitted prior to installation for systems deemed to be over 16A per phase and is a legal requirement before installation can commence. An important factor to take into consideration is the time duration for the DNO to confirm and accept that the works can commence on site, which has to be received prior to installation.

STEP 3: Procurement / Contractor Selection

The standard procurement process will apply to the installation of the PV system. Ensuring that the PV installer and roofing contractor fully collaborate and understand the site needs and are familiar with both parties requirements is paramount.

They should be fully aware of any installation constraints such as quiet hours, caveats on deliveries or site access.

STEP 4: Installation

In new build applications, scheduling can often be difficult due to site constraints, consider the following:

- Solar modules can be damaged by other trades – best practice is to leave these until all other roof trades have finished on the roof.
- Often, the roof elements will be installed in advance of the internal installation and commissioning – has this been allowed for?
- Have other trades especially the roofing contractor, been made aware of the array and its impact on their systems? i.e are any penetrations required for cabling or hand rail mansafe systems etc.
- Modules are large, high value items and should be lifted to the roof palletised rather than by hand.

STEP 5: Sign Off and Guarantee

Guarantees can take many forms including coverage for performance, product manufacture and system warranty for the proper operation of equipment for a specific period of time; less frequently though are yield warranties guaranteeing a minimum energy output of the PV panels over time.

It is worth bearing in mind that other components for the system, including inverters and the waterproofing system, may have different life expectancies than the PV panels. Clearly the best route is to ensure that the replacement of any elements should be safe and easy to reinstate and not entail significant disruption to the roof, building or running of the system.

STEP 6: Monitoring and Maintenance

In commercial applications, providing the opportunity for staff, clients and building managers to see how much power is being produced by the PV system can encourage energy saving practices and enables the building operator to confirm the real energy output as well as compare it to the array design estimate.

Sophisticated monitoring systems are easily incorporated into the specification and should be set up by the installing contractor. The client or building operator should be trained on how to maximise the system and how to identify outputs that could be increased through safe maintenance.

Where possible the client should undertake a maintenance contract with a specialist.

SOLAR TRADE ASSOCIATION

NFRC LEADING ROOFING EXCELLENCE

SPRA Membrane Manufacturer

7 PROJECT STUDIES

UWE Enterprise Zone

BauderSOLAR PV

BUILDING BOARD

Project:	**UWE Enterprise Zone**
Location:	**Bristol**
Roof Size:	**12,000m²**
Client:	**University of the West of England**
Main Contractor:	**BAM Construction**
Specifier	**Parsons Brinckerhoff**
Approved Contractor:	**Mitie Tiley Roofing**
PV Installer:	**Dulas**

The University of the West of England (UWE) quadrupled its solar generating capacity through the installation of 1,731 solar panels, enabling it to produce over 400 MWh of electricity each year and making it the largest solar panel array in the UK university sector.

The solar array was installed on the roof of the University Enterprise Zone and the Bristol Robotics Laboratory, which both underwent extensive refurbishment as part of the required works. Prior to the PV being installed, approved contractor Mitie Tilley Roofing overlaid the original single ply waterproofing with over 12,000m^2 of Bauder's lightweight, robust PVC single ply waterproofing system Thermofol. The solar modules, which weigh less than 12Kg/m^2, were then fitted using a unique penetration-free method by renewable energy specialists Dulas.

The PV system should generate enough electricity each year to; cover half of the energy usage within the building, save around 200 tonnes of carbon and provide annual savings of over £50,000 a year. The university is committed to sustainability and this project is just part of a much wider plan to achieve its carbon reduction goals.

Fabia Jeddere-Fisher, Energy Engineer at UWE: *"The system we chose means the panels are welded into place, reducing load, and the need for roof penetrations and thereby risk of leaks. The University will use 100% of the power generated, equal to the amount of nearly 200 homes with solar panels. As a large organisation we want to set an example for others to undertake similar projects."*

APPLIED PRODUCTS

- 1,713 BauderSOLAR PV modules were fitted generating at least 402 Megawatt Hours of solar power each year.

BUILDING BOARD

Project:	**Clapham Park**
Location:	**Clapham Park, Lambeth, London**
Roof Area:	**500m² green roof layered with 11m²6 of PV**
Specifier:	**PJMA Architects**
Approved Contractor:	**EJ Roberts Ltd**
PV Installer:	**M & M Electrical Ltd**

APPLIED PRODUCTS

- Bauder Total Green Roof System is a premier bituminous waterproofing with a life expectancy of over 40 years.
- Bauder BioSOLAR integrates a green roof and photovoltaics into one system drawing the maximum potential from a flat roof.
- Flora 3 Seed Mix is a blend of 49 British native species seed, to maximise diversity of vegetation on green roofs.

Visit bauder.co.uk/biosolar for more information on the system.

The regeneration at Clapham Park involved the demolition of old housing stock to make way for new affordable homes. The 5-storey building with 21 dwellings incorporating the latest rooftop technology which blends a biodiverse green roof and unified solar PV array. This approach met the planning requirements and maximised the limited roof space to generate energy for the residents. The development was certified BREEAM 'Outstanding' due to its environmental, economic and social sustainability attributes.

One of the major challenges of the project was the roof area, which at only 500m² needed to include a green roof and a renewable energy system to meet the main objectives of sustainability and energy efficiency of the development highlighted by the planning committee. The roof contributed towards requirements under National Planning Policy Framework (NPPF) Chapter 11: Conserving and enhancing the natural environment and The London Plan 2011 Policy 5.2 – Minimising Carbon Dioxide Emissions, Policy 5.3 – Sustainable Design and Construction and Policy 5.7 – Renewable Energy. The green roof is layered with a raised PV array so that the entire roof qualifies as a green roof whilst also providing energy generation.

The Bauder BioSOLAR system has National House Building Control (NHBC) approval and meets local authority building control (LABC) requirements. The system was installed on zero falls roof deck, making it a very cost-effective solution.

The biodiverse green roof which includes 35 plant species recognised by the RHS as Perfect for Pollinators, covers the totality of the roof area and offers a large variety of vegetation. The building reduces its carbon impact with the highly efficient PIR insulation and generates approximatively 10% of the flats usage with a maximum possible output of 75kWp from the 70 PV modules. The solar PV mounting units are ballasted by the substrate and vegetation, removing the need for any penetrating products in the waterproofing.

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