



PV DESIGN CONSIDERATIONS

NEW BUILD
FLAT ROOFS

1 INTRODUCTION



Tom Raftery
BauderSOLAR Product Manager

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.

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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% CO₂ reduction from site based renewables is required to achieve maximum credits.
- Satisfying the obligations of the 'Merton Rule' that now applies in many local authorities. This requires a development to ensure 10-20% of a building's energy usage is supplied by site sourced renewables.
- Scottish government has tightened code requirements calling for a minimum 1.5kWp per plot for new homes.
- Provide energy security for the future and save money.

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:

Building Energy Consumption

To ensure the optimal return on investment (ROI), the system should be 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.

Usable, Non-Shaded Roof Space

Once shading items and other pieces of plant and equipment have been allowed for the size of the usable space can often be limited significantly.

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.

Mismatched Expectations

On new build developments, the size of the array will usually be determined by either BREEAM requirements or local planning conditions. This can lead to complications if the size of the output required is not applied to the available roof space to ensure that the system will physically fit on the roof and avoid shading items. Other considerations when determining usable roof space are; rainwater outlet locations, edge protection, maintenance access, mansafe systems, rooftop plant equipment and green roofs.

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.

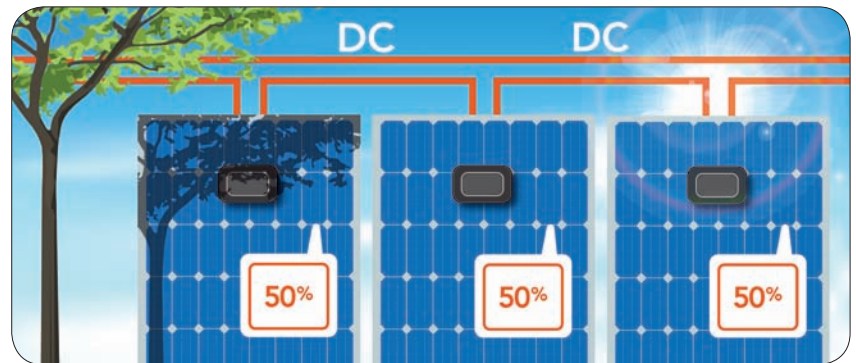


Shading will adversely affect the output of any solar array whether this is from other buildings, rooftop plant, balustrades or tall trees and all efforts must be made to avoid this. The risk of shading should be limited through design of the array and its location, but some shading could be unavoidable,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

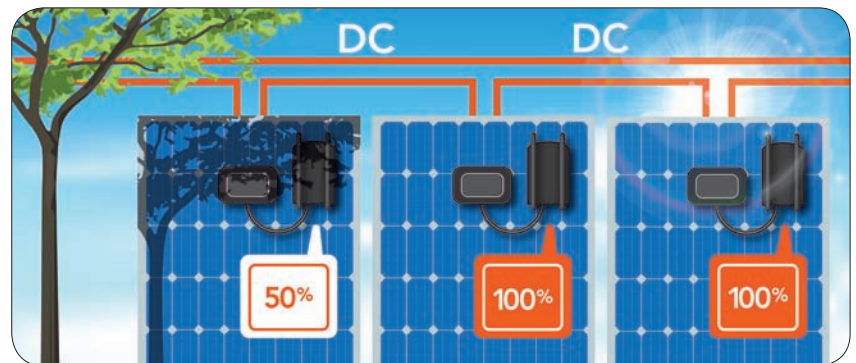
Power Optimisation

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.



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.

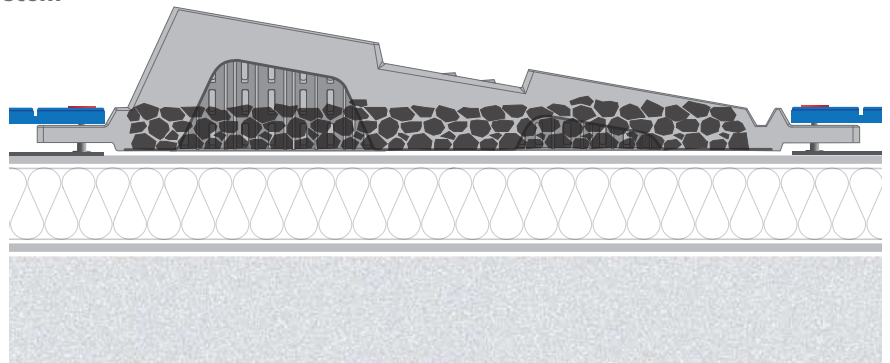
Ballasted Systems

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.

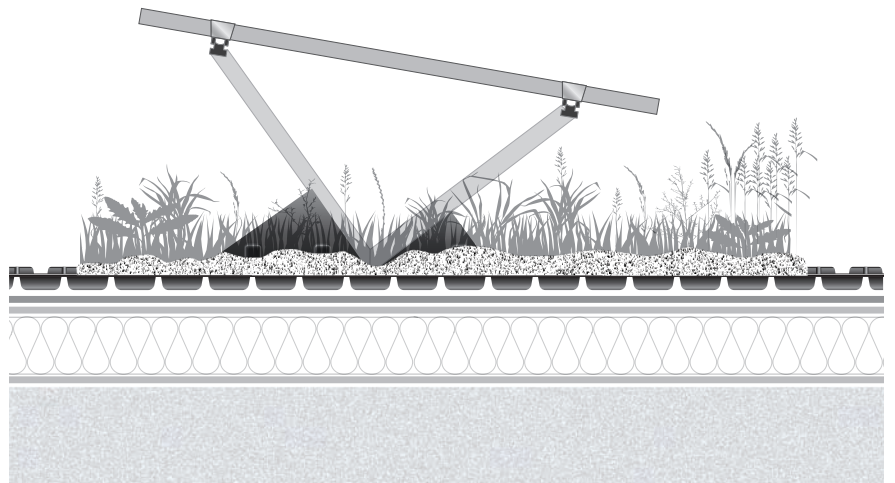
Generic Ballasted System



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

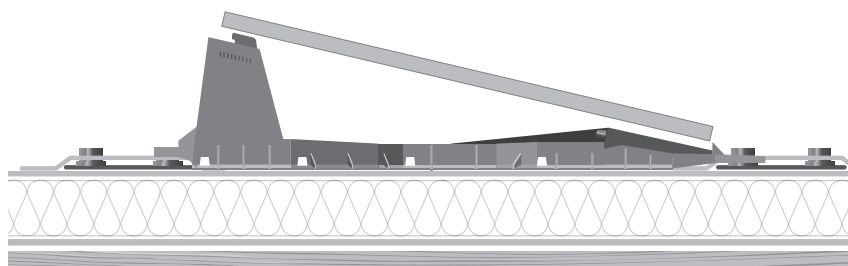
Mechanically fixed solutions are used where ballasted systems are not suitable due to the additional imposed load.

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.

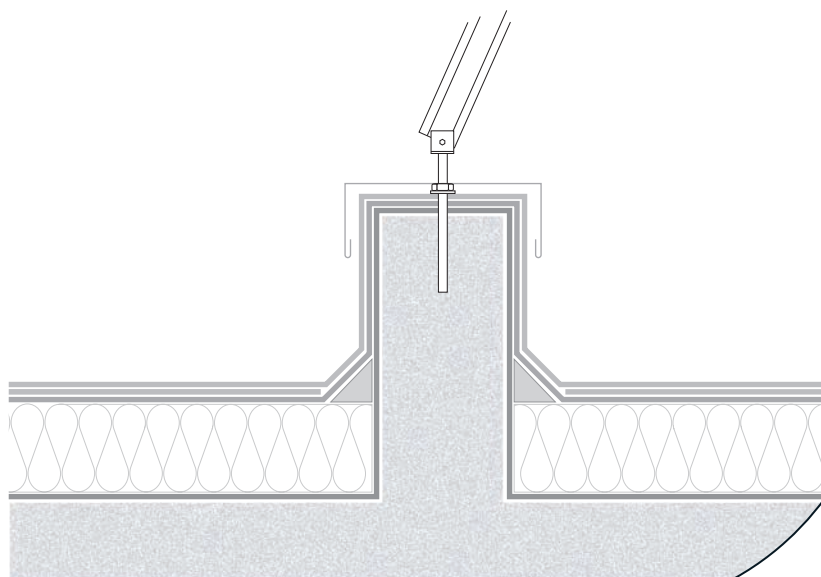
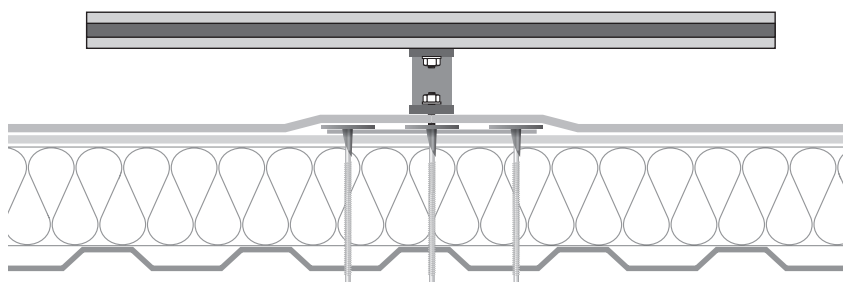
BauderSOLAR for Flat Roofs



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.

1

Delivering the Brief



6

Monitoring and Maintenance



5

Sign Off and Guarantee



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.

2

Design and Specification



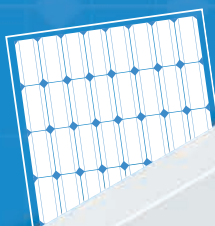
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Procurement / Contractor Selection



4

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.



**Sybil Andrews Academy
Bury St. Edmunds, Suffolk**

Collaboration is key to achieving first class results on new build school roof

A brand new school has been built on the outskirts of Bury St. Edmunds in Suffolk to accommodate 1,600 students. The project was designed and managed by Concertus Design & Property Consultants on behalf of Suffolk County Council, who wanted the school to act as a benchmark for sustainability with the building's roofs playing an integral part in achieving this.

Working closely with the architect and the client, Bauder developed a bespoke specification package that was designed to maximise the solar output from the available roof space and satisfy all relevant local planning conditions. Four buildings on the school's campus were waterproofed with

over 5,000m² of Bauder's reinforced bitumen membrane system by approved installer GRM Roofing Co Ltd, before having 313 PV modules fitted by Chelsfield Solar; enabling the client to generate at least 74.32 Megawatt Hours of solar power each year.

This report highlights the positive impact that a collaborative approach from all those involved with the delivery of the school's solar solution, from the architect through to the installer, had on the successful completion of the project.



Paul Denton
Sustainability Engineer -
Concertus Design & Property
Consultants

The Specifier and Project Manager - As well as project managing the build, we were also responsible for providing a number of multi-disciplinary services including the design and specification elements. This process was made easier by the technical calculations and specification support provided from Bauder, which meant that from the initial design stage through to the installation and sign off, there was a clear plan and chain of responsibility in place. Several design iterations were necessary, however these were all promptly provided and effectively communicated to all members of the project team.

Bauder's comprehensive system portfolio of waterproofing and solar solutions also made the specification process straightforward, as we were able to select an integrated roof and PV system that could be delivered from a single source supplier. Having an all-inclusive guarantee was another key driver for the client and it has provided them with complete confidence in the roof's future performance.

A collective approach was also essential due to the tight deadlines, making sure this part of the project finished on time for the school's completion and handover. As a result, regular site meetings were attended by all parties of the project team, including our architect, the M&E contractor and suppliers; thus ensuring project stages were met, avoiding unnecessary delays.

Bauder went above and beyond its duty throughout, assisting further down the supplier chain to ensure an integrated and fully collaborative programme. It helped with the monitoring of the roof installation and in cooperation with Chelsfield Solar provided us with periodic progress reports. Since completion, we are now looking for other opportunities to implement solar elsewhere on the school's campus.

The PV Installer - Our job is made a lot easier by other parties involved in delivering a project. Being a Bauder approved installer we know that we will be supplied with all the relevant design information throughout the project and that the workmanship of the roofing will be of the highest quality when we arrive on site. These logistical elements and quality expectations are crucial on a project like this where rigorous deadlines have been set.

The solar installation was simplified by the fixing method used for the PV system, which involves a non-penetrative membrane-to-membrane bonding technique. This highly effective and time efficient method meant that

the entire array could be fitted on the two school buildings in under three days, saving the client valuable time and money. To assist us with the installation, roofing contractor GRM bonded the pre-fabricated membrane sleeves over the module's base plates and into position on the roof surface, which enabled us to focus on fitting the modules and connecting them to the external electrics.

It was important that the team was responsive and operating in unison, and Concertus worked in conjunction with Bauder to help orchestrate the relationships between all the various parties on site, which has undeniably contributed to the overall success of this project.



Adrian Clayton
Sales Manager -
Chelsfield Solar

Image courtesy of
Chelsfield Solar





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