



Image courtesy of
Ivan Moore
Lambert Smith Hampton



PV DESIGN CONSIDERATIONS

REFURBISHMENT 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 refurbishment section of the construction industry, photovoltaic specifications focus on energy efficiencies and outputs of solar, omitting to give the same focus to ensuring the rooftop array is installed with methods that ensure 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 consultants, surveyors and clients considering the inclusion of a PV array on an existing flat roof and outlines insightful explanation to be mindful of to ensure the design is sustainable and meets lifespan expectations.

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Drivers for Retrofit Applications

Retrofitting photovoltaic panels brings all the benefits of low maintenance renewable energy generation to your project. Below are just some of the key drivers for choosing to add PV to an existing flat roof:

- Provide energy security for the future and save money.
- Reducing carbon footprint.
- Minimum Energy Performance Standard (MEPS) for private rented properties in 2018. Minimum energy standard to be an EPC rating of 'E' - 20% of commercial properties are thought to have an EPC less than an 'E'.
- London RE:FIT scheme supports public sector organisations, charities and third sector organisations to reduce CO₂ emissions.
- Better Buildings Partnership. Leading property owners who are improving sustainability of existing building stock with collaboration and sharing best practice.

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 refurbishment applications, common motivating factors are 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 allow allow for the inclusion of a PV system and capital budget may determine scheme size rather than optimal return on investment or roof size.

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 and the most suited energy profile to benefit from a PV array.



3 ROOF CONDITIONS

HAVE YOU CONSIDERED?

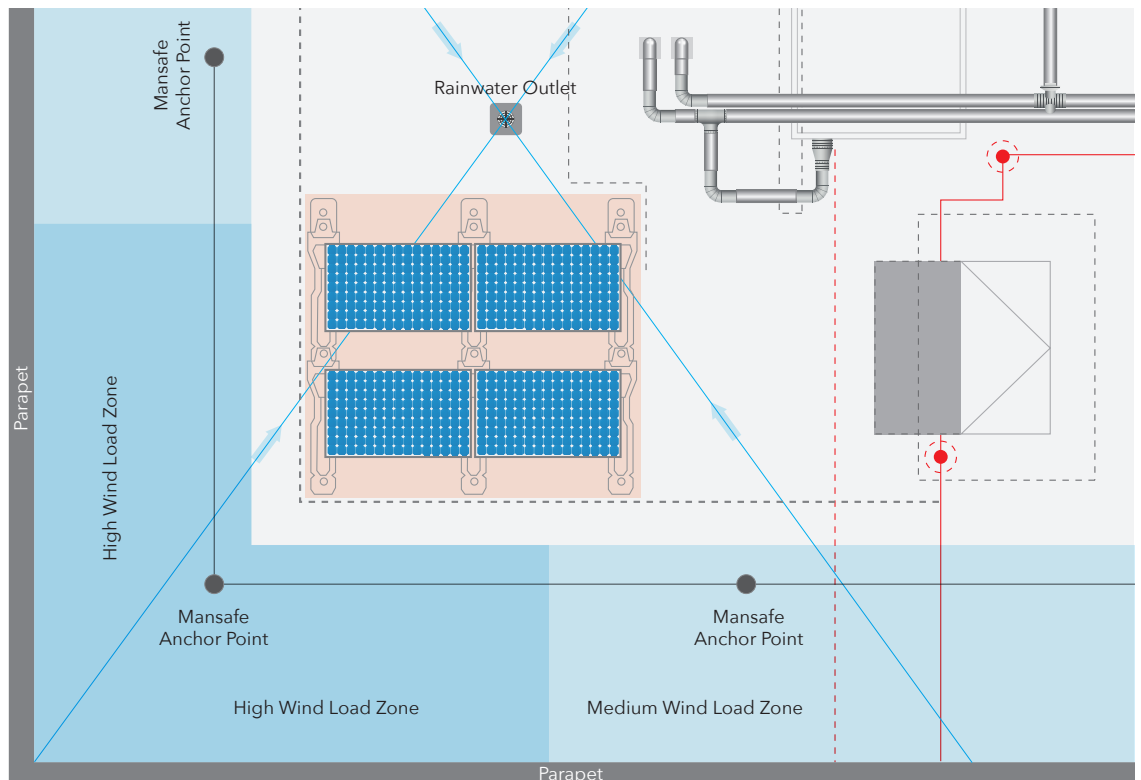
Durability of the waterproofing system is key and its remaining life span should, at a minimum, match that of the PV scheme, as well as be able to withstand any additional access requirements for maintenance.

When planning a PV array for an existing building the condition of the flat roof should be taken into account before the mounting method and array location can be determined.

These are some key points to consider and clarify before proceeding with the project:

- Can the building withstand additional weight loadings and wind forces? If not, the project should be evaluated to determine whether additional structural support costs are worthy.
- Does the current roof covering warranty or life expectancy match that of the PV array? If not, the roof covering may need replacing before the PV.
- Is the roof covering due for renewal? If so, it may be worth bringing forward the installation so that both are installed simultaneously.
- Will the mounting or ballasted system put the current waterproofing at risk? If the waterproofing system is penetrated by the PV fixing methods, the integrity of the roof could be compromised and the warranty invalidated.
- Is the current waterproofing system able to withstand required access traffic for the installation and maintenance? If not, suitable protection is required.
- Are there shading items that could reduce the array's efficiency and if so, to what extent? Shading on the PV cells reduces electricity flow and therefore output. If this is the case, the array could be located on a different roof area. The inclusion of a power optimiser can mitigate the efficiency reduction and actually improve efficiencies.
- Does the existing safe access system meet the needs of additional traffic and equipment required to maintain the PV array? If not, the mansafe system may need updating or a permanent barrier may be required, which itself may shade the panels.
- Are there access limitations, such as timing of work or health and safety of the building's occupants, which would impact costs or installation? A discussion at pre-tender stage can identify challenges early on so a different delivery schedule can be developed.

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.

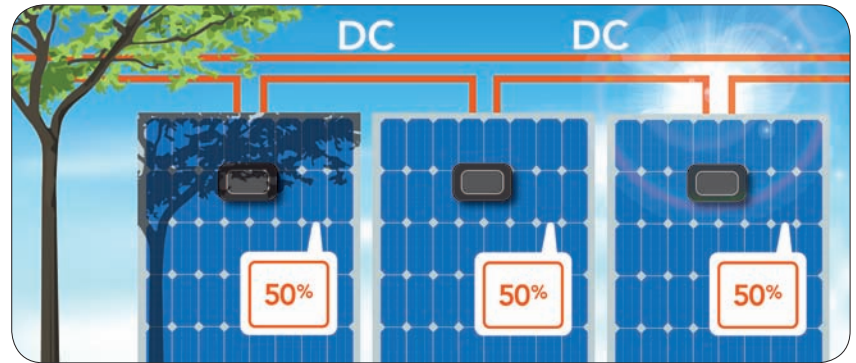


Shading will adversely affect the output of any solar array whether this is from other buildings, rooftop plant, balustrades or tall trees and all efforts must be made to avoid this. The risk of shading should be limited through design of the array and its location, but some shading could be unavoidable,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

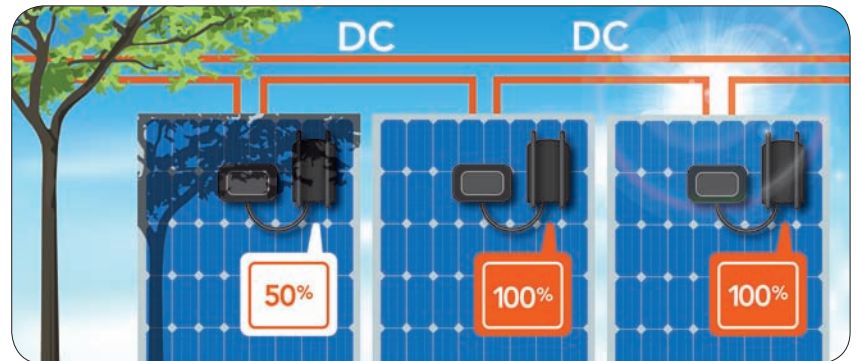
Power Optimisation

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.

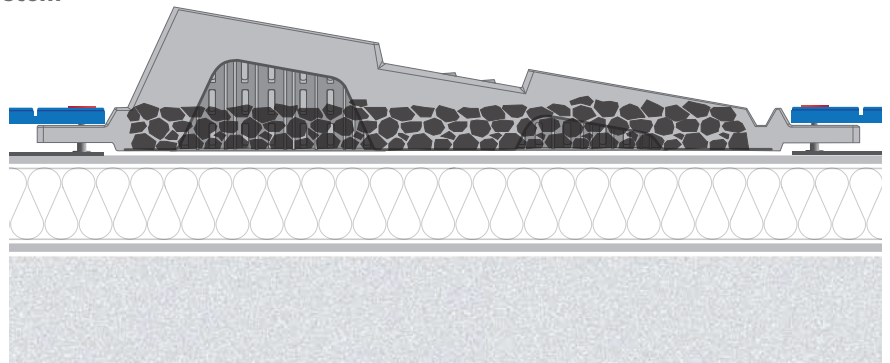
Ballasted Systems

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.

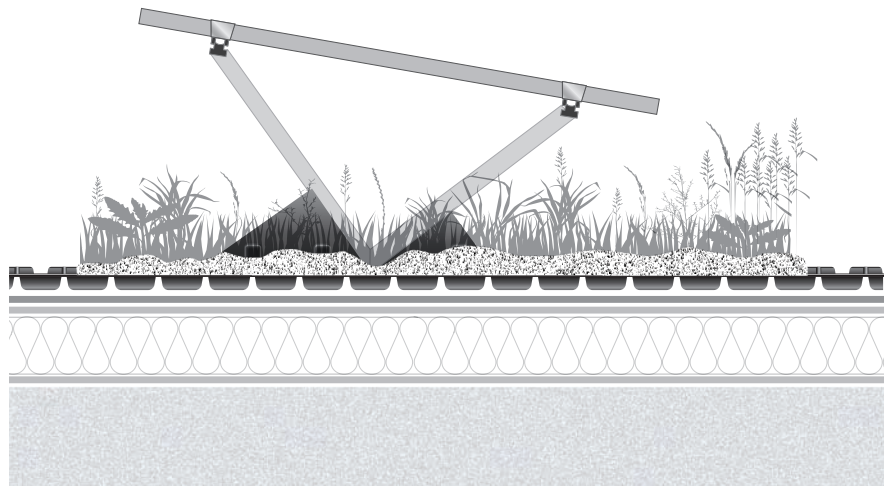
Generic Ballasted System



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 roof element.



Mechanically Fixed Systems

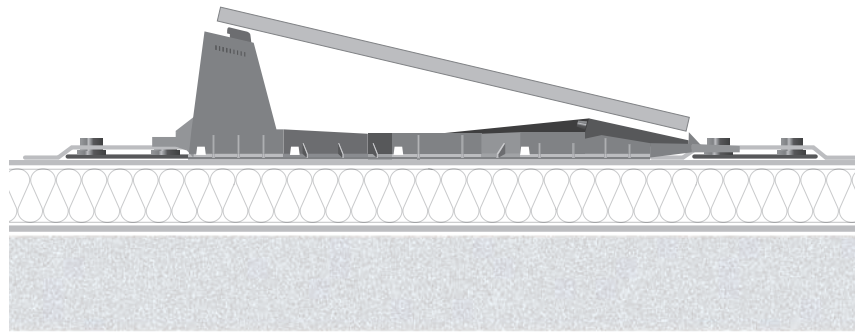
Mechanically fixed solutions are used where ballasted systems are not suitable due to the additional imposed load.

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 or bonding 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.

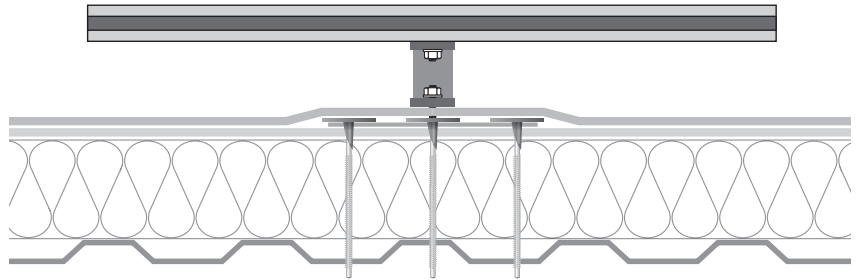
BauderSOLAR for Flat Roofs



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.

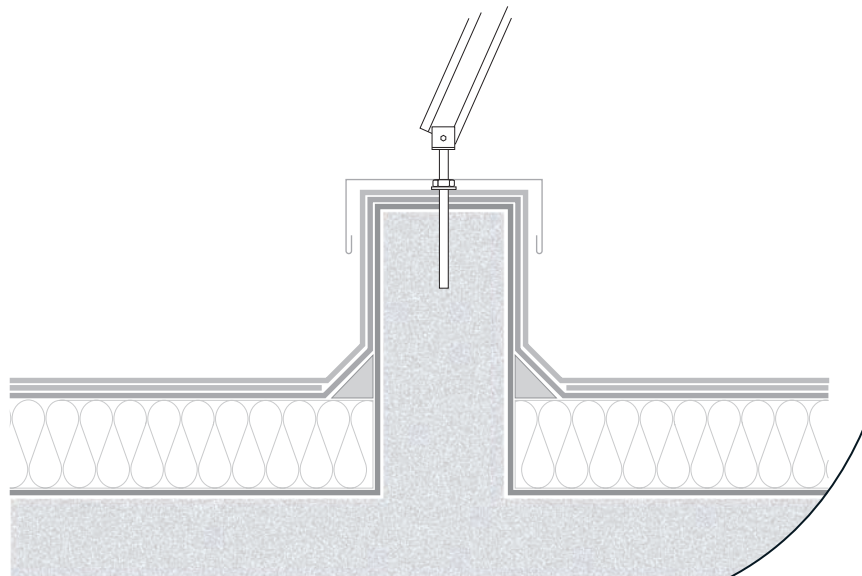
These illustrations show typical detail designs for penetrative mechanical fixings.



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 and suitability of existing waterproofing.
- What the scheme is 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 surveyor, 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 or access points and walkways.

Take into account how the different specification elements can get fragmented and consider a solution where all elements can be designed and sourced from a single company. This prevents miscommunication and delivers a single point of contact for all queries.

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 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 and 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.

STEPS
ALL
TAKES

2

Design and
Specification



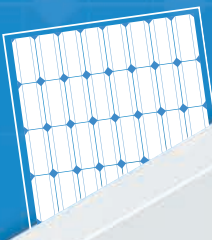
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Procurement
/ Contractor
Selection



4

Installation



STEP 3: Procurement / Contractor Selection

The standard procurement process will apply to the installation of the PV system. Ensuring that the installing contractor understands the site needs and are familiar with both the solar and roofing 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

Working with existing buildings can provide a number of restraints, consider the following:

- Is the structure suitable for ballasted applications?
- Are you able to 'load out' the roof temporarily?
- What protection is required for the waterproofing whilst the materials are transported around the roof?
- Inverter locations – where is best to site the inverters? If possible site them in a cool shaded area in a roof level plant room or on the roof.

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 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 and 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.



7

DELIVERY TEAM INSIGHT

11 Freebournes Road Witham, Essex

Collaboration is key to solar success on retrofit roof refurbishment

A large derelict warehouse located in Witham has undergone major renovation to transform it into a storage centre for Essex County Council that will assist its services and benefit the local community. The refurbishment works were designed and project managed by Lambert Smith Hampton on behalf of the client, who wanted the building to act as a benchmark for sustainability with the roof playing an integral part in achieving this.

Working closely with the surveyor and the client, Bauder performed a comprehensive roof evaluation survey to identify the full extent of water ingress being experienced. The bespoke

survey report highlighted that the roof needed to be stripped back to its original deck, before being waterproofed with over 5,200m² of Bauder's reinforced bitumen membrane system by Acclaim Contracts. 588 PV modules were then fitted onto the roof by CJ Solar, enabling the client to generate at least 134.70 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 county council's solar solution, from the surveyor through to the installer, had on the successful completion of the project.



Julian Sanchez
Commissioning Delivery
Manager,
Essex County Council

The Client - Part of our strategy at Essex County Council is to improve our energy resilience by adhering to our sustainability policy of 'buy better, use less and generate more'. That being said, we actively look for opportunities to implement renewable energy and believed our storage facility in Witham lent itself well to PV retrofit due to its size and orientation. This suitability was confirmed by the surveyor from Lambert Smith Hampton who, in cooperation with Bauder, highlighted the necessary remedial action and how to best maximise the solar output. We realise that matching the life expectancy of the waterproofing system with the new technology is key so this was the ideal time to add the PV array while we reinstated the roof's integrity.

We held regular site meetings during the project that were attended by all key parties of the delivery team, including the surveyor, M&E contractor and suppliers, so that deadlines were adhered to and clearly communicated. Our system selection process involved the due diligence you would expect from a local authority and we decided to go with Bauder because of its comprehensive system portfolio that meant we could have a single source supply and all-inclusive guarantee; giving us complete confidence in the roof's performance. Thanks to the team involved in the delivery of the PV system our facility has been transformed in terms of appearance, performance and functionality.



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

From our perspective the most fundamental consideration for this PV retrofit was the system weight loadings. A ballasted arrangement was not feasible due to weight restrictions, so we needed a system that was both lightweight and non-penetrative, and Bauder's solution delivered just that. Bauder also assisted us with the monitoring of the installation allowing us to provide weekly progress reports back to the client. Since completion, we are now working on other retrofit PV projects for the client using the same system.



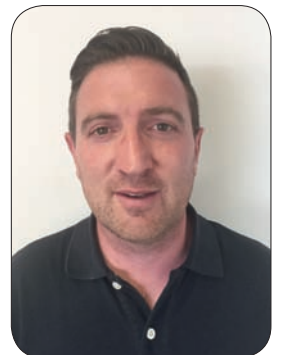
Ivan Moore
Associate Director Building Consultancy,
Lambert Smith Hampton

The Waterproofing Installer, Acclaim Contracts
We had already completed internal works on the building when we became involved in the roofing element. This meant we were familiar with both the site and delivery teams; which was beneficial as our job is often made easier by being accustomed with other parties involved in delivering a project.

Bauder supplied us with the relevant design information throughout the project and enlisted the help of electrical installer, CJ Solar, to fit the modules. We worked in close partnership with the client, Bauder and CJ Solar to agree delivery times, which occurred on a weekend with all the modules being craned onto the roof due to the minimal storage space at ground level. These logistical elements are crucial on a project like this where strict deadlines are in place.

The PV Installer, CJ Solar - This large scale solar installation was simplified by the fixing method used for the PV system, which involves a highly effective, non-penetrative, membrane-to-membrane bonding technique that enabled us to fit the entire array in under two weeks; saving the client valuable time and money. To assist us with the installation, roofing contractor Acclaim Contracts bonded the pre-fabricated membrane sleeves over the module's base plates and into position on the roof surface, allowing us to focus on fitting the PV modules and connecting the system to the building's electrical infrastructure.

Ultimately, a collaborative approach was needed throughout the survey, design and installation process from all members of the delivery team to ensure the maximum benefit for the client, and this was achieved by establishing a clear line of communication and accountability at the earliest possible stage.



Ian Duggan
Director,
Acclaim Contracts



Steve Daley
Director,
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Image courtesy of
Essex County Council



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