LABC Guide to retrofitting solar panels

Introduction

Photovoltaic and solar thermal collector panels are being increasingly added to existing roofs. This best practice note provides guidance on the effect of retro-fit installation of panels on existing domestic-scale roof structures and how this affects compliance with the functional requirement A1 of Schedule 1 to the Building Regulations 2010 (as amended).

Considerations

Competent Persons Scheme - Schedule 3 of the Building Regulations 2010 enables installers to gain membership of a Competent Persons Scheme (CPS) and to self-certify certain types of building work including solar-thermal and PV installation. All relevant CPS are listed on the DLUHC website. Many installers are also registered under one of the Microgeneration Certification Schemes (MCS) which exists to register installers for membership of the Government Feed-in-Tariff scheme, but the MCS is NOT a CPS.

Where an installer is a member of a CPS that requires Part A, C and P competency, building control bodies would not be involved unless they believe the work to be in contravention of regulations, in which case, a local authority would consider what enforcement action is required.

Where the CPS criteria only require Part P competence the remainder of the work is subject to formal consent under the building regulations, generally under a Building Notice.

Building Regulations

Regulation 3 defines Building Work which must comply with the regulations. The installation of solar panels primarily falls within the category of 'Installation of a Controlled Service or Fitting' and also involves a 'Material Alteration' for the structural alterations element with regard to an existing building. Approved Document A includes guidance on achieving compliance with this aspect and suggests that additional loading to a roof structure would constitute a material alteration if the loading to the roof is increased by 15% or more.

Membership of some CPS may allow self-certification of Part A requirements and installers will be deemed competent to carry out structural assessments of existing roof structures if credits have been gained in City and Guilds 2372 - PV.

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T: 020 8616 8120 **E:** consult@labc.co.uk
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• In this case installers may self-assess whether compliance with Part A will be achieved and reference to the 15% increase in loading threshold may be a suitable benchmark, i.e. an increase of load that is less than 15% can be assumed to fall outside the remit of Part A. However, it is very important to bear in mind that not all CPS scheme operators encompass Part A issues. The installer remains responsible for the commissioning of all surveys and any remedial design work.

Image 1: Installing panels generally results in an increase in dead load of around 15%.

Panel loads and their effect on the roof

Panels currently in production have a fitted mass of around 20kg/m2 (both PV and Solar Thermal). Considering an average total rafter load of around 140 kg/m2, the addition of 20 kg/ m2 would represent an increase in loading of some 15%. It is the duty of an installer to assess the effect of this increase in loading in order to maintain an adequate factor of safety against failure. Individual roof structures will vary by construction/ type, workmanship, materials, maintenance/decay, exposure etc.
Some roofs may already be overstressed if carrying heavy roof coverings or in exposed locations.

Typical roof constructions

A. Trussed rafters:
Modern trussed rafters have been in common use since the 1970s. Assessment by leading structural consultants and the BRE has established that small dead load increases to standard configuration fink trusses (of up to 9m span) will not overstress truss members or their connector plates to any significant degree. Installation of a single row of solar thermal or PV panels is considered acceptable, without further structural investigation. An installer should always carry out a basic assessment to establish a minimum level of robustness in the construction, which includes truss fixings to wall plate; ensuring bracings to internal members are in place; centrality of connector plates at node points; general timber degradation or metal fastener corrosion.

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B. Traditional cut roofs – purlins, binders, principal trusses:
Historic roof structures, which are generally defined as
pre-Victorian, will often comprise an arrangement of principal trusses, with supporting beams spanning between them (purlins and binders). The secondary members supporting the building fabric (rafters and ceiling joists) are in turn supported by the primary members. These roofs are usually constructed of locally sourced hardwood and section sizes tend to be conservative. Connections may be traditional (e.g., mortice and tenon, dove-tailed etc.) with timber dowels, bolted with iron straps or fixed with large iron nails. Kept dry, the timber will tend to gain in shear strength over time, as seasoning continues.
Valley and hip members are sized accordingly, depending on their degree of support and restraint.

Victorian and 20th century roofs saw the widespread use of softwood construction. In the 1950s the Timber Development Association (TDA) produced standard pattern roof arrangements, comprising softwood principal trusses, purlins, binders etc.
Studies of these roofs have shown them to be near capacity at present, with the principal variable being the standard of timber used (quality, stress-grading, seasoning etc.). Bungalow roofs, on estates constructed in the 1960s and 1970s, tend to push these roof types to their limit, as spans increase.

Connections are critical in principal trusses, many of which have been found to comprise heavily corroded bolts, varying sizes of washer and inadequate projection of bolt threads.
Internal members are often only connected by 2 no. nails!

Structural modelling of the addition of solar panels has indicated that bending stresses would approach 100% capacity and more. This erodes any factor of safety and presents the possibility of an ultimate failure condition (collapse). Member deflections in TDA roofs currently run at around 150% of that recommended for brittle finishes, i.e. plasterboard and plaster skim. Imposition of further dead load increases this potential for cracking.

Any proposed loading increase in both historic and more recent cut roofs should therefore be investigated by a structural engineer.

Wind uplift

The addition of solar panels should not affect the positive wind pressure acting on roofs, as they are aligned to the profile of the roof. However, the unit size of the panel may be sufficient to act as a wind-suction collector and generate concentrated uplift forces at certain locations on the existing roof. An average wind load to apply to all but the most exposed areas of England and Wales would assume a Dynamic Pressure, q = 1.2 kN/m2. Further specific guidance is given in BRE Digest 489.

It is unlikely that such forces would have any net effect on the overall negative wind load on the roof, as the roof dead load will remain the dominant effect. However, a localised concentration of

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uplift force will be expected at fixing points. The critical element is the connection of the clamp brackets to the rafters; fixing to tiling battens is not considered a suitably robust solution. On trussed rafter roofs, individual truss fixings may need strengthening in exposed locations.

Rafters may be as little as 35mm wide in prefabricated roof trusses and careful consideration must be given to the specification of fixings into this timber in order to achieve
the necessary edge distances required by the design codes. The absolute minimum acceptable edge distance is 4x screw diameter and the minimum screw spacing is 7x screw diameter. The installer of the clamps must ensure that these minimum distances are achieved. Brackets and fixings should also be suitably durable for their exposure (e.g., galvanised).

Snow load

It is suggested that snow will be less likely to build up on PV panels, due to their thermal property as a “black body”, flat profile and low coefficient of friction. Solar thermal collectors are different in profile, however, and may encourage a localised accumulation of drifting snow. Current research data suggests that this effect is not significant, but installers should make an assessment of any risk of snow accumulation. Installers will have specialist knowledge of solar-thermal panel profiles and any likelihood of localised drifting, caused by evacuated tubes which have a raised profile, compared to flat PV panels.

Non-members of a CPS should always obtain Building Regulations consent.

Image 2: Any proposed roof loading increase should be investigated by a structural engineer.

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Photo: BRE Fire and Solar PV systems-Investigations and Evidence showing Inverter fire (Part of 3-year study by BRE, published July 2017 by BEIS)

Fire safety

The use of solar and PV panels has seen a significant increase in the number of installations. The risk of a fire can be kept to a minimum if the following advice is followed:

It is recommended that panels should only be installed on non-combustible roofs, and as such you should not install a PV system on a roof containing highly combustible materials, such as polystyrene insulation or thatched roofs. It is also considered that if panels are placed over the thatch that the thatch could rot over time as the panels will prevent the roof covering from seasonal drying out.

You should ensure the system is designed and installed by competent contractors, adhering to industry best practice and regulations to ensure there are no electrical faults as there are direct current (DC) isolators, connecters and inverters that need to be installed by competent electrical contractors.

This means that solar PV panels generate electrical energy for the entire time they are exposed to natural light. This means the panels and associated electrical equipment feeding power to the building remain “live” at all times. This poses serious safety risks to persons in the immediate vicinity, and to fire fighters in the event of a fire as the system cannot be turned off, unlike conventional electrical supplies.

You should allow access for roof maintenance/ cleaning and assess how roof / PV panel sections will be replaced.

You should also ensure the PV system is suitably maintained as part of the building’s electrical inspection and testing procedures

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Key points to consider

• Installing panels generally results in an increase in dead load of around 15%. All roof structures should be assessed for their strength and robustness to accommodate additional dead load. Additional loading to a roof structure constitutes a material alteration if the loading to the roof is increased by 15% or more.
• Installation of a single row of solar thermal or PV panels on a modern trussed rafter roof of up to 9m span is generally considered acceptable, without further structural investigation. Proposed loadings beyond this scale would require a survey by a structural engineer.
• Any proposed loading increase in both historic and more recent cut roofs should be investigated by a structural engineer as these are likely to be over-spanned if panels are installed.
• Wind effects on the overall roof structure will not be changed significantly but adequate fixing of panels to rafters is necessary to prevent panel uplift. Connection of clamp brackets to the rafters is critical; fixing to tiling battens is not considered a suitably robust solution. On trussed rafter roofs, individual truss fixings may need strengthening in exposed locations.

• Competent Person Scheme members may self-certify all aspects of installation, and would be expected to address all the issues discussed above but not all CPS administrators require, or expect their members to carry out a structural assessment of roof structures
• It may sometimes be necessary for a Building Regulation application to be made for the structural aspects of solar installations.

Further guides

Building Regulations 2010
https://www.legislation.gov.uk/uksi/2010/2214/contents/made

Approval Document A
https://www.gov.uk/government/publications/structure-approved-document-a

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