Solar Photo-Voltaic (PV) Panels

Summary: Solar Photo-Voltaic (PV) panels generate electricity from daylight which can be used directly in a building (most efficient), stored in a battery (to be used within 24 hrs), or sold back to the grid (at low, commercial rates). Therefore, they help the most in churches used in the daytime every day, then those with regular evening use. They can be a helpful solution but with many factors to consider…

Description of the solution and how it supports decarbonisation

Solar Photo-Voltaic (PV) panels are rectangular panels, typically fixed to a roof or to a frame fixed to the ground, that generate electricity from daylight. As they generate electricity from the sun, they are a renewable source of electricity and produce no carbon emissions in operation. Electricity is the main energy source for most decarbonised heating and hot water solutions, therefore being able to generate, for free, towards this requirement on site, can be a useful part of a holistic decarbonisation solution.

PV panels generate energy from daylight (not just direct sunlight) so do work on a cloudy but light day. However, the brighter the light the more energy they produce, so direct sunlight is most advantageous for good levels of generation.

The panels come in two main sizes; a smaller size used typically on domestic roofs and a larger commercial size used for solar farms and industrial settings. They can be of a standard appearance where one can visibly see the wiring of the cells, or they can have an 'all-black' appearance where there are no silver elements and the panels appear to be a uniform black colour and frame when viewed from a moderate distance. Most people tend to find that all-black panels look more attractive. Panels can be wrapped in various coloured sleeves or coatings such as a terracotta colour, but these are bespoke and do slightly reduce the performance of the panel. Panels have increased significantly in their efficiency over the years so, where a panel produced around 250W of electricity at its maximum performance 10 years ago, the same size panel now will generate around 500W at peak. Solar slates or tiles are available, they fit very nicely into the appearance of a blue/black slate roof and have been used on churches. They tend to be more costly and less efficient but are very discreet in terms of their appearance.

PV panels generate energy with a Direct Current (DC) and this needs to be converted into an Alternating Current (AC) for use in the electrical systems in buildings. The conversion from DC to AC is undertaken in an electrical device called an inverter, which is typically the size of a small suitcase and can be located in the roof space near the panels or near the electricity distribution board. Inverters do have a small fan within them as they can generate some heat in the conversion process. This fan can have a slight noise (normally the equivalent of a domestic fridge) and benefits from being located in a space which does not have other major heat gains.

PV panels can be installed with a battery storage element. These store the electricity generated from the solar panels for use later in the day. The batteries tend of be large lithium-ion batteries and are typically modular units of around 7 to 10 kWh each. Each module is a similar size to the inverter. Excess generation can also be stored by way of heating hot water in hot water storage tanks (typically found in most domestic settings but rare to find in churches) using a solar PV divertor unit, or excess energy can be automatically directed to charge a plugged in electric vehicle (EV) with the right control system. It is important to consider the fire safety and insurance requirements for batteries (see insurance considerations section).

Suitable churches

The main consideration with PV is where the electricity generated will be used. All systems have to be connected back into one meter. There then needs to be a steady and regular demand, preferably during daylight hours, for the electricity generated from whatever is connected to that meter. If a church has several meters serving the building it may be prudent to change the meters to one larger meter (often moving from three single phase meters to one three phase meter) so that the PV system can supply the whole building rather than one part of it.

PV panels therefore work best in churches that are used every day, during the day.

To be able to successfully install a PV system the church needs to have a roof that is structurally sound and unshaded. Panels can be successfully installed on roofs that face from east, through south and also to the west. The ideal orientation is a roof with a pitch of 30 to 40 degrees facing south, but less than a 10% reduction on performance is found as this moves to an east to west orientation as shown in the chart below.

Elevation	Orientation in degrees from north												
	West			SW		South			SE				East
	270	255	240	225	210	195	180	165	150	135	120	105	90
Horizontal	90	90	90	90	90	90	90	90	90	90	90	90	90
10 deg	89	91	92	94	95	95	96	95	95	94	93	91	90
20 deg	87	90	93	96	97	98	98	98	97	96	94	91	88
30 deg	86	89	93	96	98	99	100	100	98	96	94	90	86
40 deg	82	86	90	95	97	99	100	99	98	96	92	8	84
50 deg	78	84	88	92	95	96	97	97	96	93	89	85	80
60 deg	74	79	84	87	90	91	93	93	92	89	86	81	76
70 deg	69	74	78	82	85	86	87	87	86	84	80	76	70
80 deg	63	68	72	75	77	79	80	80	79	77	74	69	65
90 deg	56	60	64	67	69	71	71	71	71	69	65	62	58

Most historic church roofs are extremely solid with large timbers and the increased weight of the solar panels rarely causes concerns, but this should be checked by a structural engineer and the condition of the timbers reviewed. Systems which use a self-weighted or additional ballast to prevent the solar panels from being blown off the roof in high winds will need more careful review of the additional imposed weight on the roof.

A battery system can be added but for these to be useful the battery needs to be discharged and the electricity used, preferably each evening, so that the battery is almost empty and ready to be recharged when the sun shines again on the following day. PV systems with batteries can therefore be useful on churches which may have more limited daytime use but are used most evenings during the week. Small PV systems with batteries can also be a consideration where the church is floodlit every night (although the need for any floodlighting should be carefully considered first).

PV panels are likely to be unviable in churches which are just used for one or two services on a Sunday and a couple of mid-week services, or bellringing or choir practice only. In these circumstances a PV system will be exporting its electricity most of the time. See the Myth Busting section answer on ‘Solar panels should be installed on every roof’ below.

Permissions and Harm vs Benefit

There is a commonly held misconception that PV systems are not allowed on listed buildings. This is NOT true. There are many examples of PVs being permitted and allowed on listed buildings including important Grade I listed buildings and also including listed buildings where the array may be visible in some way.

When considering whether a PV system would be acceptable on a listed building, one has to consider whether the harm caused by installing the panels will be outweighed by the benefit that they create.

The benefit is the renewable and free electricity that they generate being used in the listed building to which they are connected to. The export of electricity to the grid is not considered to be of any benefit, as this benefit could be equally derived from installing the panels on any other building connected to the grid and it would be more sensible to install them on a less attractive building where the installation will be easier and cheaper. So, the key aspect to consider is whether the panels will generate electricity that can be used in the church.

The harm is mainly the visual harm that the panels could create. Harm can also be caused from the fixing of the panels into the historic fabric, damage to the roof via wind load, the cable runs from the panels to the electricity infrastructure needed, and the location and risks associated with the electrical infrastructure. All these other areas of potential harm can be typically managed through thoughtful and careful consideration of the specification and installation. Ensure you choose an MCS certified installer (on the Find an Installer webpage, filter by the "Solar PV" button to find contractors suitable for specifying installations on churches).

Where possible, PV panels should be located on the least visible roofs and ideally where they cannot be seen. Where this is not possible, discreetly visible panel locations can still be acceptable. This may mean locating them on a lower and shallower pitched roof of a side aisle rather than the main nave roof. Roofs where the panels cannot be seen from the immediate surroundings of the church but might be seen from distance in the wider landscape may also be acceptable, as if panels on roofs can only be seen from a hill on the opposite side of the valley, they may not affect the overall view of the landscape or the building. Care should also be taken to design any partly or fully visible arrays with a degree of design and elegance. This usually means never mixing panels in portrait and landscape formats, using all black panels, designing arrays with a complete block of panels rather than having a missing panel from a corner and following the symmetry of the original building so arrays are centred or arranged to fit into the original rhythm of the architecture.

Listed churches and those in a conservation area will need planning permission and faculty approval. Unlisted churches that are not in a conservation area will not need planning permission as the array will fall under the permitted development rules (so long as the conditions on these are met) and the installations can be dealt with as a List B matter through the faculty process.

Fitting

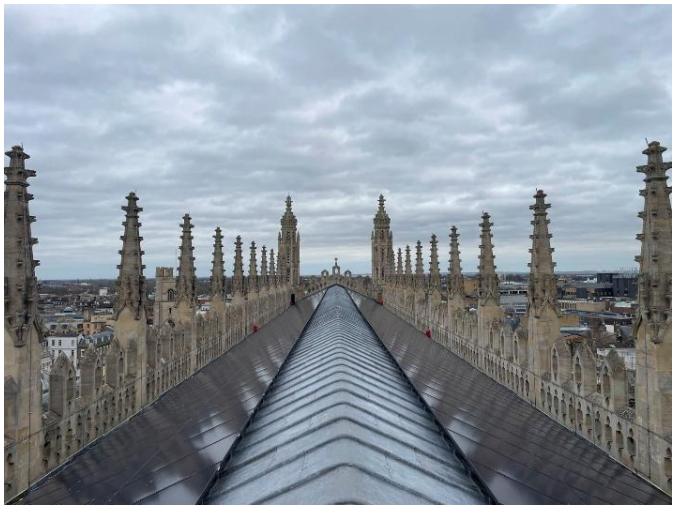
The panels do need to be secured to the roof in some way. For pitched roofs this tends to involve some form of mechanical fixing into the timber roof structure below and care needs to be taken with the detailing around the weatherproofing to ensure it does not add to a risk of leaks. Good proprietary systems for fixings are widely available for all roof types including lead and other metal roofs. For flat

roofs, a self-weighted system which involves no penetrations into the roof can be used. For low pitched roofs (typically seen in lead or copper roofs on churches) it is possible to use a self-weighted system which 'hooks' over the ridge of the roof and is weighted down. With some modern standing seam roofs, it is possible to use clamps on to the seams, but the standing seams need to be strong enough and pinned. When re-roofing a roof 'in roof' (as opposed to 'on -roof') systems can be used, where the panels become part of the weather proofing layer and sit flush into the roof. Your architect can work with the contractor to select or design an appropriate system to minimise risk to the roof covering.

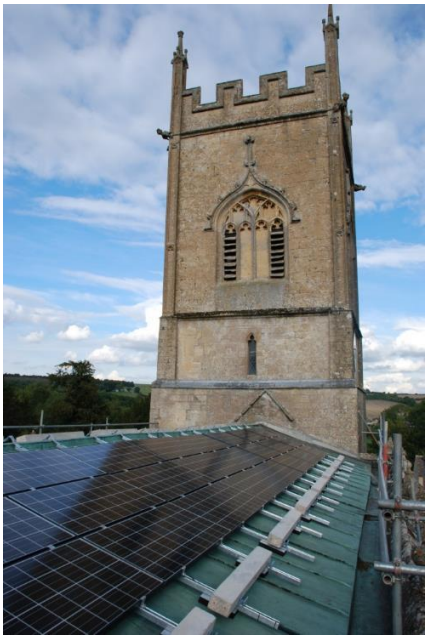
Pros and Cons

Pros:	**Cons:**
PV panels can generate free and renewable electricity on the building. System are largely maintenance free as panels are self-cleaning when installed on a significant enough pitch (although often they do benefit from an annual clean especially in areas with heavy bird populations and the like). Can be linked with battery storage systems to extend the energy use period into the evening/night.	Can be considered as ugly and not welcomed in highly visible locations on attractive buildings. Provide no real benefit when there is no demand for electricity during the day of every day (or every evening with batteries), therefore not viable on Sunday only or occasionally used churches. Scaffolding costs for installation can be very high so avoidance of roofs with poor accessibility is important. Careful sourcing of the panels is important as much of the world's silicone used for the cells in solar panels is manufactured in China in regions which are associated with forced labour and human rights issues. Poorly installed or specified systems can create an increased risk of fire and damage to the roof via water ingress, structural load or wind load. This can be easily managed out by good installation and specification of systems that include arc fault detection, thermal cut outs and the like. Invertors can emit some noise and heat. Insurance implications, particularly for systems with batteries (see Insurance Considerations section below).

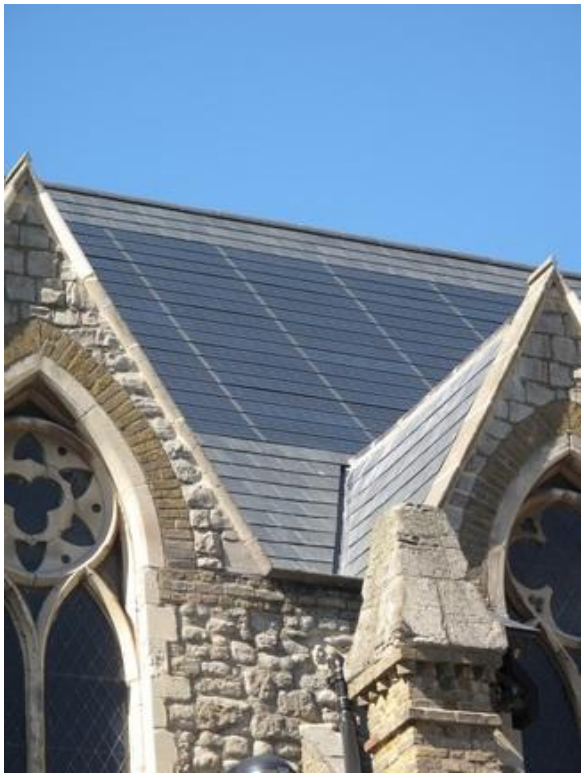
Photos



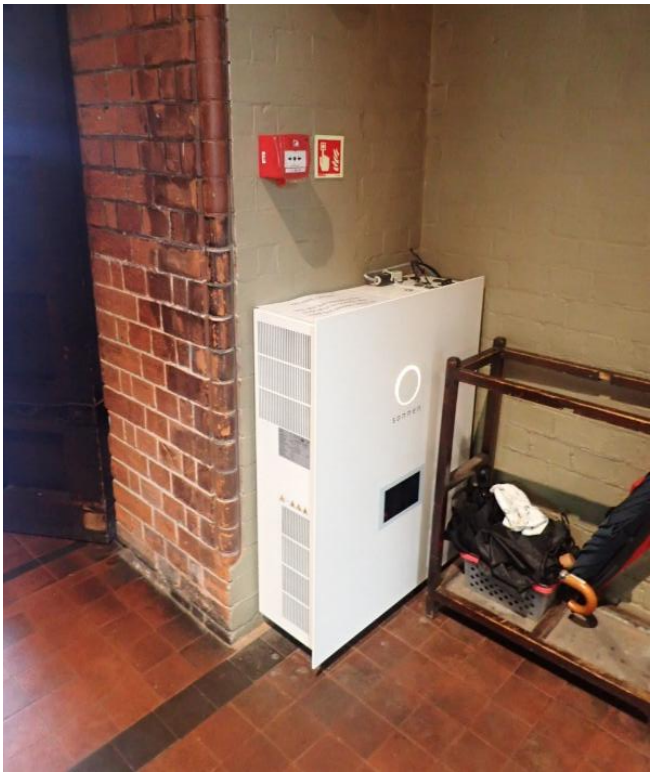
Kings College Chapel, Cambridge (all black panels, discretely visible. Mechanical fixings through lead roof)



St Michaels, Withington, standard panels, self-weighted system on copper, non-visible



St Silas, Pentonville - Solar slates



St Thomas, Finsbury Park - Combined battery and invertor

Links to local or national case studies or relevant guidance

Christ Church Abingdon, Oxfordshire

St Mary Magdalene's Woodstock, Oxfordshire

St George's Wash Common, Berkshire

All Saints' Bedworth, Coventry

Kings College Chapel, Cambridge

St Peter's Mancroft, Norwich

St John's Waterloo, London

St Augustine's Highbury, London

St James' Piccadilly, London

St Michael and All Angels' Withington, Cheltenham

St-Paternus' North Petherwin

St Helena's South Scarle, Newark

St Michael's Brentor, Dartmoor

All About Solar, a Diocese of Oxford webinar recording

Church of England renewables information

Insurance Considerations

There can be significant insurance issues raised when solar panels are proposed to be installed. These mainly revolve around fire risk concerns. When the installation is only solar panels these tend to be relatively straight forward to manage.

The inclusion of batteries can create more significant insurance implications. Though not a regulation there is a Publicly Available Specification (PAS), issued by BSI on fire protection of battery systems PAS 63100:2024. Insurers are likely to insist on the PAS being followed.

Safety features such as thermal cut outs, arc fault detection and links to fire alarm systems are likely to be required. It is recommended that churches engage with their insurer early in the process and may wish to gain the views of different church insurers as different underwriters have different views on the risks.

Sourcing Considerations

The two major considerations when sourcing solar panels systems are ensuring an ethical supply chain (especially of the source of the silicone used in the panels) and consideration of the embodied carbon.

Over 80% of the PV panels are manufactured in China with 95% of the silicon wafers being produced in China where much of the manufacture centres around Xinjiang province where Uyghur Muslims and other minorities are allegedly subjected to forced labour in internment camps. European supply chains are available but the sourcing of the silicon in these must be checked.

The components, particularly the glass and metals, within solar panels can result in them having a high embodied carbon (the amount of carbon emitted in the manufacturing and supply of the panels). Some suppliers have now invested in net zero factories and those with short distribution routes tend to be associated with lower embodied carbon values.

Myth Busting

- Solar PV panels are not permitted on listed buildings

  This is un-true, there are very many case studies of solar panels being installed in listed buildings, including churches for over 15 years, where careful detailing and consultation with appropriately accredited professional advisors (architect, structural engineer, installer) is employed. This includes Garde I listed buildings and, in some cases, the panels are partly visible. Kings College Chapel Cambridge, Gloucester and Salisbury Cathedrals, and York Minster all have solar panels on their roofs. (See the Permissions and Harm vs Benefit section above.)

- Solar panels should be installed on every roof

  It is only sensible to install solar panels if you are going to use the electricity that they generate. Installing solar panels on churches which are only used for a few hours a week makes little economic, or environmental sense and the investment would be far better spent on the solar panels being installed on other buildings such as the local church school. While the panels will export their electricity onto the grid, when this is exported in small levels on the low voltage end of the grid the environmental benefit of export is very marginal, and the economic benefit is low.

- Solar panels and batteries are a major fire risk

  There are cases of solar panels and batteries causing fires, but these are almost always causes by poor installation or specification. A well specified and well installed solar PV system, even with a battery, presents little more fire risk than any other part of the electrical installation within a building. (See the Insurance Considerations section above.)

- Solar panels add to the maintenance costs

  Panels are largely maintenance free; most are self-cleaning although adding them to the window or gutter cleaning regime is a good idea. They will be tested as part of the 5-year fixed wire electrical testing. Invertors tend to have a life expectancy of around 15 years and the panels themselves have a life expectancy of 25 to 30 years.

- The church will make lots of money by installing solar panels

  The Feed In Tariff regime ended some years ago so the main financial benefit from solar panels is that you do not need to buy so much energy from the grid. Churches can get paid for exporting electricity onto the grid, but this will be at commercial export rates (which are less generous than some of the domestic rates advertised) and are currently in the region of 6 to 8 p/kWh exported. (Whereas buying electricity is currently around 25p/kWh). New solar panel installations (other than large solar farms) are rarely a major source of incoming generation but if you use electricity all day, every day, they will provide a big saving on your electricity bill.

- Solar panels don't generate enough electricity to cover the carbon footprint of their manufacture

  A study by researchers from the Netherlands and the USA analysed PV production processes based on data from 2004-2006. They found it took 250kWh of electricity to produce 1m2 of crystalline silicon PV panel. This does vary depending on where the solar panel is made (European production tending to have a lower carbon footprint to that of panels produced in China). In the UK, 1m2 of PV panel will typically produce around 100kWh electricity per year, so it would take around 2.5 years to "pay back" the energy cost of making the panel. PV panels should last 25 to

30 years and so generate many times more energy than was needed to manufacture it. Panels located in less optimal situations (such as facing north or on shaded roofs) can produce much less than 100kW of electricity per year and therefore need to be carefully assessed with respect to their carbon payback. As the UK's electricity generation decarbonises there is a debate about whether the carbon payback of solar panels increases but the grid needs to have solar panels installed to be able to decarbonise and therefore this is a circular argument at the present time.

Estimated price brackets

The cost of solar panels is typically between £800 - £1,500 per kWp installed (kWp is kilowatts peak, the rate at which the panels generate energy at peak performance). The panels and their installation are very much less than this, it is often the scaffolding and specialist fixing systems which add considerably to the cost. Professional fees for consultants should also be considered within project costs.

Battery storage elements are rapidly falling in price and tend to cost between £500 to £800 per kWh of storage.