DESIGN & ASSET MANAGEMENT OF SOLAR PARKS

An insider's guide to maximising profit, minimising costs and reducing risk

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PUBLISHED:
NOVEMBER 2016

Contents

Glossary

AC	*Alternating Current*
Bencom	*Community Benefit Society*
CoP	*Code of Practice*
DC	*Direct Current*
DNC	*Declared Net Capacity*
DNO	*Distribution Network Operator*
DTI	*Department of Trade and Industry*
EPC	*Engineering, Procurement & Construction*
FIT	*Feed-in Tariff*
Grid	*At a local level, the GB electricity distribution network or nationally, the GB electricity transmission network*
HV	*High Voltage*
ICP	*Independent Connection Provider*
IEC	*International Electrotechnical Commission - the world's electrotechnical standard-setting body*
IET	*The UK's Institution of Engineering and Technology*
LV	*Low Voltage*
MCS	*Microgeneration Certification Scheme*
O&M	*Operation & Maintenance*
PV	*Photovoltaic*
REGO	*Renewable Energy Guarantee of Origin*
TIC	*Total Installed Capacity*

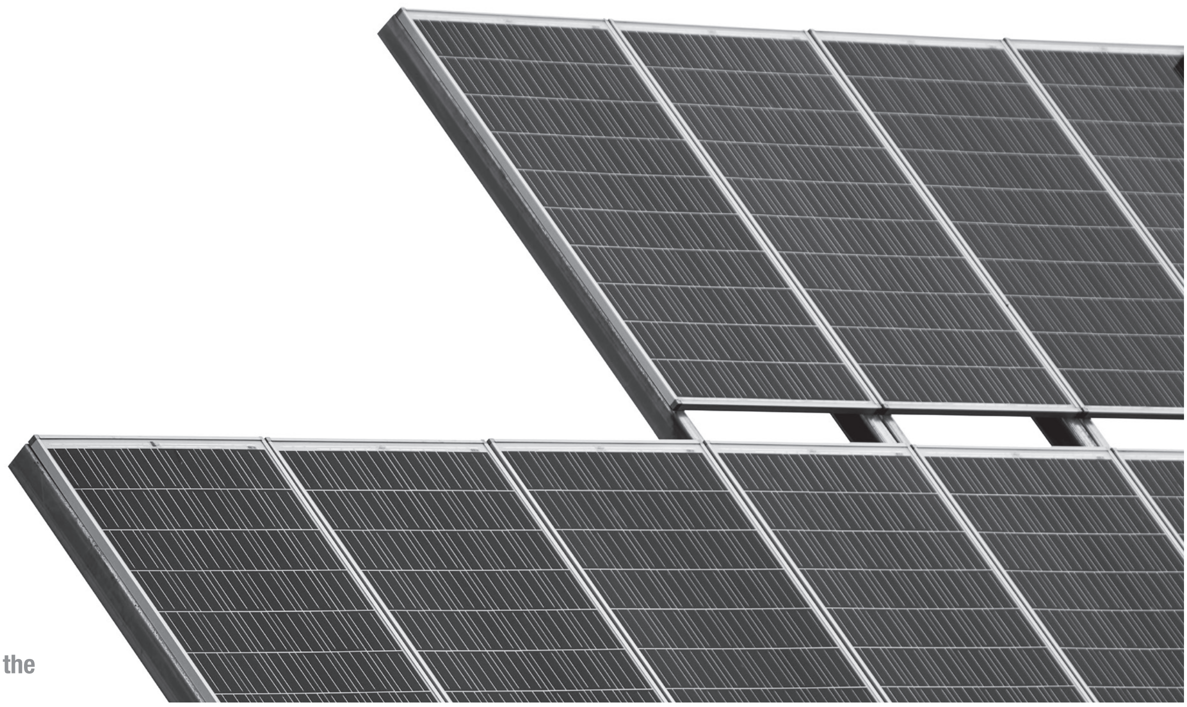
Introduction

A solar farm, although it makes no noise, does not pollute[1] and does not have external visible working parts, is complex.

Much of the complexity is in the design, which is the foundation on which safe, reliable and efficient operation is based.

A high quality and cost effective design, taking into account the need for 'operability' and 'maintainability' pays dividends in terms of securing the maximum life and generation output and hence revenues.

This paper identifies many of the key factors and issues that need to be considered as part of any solar project, together with recommended approaches to their management.



1 Subject to proper decommissioning at the end of its life

Design Standards

Problem # 1
Lack of design standards for solar farm construction.

Whilst DTI and MSC guidance for smaller solar PV installations has existed since 2002, the engineering standards for early larger-scale UK solar farms were not adequately regulated and hence the design approach that was taken varied considerably.

Areas particularly affected by this included: module interconnections; the conversion of DC (direct current that comes from the panels) to AC (alternating current that can be exported to the Grid); the configuration of HV switchgear and the connection to the DNO substation.

Today, solar design and yield calculation is done through industry standard software. These packages design the layout of a PV project and provide estimates of the possible electrical power generation depending upon the types of modules and inverters to be used, their installation and the location of the solar farm geographically. There is however often a difference between UK software and packages used in mainland Europe. Indeed, many EPC contractors who construct sites in the UK have commercial arrangements and relationships with European developers and designers and it is very common for UK sites to have been designed by European engineers to European standards using European software. This can cause problems during the life cycle of the site.

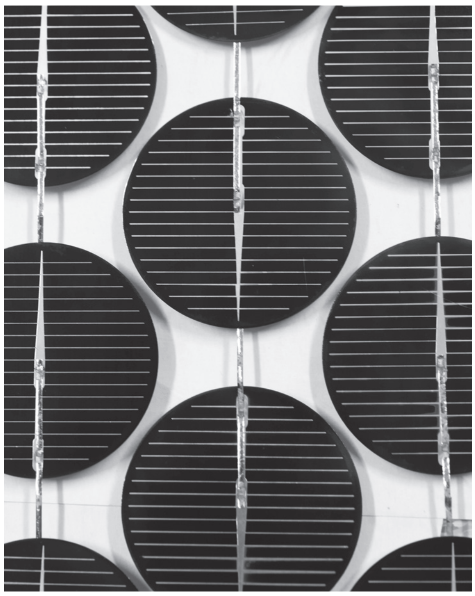
Since a primarily financial model has dominated UK solar farm development, with design objectives predominantly to reduce initial capital cost, it has resulted in too little attention being placed on whole lifecycle cost, maintainability and operability.

In addition, the application of IEC standards does not necessarily mean that a particular design approach is suitable for operation in the UK. For example, in the UK if work is carried out on de-energised HV networks then the earths must be capable of being locked on, however some IEC based designs of HV switchgear do not allow for this.

In 2015 UK stakeholders under the co-ordination of the Institution of Engineering and Technology formulated a Code of Practice for Grid Connected Solar Photovoltaic Systems (ISBN 978-1- 84919-721-2) known as the IET Code of Practice: www.theiet.org/standards. Professional engineers representing the DNOs, EPC contractors, designers, equipment manufacturers and trade associations were represented on the working group. The resulting CoP is a comprehensive document which refers to relevant industry and IEC standards in the context of how they need to be applied in the UK.

Recommendations:

- **ICP designs should be approved by both the relevant DNO and the client and should comply with the published standards.**
- **The client should approve EPC designs and a contractual stage gate should be created for this purpose.**
- **EPC designs should be informed by and carried out in accordance with the IET Code of Practice.**



Need to approve EPC (as well as ICP) design – a fundamental change

Problem # 2
Historically the client does not approve the EPC Design!

Unless a solar farm is to export the power it generates to a source of demand via a private wire system, the connection of a new project to the Grid requires the DNO to first provide a connection offer.

There may be certain conditions associated with allowing the connection of a new project to a particular point on an existing public network and the DNO will describe these in their connection offer letter. The DNO may need to reinforce or upgrade their existing network for a connection point to be possible.

Work on the DNO network and the extension to the solar farm is classed as either:

- **non-contestable** (only the DNO can do this work as it requires work in around and on the existing network); or
- **contestable** (where an approved designer and installer may do the work if it is designed and constructed to DNO standards).

For both contestable and non-contestable work, the Electricity Network Association and the DNO publish relevant engineering standards. For each individual project the contestable work – if it is to be designed and constructed by others – needs to be carried out by approved companies and the design for an individual project needs to be approved on a case by case basis by the DNO.

The result of this process is that both the contestable and non-contestable works are delivered so that they comply with the relevant DNO approvals and standards. Hence they can be readily incorporated and adopted by the DNO and will eventually, once adopted, become part of the DNO's network.

For the design of the customer's equipment (the solar site itself) there is no equivalent list of published standards, there is no concept of approved design companies and the technical design of the individual solar farm is not usually subject to technical review and approval by the client. In the case of community projects, it is not uncommon that there is little (if any) technical engineering capability on the client's side.

The result of this is that the design of the EPC solution (the solar farm) is not subject to the same technical rigour as the ICP and other DNO works. Usually the EPC solution is driven by price. However, in the long term, the cost of maintaining and operating the asset needs to be factored and designed into the economic life of the asset – at least 25 years. Until the IET Code of Practice was published in 2015 there had been no explicit stage gate in the award of the EPC contract where the design was audited and approved prior to and during construction. This is now being addressed but is often an unknown issue with the client.

It is also common that the interface between the DNO substation and the input to the customer substation is forgotten and is not covered by the scope of either the ICP or the EPC contract. In addition to HV and LV cables, there is a need for additional control and signal cables to pass between the two substations, so knowledge of both DNO and client substation design is necessary to design and construct the site in an integrated manner. Without this there will be greater costs during the life of the asset.

Recommendations:

- **EPC designs should comply with the IET Code of Practice.**
- **The EPC design should be carried out by organisations which have the necessary skill and capability.**
- **Introduce timed reviews and approval of both the ICP and EPC designs by the DNO and the client.**
- **Contractual provision for adherence to technical performance standards should be part of the EPC and ICP contractual relationship and contract documents.**
- **Ensure there are no design gaps between the interface of the IPC and EPC contract – especially the design of the power and control cables between the DNO and client intake substation.**

Design in Operability and Maintainability versus the need to minimise initial capital cost

Problem # 3
Ensuring that initial capital cost is not the only driver.

The need to drive down initial capital cost and to develop a financial model that provides an optimised return on investment results in future O&M costs being pared back so far that they become unrealistic. This can result in over simplification of designs, which may result in a site being more expensive to operate in the long term. Realistic costs for ongoing O&M need to be built into the financial model at the outset.

It is not unusual that decisions taken very early in a project, during financial modelling by non-engineers, can have significant impact on long-term maintainability and operational cost. There is considerable merit in developing early design principles; however organisations at the concept stage may not have the full range of skills and experience to understand their impact and value.

The cost of complying with planning, environmental, landscaping and operational factors also need to be considered. Often planning conditions are not thought about and can contain expensive outputs – such as tree planting or wildflower meadow planting. It is essential that the financial model includes inputs from those experienced with solar farm operations and maintenance. Again, the physical design of the plant needs to make provision for maintainability and reliability.

Factors that increase initial cost, yet in the long term could impact positively on reliability and maintainability include:

1. Ensuring that during the construction phase all planning requirements are completed.

2. Provision for installation of string cables in cable trays and channels rather than clipped to frame structures.

3. Installation of underground DC and AC power cables in ducts rather than directly buried.

4. Provision of adequate switchgear so that sections of plant can be isolated rather than requiring whole-scale disconnection for work and maintenance.

5. Adequate provision of onsite spares (circumstances have been seen where no spares at all were provided to save initial cost).

6. Adequate security and monitoring to avoid vandalism and trespass

7. Adequate site drainage to prevent flooding and ensure water is discharged away from site.

8. Adequate provision for weed treatment, seeding and grass cutting.

9. Legal matters pertaining to leases, wayleaves, easements, access rights and ownership are identified early.

Recommendations:

- **A whole life asset management plan needs to be part of the financial model at the outset.**
- **Realistic costs for O&M need to be built into the financial model.**
- **Even at the concept and option stage of a new project, modelling should be carried out by a multi-disciplinary team having the full range of experience required.**
- **Design principles should be agreed and documented early where these may have a financial and long term impact on cost.**

Community owners may be less experienced in managing solar assets

Problem # 4
The end client may not have sufficient technical expertise and needs support from independent experts.

Community Energy companies do not necessarily have access to technical and experienced engineering resource. Bencom management teams comprise individuals with a wide range of skills who may not necessarily have been involved with large-scale solar farm development or may have limited experience and may not be aware of best practice or local issues.

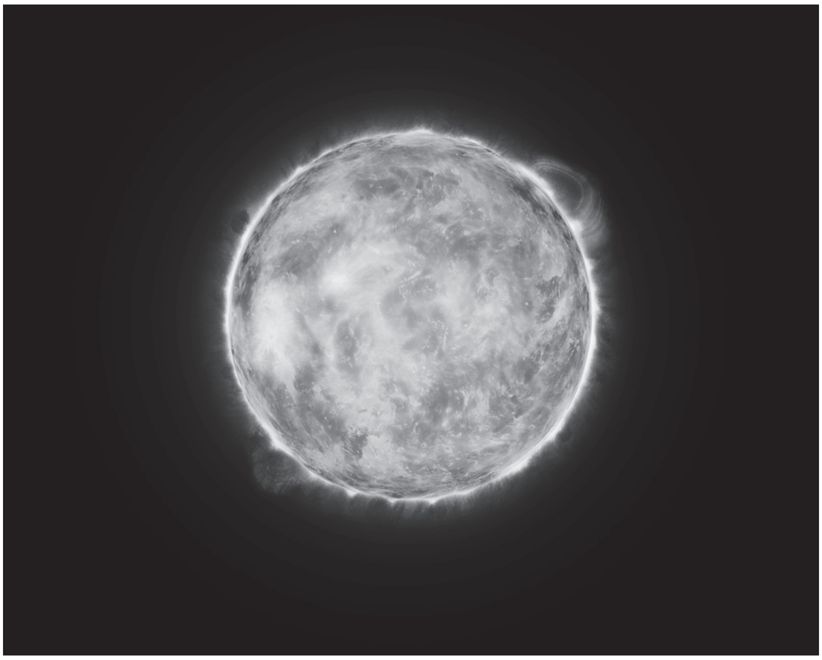
Experience shows that although national standards may apply, often local external stakeholders take different approaches and interpret standards and regulations in an alternative way.

Local Planning Officers may have a particular approach to some matters; regional DNOs interpret standards differently (even within their own areas) and may also have local constraints that need to be addressed. Early engagement with external stakeholders by Bencoms supported by individuals who are technically experienced and familiar with the range of options and how others have interpreted and satisfied these in the past, allows for early agreement and a reduction in risk for the asset owner.

Clearly the ICP and the EPC contractor will have their own preferred and standard approach but these may not necessarily be the optimal approach for an individual project in a specific geographical site.

Recommendations:

- **Consider holding a meeting with technical advisers at the commencement of scoping of a project.**
- **Ensure local knowledge is sought concerning the approach taken by local external stakeholders.**
- **Appoint client side advisors in areas where there is little or no in-house expertise (technical, legal, engineering, financial and commercial) to represent the interests of the client and to interpret and advise on the best options.**



Lessons learnt about key transition stages – construction, testing, handover and O&M

Problem # 5
Unless project stage gates are managed, information is not explicit and the differing skills are not provided, project progress slows and becomes disjointed.

A typical project passes through discrete stages where different skills are needed. The early stages of identifying the potential for a project, identifying and securing a site, gaining planning consent and fund raising are acknowledged as being critical but are not the main focus of this paper.

From an asset management perspective key stages of the project are:

1. Contract development tendering and award against a specification
2. Contract management
3. Design
4. Design approval
5. Construction
6. Testing, commissioning and go live
7. Metering – appointment of a meter operator, data aggregator and data collector
8. Installation testing and validation of metering equipment
9. Project acceptance
10. DNO adoption of contestable work
11. Handover and snagging
12. Transition to operations and maintenance
13. Day-to-Day operations, ongoing maintenance management, reporting and audit

All the above stages require proactive management and leadership on behalf of the asset owner. Experience shows that unless the client seeks specific assistance with these activities then critical items will be overlooked.

Recommendations:

- **Clients should identify the necessary technical expertise that is needed to support them through the contractual and technical construction phases and ongoing maintenance.**
- **Post-construction transition to a 'business as usual' status is important as it secures the necessary long term information necessary for the plant to be efficiently managed.**
- **Formal stage gates for transition between stages should be implemented.**

The need for technical, commissioning and handover records

Problem # 6
Providing technical data that the equipment has been installed, tested and commissioned correctly and a set of technical design drawings, reports, test data and 'as built' information is critical.

Agreeing in advance the full range of electrical and non-electrical tests that will be carried out to ensure that all types of assets have been installed correctly and then properly commissioned is essential. Appropriate tests and a record of and report on test values obtained are required for third parties to evidence that design and installation have been successful.

These include:

1. Earth resistance values of the installed earthing system.

2. AC and DC cable insulation and pressure testing data to evidence installation and damage free installation.

3. DC string test data to demonstrate that the PV modules have been installed correctly.

4. Electrical on site tests (as opposed to factory tests which do not evidence on site correct installation) for HV and LV switchgear, transformers and substation equipment.

5. Validation of generation and DNO metering.

Asset companies need to develop a standard form of document library and experience shows that each EPC contractor has their own process and list of documents that they provide at the end of the construction phase as part of the handover process.

It is essential that the client ensures that the handover pack is a complete and full set of documents. In most cases the O&M contractor who needs this full set of information will be the same EPC contractor that constructed the site. However, the client must ensure that the information passed over would be the full complete set of records that a new third party would require.

Recommendations:

- **Agree the contents of the 'handover pack' in advance of the contract. Preferably the contents of the pack should be an appendix of the main EPC contract.**

- **Ensure that the actual documents are provided and transferred to a secure client administered folder structure so that these are independent of the main O&M provider and that a process exists to keep them continually updated.**

Experience of OFGEM post-construction site audits

Problem # 7
If a project is audited by OFGEM will you have the necessary documentation and test evidence available?

Since fundamental changes to the Feed-in Tariff that were introduced in late 2015 OFGEM has moved its focus onto existing members of the scheme. There has been a significant increase in the number of OFGEM audits to investigate generating stations with existing full accreditation under the scheme. These audits are comprehensive and investigate all aspects of the generating station's compliance with the underlying requirements of the FIT scheme including the specifics of commissioning; the 'site' of the generating station; the metering arrangements and the information provided in support of the accreditation application.

In a recent audit that was carried out by an OFGEM Auditor the following information had to be provided:

1. 'As-built' single line diagram and general arrangement diagram
2. Commissioning documents (G59-3 test certificate, DC string tests, AC electrical test certificates, inverter commissioning tests, time-stamped photographic evidence, third-party or EPC commissioning letter)
3. HHD associated with meters used for FIT and REGO claims (since commissioning until the date of the audit)
4. Proof of payments received from the FIT provider
5. Third-party TIC and DNC confirmation and calculations
6. Power Purchase Agreement and Grid Connection Agreement
7. Meter calibration certificates
8. Planning permission

Following the provision of this information the OFGEM consultant visited the site to carry out a physical audit. Since the information requested had been provided in advance, the audit process was straightforward.

The requirement to provide this information reinforces the need to ensure that detailed records, testing and commissioning data is managed proactively.

Recommendations:

- **Ensure that the 'handover pack' contents provide the information that the OFGEM Auditor will request.**
- **Where this is not available from the EPC contractor, identify where this needs to be obtained from.**
- **Comply fully with the OFGEM Auditor request for information.**

Lessons about Operation & Maintenance

Problem # 8
Ensuring that the Operation and Maintenance contract is scoped and managed correctly is critical as otherwise costs can get out of control.

It is common practice that the EPC contractor will, as a follow on from the construction phase (and sometimes as a condition of the EPC contract) be awarded the O&M contract. If that is the case, the transition from the construct phase to the maintain phase needs to be carefully managed by the client's representative since the construction manager will want to demobilise the construction team as early as possible. Common practice is to create a 'Snagging' or 'Punch' list of items needing to be finished off or remediated and often the last remaining items will overhang the end of construction. It is important that the O&M team take on ownership of the remaining open 'Punch' list items and retentions for each outstanding item to the original EPC contract are agreed.

Ensuring that the handover pack of: 'as-built' drawings, final design documents, test data and manufacturer's manuals and the assignment of warranties from the EPC contractor to the asset owner is essential. If the EPC contractor is the same as the O&M provider there is a risk that this information is incomplete. The Client's representative should ensure that all the information necessary to maintain and operate the plant is complete and the test to apply is whether a completely new O&M contractor would have all the information necessary.

The O&M contract should specify the scope and frequency of inspections, preventative and maintenance operations. The contractor should provide a programme for the year so that it is clear when each type of work is carried out.

The O&M contract should also specify the Service Level for response to different types of incident/fault and categorise them in terms of response times and fix times against relative impact. For example, a G59 trip and lockout incident should result in a same-day working day response and this type of incident should have an agreed and specified service response.

The scope and provision of critical spares will be specified in the EPC contract and common items will usually be held on-site in a secure area or container. The inventory should be checked at the commencement of the contract and periodically. It is common that the EPC contractor will take title of any items that are replaced under the O&M contract and although the manufacturer (if replaced under a manufacturer's warranty arrangement) may retain these, there may be valuable or re-useable components in a removed item. Rather than automatically becoming the property of the EPC contractor the client should demand ownership of the redundant items. This is an example of the need for close contract review before acceptance.

The O&M contract will require the contractor to provide a monthly performance report including a report on unplanned incidents and progress against the scheduled programme of maintenance work. Maintaining a close working relationship with the O&M contractor and the field staff is important so that the site is well-maintained and incipient matters caught early. Overall site performance can deteriorate if not closely monitored and any departure from the assumed and modelled output should be examined against actual performance and the response to this investigated jointly.

Recommendations:

- **Ensure that the handover pack contents are complete and extensive and includes all the information that an independent O&M contractor requires.**
- **Ensure the 'Punch' list is completed by the construction team and minimal and minor items are carried through into the O&M phase.**
- **Ensure the O&M contract specifies scope & frequency of planned maintenance activities.**
- **Ensure there is a process to manage unplanned maintenance and for incident management.**
- **Ensure that the contract specifies performance service levels for O&M activities.**
- **Ensure critical spares are held locally and the inventory is managed.**
- **Consider who should retain damaged or failed components replaced under the O&M contract (especially high value items) where these may contain components that could be refurbished or reused.**
- **Ensure that the opportunity to maintain engagement and review monthly performance is retained as part of the monthly O&M reporting process.**
- **Consider who owns the O&M company and whether insurance is required in the event ownership changes or the company goes into liquidation.**

Technical due diligence experience

Problem # 9
Acquiring an existing project requires a multi-disciplinary team of legal, financial, technical and operational capability. The process is drawn out and extensive and if a commercial loan is involved the bank will appoint its own technical auditor.

Technical due diligence will be carried out when an existing solar farm, which may already be in operation or in the final stages of construction, is being acquired by a new owner. Technical due diligence is in addition to commercial and financial due diligence and the importance of it can sometimes be overlooked.

It is not uncommon that the technical due diligence activity is not commenced sufficiently early or the importance of it not recognised. By analogy a large value capital asset (a house/factory/ship) would not be purchased without a survey and report on its condition. Yet in the solar industry the need for technical due diligence is sometimes not seen as being of the same level of importance.

If the project is being funded in whole or in part by a lender, then that lender needs to know that the revenue stream is assured. An asset owner is also looking at operability and maintainability and ensuring the project is financially viable for the whole of its life.

If a lender or third party is involved in financing the project they may wish to appoint their own technical evaluation team. However, a lender will only wish to establish that the loan amount is not at risk and ensure that the value of the asset is greater than the loan amount. The objective of the new asset owner's assessment is more extensive as they need to ensure that the asset is capable of providing the full anticipated revenue stream over the life of the plant. If a purchaser relies solely on the lender's technical auditor, then it will not be sufficient to identify all the risks and issues that need to be considered.

Recommendations:

- **Technical due diligence is of equal importance as financial or commercial due diligence and needs to be carried out early to ensure that no factors which might have a commercial impact are discovered. If any are discovered they can be incorporated as risks and funding provision for their remediation can be included in the overall transaction.**
- **The asset owner needs to ensure the plant has been built as specified, the technical documentation is complete and accurate, the plan has no outstanding construction items remaining to be remediated, the plant is being operated and maintained according to the contract and there is no underlying issue of reliability or performance.**
- **The technical due diligence team will inform the commercial structure and content of the calculation of value and price. Their work needs to be completed several weeks before final contracts for purchase can be finalised.**

The importance of ensuring a Safety Management System exists - and operates both during construction and afterwards

Problem # 10
The directors of the entity owning the asset are legally responsible for safety management. They can discharge this responsibility by appointing an expert who will manage on their behalf.

In almost all community owned projects it is unlikely that the Management Board will include members who have a professional background in safety management and especially in High Voltage Safety Management Systems. UK law places legal responsibility on Directors to ensure that their activities are managed so that they do not endanger members of the public, their staff and those who may be involved in their activities including those contractors who may provide services.

However, this responsibility can be delegated to a person who is appointed on the Director's behalf to provide this role but this person must have the experience and qualifications to carry out this activity.

During the course of construction the provision of and responsibility for safety management can be discharged contractually under a services contract if the service provider works under his own safety management system. If the asset owner carries out an audit it must ensure that the safety systems the contractor is applying are sufficient.

Members of the asset owning company or community enterprise need to ensure that if they visit the site they do so under an approved Safety Management System. Some community energy organisations may have the ability to develop, maintain and manage their own Safety Management System. However, most do not have this capability and should only go onto site under the direct supervision of their EPC or O&M contractor.

Recommendations:

- **Ensure that all operations and contracts impose a requirement for a formal Safety Management System to be in place.**
- **Consider appointing a suitably qualified person to provide the expertise and experience necessary to implement a Safety Management System and/or to audit those contractors who are working for the asset owner and that the system is rigorously enforced.**
- **Ensure that no-one can access operational sites unless authorised to do so individually under a formal Safety Management System or accompanied by a contractor working under his own Safety Management System.**

Summary

- Formal approval by the site owner is necessary for the design of the EPC contract.
- The EPC design needs to be governed by agreed standards such as the IET Code of Practice.
- The design of a solar farm needs to build-in long term reliability and minimise the long term operational cost, rather than being driven by initial formula of £ per kW.
- Community energy groups would benefit from appointing technical professional experts to represent their interests at all stages of design, build, operation and maintenance.
- The construction and handover phase is especially important to ensure that a full set of detailed technical information is provided by the EPC contractor.
- Ensure that the scope and detail of the O&M contract will underpin future asset management.
- Active management of the O&M contract and relationship management of the supplier will ensure the long term effective and efficient performance of the asset.
- Ensuring that a Safety Management System is in place, if necessary by appointing a suitably experienced and qualified engineer, will mitigate any legal liability on the asset owner.

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Conclusion

From the very first solar park to be granted planning permission in the UK, Wheal Jane in Cornwall, to our 300th solar park project this year, the renewables team at Stephens Scown have seen and been involved in pretty much every permutation and nuance involved in developing, financing, constructing and operating solar parks. We've seen good work and we've seen room for improvement!

We are proud to play a strong part in the transition of the UK to a future powered by renewable energy and to have contributed to the 10 GW of solar power now installed.

In order for solar parks to continue to contribute to our renewable future and for more to be built it is important that they are managed and built efficiently.

We commissioned this white paper to aid those already operating solar parks and those looking to build in the future; and yes there most definitely is a solar future!

If you require further advice on this subject, then please contact Sonya Bedford, partner and head of renewable energy at Stephens Scown:

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