Ministry of Justice

Photovoltaic Generation

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05/10/2020
(Performance Specification)
MEP ENGINEERING

Revision	Issue	Originator	Approved	Date
01	Draft for Comment	AP	DSO	05 October 20
02	Draft for Comment Amendments made to incorporate the Requirements of Project Standards Solar PV Roof Mounted v0.3	AP	DSO	07 October 20
03	Draft for Comment Permitted development/planning information added.	AP	DSO	12 October 20
04	For Tender Client comments incorporated	AP	DSO	15 October 20

Contents

1. Definition Terms

1.1 Supplier

The successful organisation or company providing the services under the contract for the provision of Photovoltaic Generation and infrastructure.

1.2 Contracting Authority

The organisation ordering works or services, will be The Ministry of Justice.

2. Scope of works

2.1 General requirements

This Specification is for the design, procurement, installation, testing and commissioning activities associated with photovoltaic generation and shall be read in conjunction with the Arcadis Ground Mounted Solar Assessments feasibility studies, other tender documentation and all framework documents as applicable under the HELGA DPS RM3824 contract.

This specification covers both ground mounted and roof top mounted PV panel installations.

The PV panels will be installed at a list of prioritised locations as indicated in the tender documents. All installation locations identified and advised by the Ministry of Justice at the time of the Tender will be subjected to the activities described here after. Each location is to be regarded as a different sub-Project within the overall Photovoltaic Generation Project and shall be identified in accordance with the tender documentation and as agreed with the Contracting Authority.

For each ground mounted site locations, the generated power has been specified to not exceed 75% of the minimum daytime load (defined as minimum power load between the hours of 10AM and 4PM). This is to ensure that all generated power will be utilised by the site to which the PV generation is connected, and no power is exported to the broader DNO network. A separate document has been produced detailing the power generation requirement for each site.

The contractor will be liable for all faults and damage to PV equipment and accessories that may be temporarily stored on site for use on specific MoJ projects.

The contractor will be responsible for ensuring that sufficient stocks are ring fenced at the manufacturers for the MoJ projects.

Each location's sub-project consists of a site survey assessment, full efficiency predictions, design, procurement, installation, testing, commissioning, certification, warranty and maintenance of photovoltaic generation panels and associated infrastructure as described and specified hereafter.

With respect to roof mounted installations. in all cases the contractor is required to;

- Design and install the most efficient array based on roof space available and baseload demands of the building
- Ensure that the appropriate roofing surveys have been carried out to withstand the weight of a solar array and all associated equipment
- Take due account of snow and wind loading.
- Ensure value for money
- Enable ease of future maintenance – life cycle costing and maintenance assumptions should be included as part of the tender recommendation

The requirements will consist of, but is not limited to, the following requirements for each location:

- Provide a detailed PV generation proposal, supported by relevant site intelligence, as detailed in the tender documents for each of the sites / location as mentioned
- Compile data for all the installation areas to inform the need for asbestos surveys.
- Carry out underground surveys on all installation areas where trenching is required to identify existing services affected by the work.
- Provide a plan layout of the proposed installation options for each site, including details of the materials, equipment, works for the infrastructure installation, including all connections, excavation, ductwork, reinstatement, signage, road marking and making good necessary for the end to end installation.
- An analysis of both series & parallel connection options to be provided to ensure the client understands the advantages and disadvantages of both systems. It should be noted that the client is keen that systems are designed so that a single panel does not:
  - dictate the overall generation capability at any given time
  - mean a single failed panel does not result in the failure of the whole array
- Provide structural / civil engineering specialist services in relation to the foundation ground works, where and if required for mounting bases for PV panels and associated wiring containment, any work associated with the inverter's installation and what else necessary.
- Prepare and agree installation programmes for each site with the Contracting Authority.
- Consult with, make applications for and pay all fees necessary to gain DNO approvals, planning, leases & licenses.
- Design, procure, install, connect, test, commission, set to work and demonstrate the PV generation system including metering and connection to the Building Energy Management System (BEMS) and the fire alarm system.
- Provide all necessary builders work in connection (BWIC) and making good the installation.
- Provide all necessary software and personnel training for each site, in such a way that the system will be able to be monitored online by each Regional Contracting Authority's Branch Office.
- Provide remote data reading and recording facilities on the PV generation performance.
- Provide responsible and qualified full project management for all phases of the activities on each location.
- Provide full operating and maintenance information and record drawings for the completed installation(s) for each location.
- Provide personnel training on site for each installation on each MoJ location to the MoJ nominated representatives.

The general plant, equipment and materials shall be sourced from sustainable suppliers and manufacturers, without compromising quality, service or maintainability of the final installation. All materials shall meet the relevant standards for each item as identified in the documentation and agreed with the Contracting Authority.

The Supplier shall ensure that all components can be easily accessed for maintenance activities and be able to be swapped out and replaced when and as necessary.

The Supplier shall provide one calendar year maintenance following practical completion. Extension to this initial one year maintenance to be agreed with the MoJ.

The Supplier shall not deviate from the specification and tender documentation without prior written approval from the Contracting Authority.

2.2 Standards and Regulations

All PV panels, inverters and general electrical equipment shall be provided and installed in accordance with relevant standards, Code of practice, Regulations and this Specification.

A minimum of a 10-year warranty is required on all major components along with details on the manufacturer of the panels and whether components are inter-changeable with other manufacturers should suppliers cease trading.

The Supplier shall fully comply with the above and all other requirements of the MoJ.

All electrical works shall be carried out in strict accordance with the BS7671:2018 + A1:2020 - 18th Edition of the IET Wiring Regulations, all Standards, Regulations and Code of practices as cited in this specification and to the complete satisfaction of the Contracting Authority.

All materials and workmanship shall be in accordance with the standards specified and shall conform to the requirements of the regulatory bodies as given in the specification and contract documents.

All materials specified shall be in accordance with the latest British/European Standard Codes of Practice, British/European Standard, and ISO standards (latest amendments at the date of Tender), Engineering & civils works specification. The whole of the works shall be executed in a professional manner. It shall comply with the best practices of the industry and conform in all respects with current requirements.

The Supplier shall provide certificates and letters stating that the materials and installations are in accordance with the authority having jurisdiction over them, the regulations applicable, and the applicable British and ISO standards as follows:

- Asbestos Regulations
- British Standards & Codes of Practice
- BSRIA: Building Services Legislation – a directory of UK & EU Regulations
- Building Regulations
- CDM Regulations
- Construction Health & Safety and Welfare Regulations
- Equalities Act 2010
- Environmental Protection Regulations
- Factories Acts
- Fire Officer Committee Regulations
- Health and Safety at Work Act
- Health & Safety Commission Approved Code of Practise and Guidance
- HSE publication HSG47 *Avoiding dangers from underground services*
- Ministry of Justice Regulations & Guidance
- Local Authority By-laws
- Provision and use of work equipment regulations
- Public Health Acts
- Chartered Institution of Building Services Engineers
- Statutory Instruments and any other relevant Acts of Parliament.
- IEC 60536 IEC 61140
- EN 610000 – EMC Compliance
- EN 60950 Safety Compliance to Low Voltage Directive
- The Electricity at Work Act 1994

- The Electricity Safety, Quality and Continuity Regulations 2002 and amendments
- BS EN ISO 9001 - Model for Quality Assurance in Design, Development, Production, Installation & Servicing
- BS EN 60947 - European Standard for Low Voltage Switchgear & Control Gear
- BS EN 61439 - European Standard for Low Voltage Switchgear & Control Gear Assemblies
- BS 6724 - Electric Cables 600/1000V
- BS 7671:2018 + A1:2020 - IEE Wiring Regulations 18th Edition
- Engineering Recommendation ENA G98 (current edition) – Recommendations for the connection of small scale embedded generators (up to 16A per phase) in parallel with public low voltage distribution networks.
- Engineering Recommendation ENA G99 (current edition) – Recommendations for the connection of generating plant to the distribution systems of licensed distribution network operators.
- BS EN 62446 (current edition) - Grid connected photovoltaic systems - Minimum requirements for system documentation, commissioning tests and inspection
- The Microgeneration Scheme (MCS) Installer Standards
- The Microgeneration Scheme (MCS) Product Standards
- IET Code of Practice for Grid Connected Solar Photovoltaic Systems
- MoJ standards STD/X/036 and STD/X/037
- CE – CE Marking
- BS 8300 – Design of Buildings and their approaches to meet the need of the disabled. Code of practice
- DPA 1998 – Data Protection Act
- ECR 2006 – Electromagnetic Compatibility Regulations 2006
- EESR 1994 – Electrical Equipment Safety Regulations1994
- TSRGD 2016 – Traffic Signs Regulations and General Directions 2016
- WEEE Waste of Electrical and Electronic Equipment Directive 2012/19/EU

The Supplier and their supply chain shall always adopt working practices in accordance with the requirements of, but not limited to, the Health and Safety at Work Act 1974, CDM Regulations 2015, and the Electricity at Work Regulations 1989 whether they are applicable or not.

The photovoltaic generation installation standards and requirements are fully described in this Specification. The connection of all generating systems to the building's power network is the responsibility of the Supplier, as is the process of arrangement and agreement of all associated parties and respective permissions, including permission granting by the relevant DNO.

Shall there be any item specified or shown which may be considered as not complying, the Supplier shall notify the Contracting Authority of this so that clarification can be obtained. Subsequent non-complying elements shall be replaced at no cost to the Contracting Authority.

Any apparent conflicts found between any drawings, the specification and statutory requirements, as well as any doubt regarding the principles these Performance Specifications establish, are to be notified immediately in writing to the Contracting Authority by the Supplier.

2.3 Site Survey Visits

The Supplier shall work collaboratively with the Contracting Authority Project Team to ensure the successful delivery of the installation programme, including the following:

• Liaison and co-ordination with site users and the client's FM team and their suppliers to arrange and obtain site access for the surveys and works.

- Liaison and co-ordination with the client's Estates Management Provider in connection with obtaining landlords licences where necessary.
- Liaison, co-ordination and reporting information to track progress and costs against the delivery of the installation programme.

The Supplier shall visit the site(s) to familiarise themselves with local conditions, ground conditions, means of access, existing services etc. as no claims shall be entertained on the grounds of ignorance of such conditions.

All visits to Contracting Authority's premises shall consider the daily operational activity of that site and the Supplier is to be understanding and accommodating of any specific or general building' and user' requirements and sensitivities.

Any such visits shall be made by prior appointment with the Contracting Authority & site management staff. The Supplier shall make a formal appointment with the site through the Contracting Authority, attend promptly, familiarising and observing all local procedures such as evacuation, signing in and out of site and Health and safety routines including Asbestos register. The site visit shall consist of non-intrusive inspections of all areas where works are proposed to take place.

If and where intrusive inspections may be required, the Supplier shall notify the Contracting Authority and jointly establish a follow-up Intrusive Survey in such a way as to minimise the establishments activities disruption, preserve the premises Security and sensitivities and ensure the H&S of all occupants and Surveyors. A Method Statement for the Intrusive Survey will be required by the Contracting Authority to ensure that proper Safety and Security Procedures will be adhered to.

2.4 Work within existing buildings & Sites.

The Supplier shall note that they shall be working within buildings which are used by the Contracting Authority's staff, the general public and, in some cases, vulnerable persons. The Supplier shall not impede or interfere with the day to day operations of the buildings or sites in any way and be considerate and accommodate the staff's building user requirements.

The Supplier's access, car parking, and compound requirements shall be agreed with the Contracting Authority before starting work.

The Supplier's personnel is required to have a Baseline Personnel Security Standard Clearance (BPSS) if working outside the MoJ premises. No deviation will be accepted.

The sites Fire evacuation strategy shall be fully understood by the Supplier and considered within any visits or H&S documents and Permit to Works.

Under no circumstances shall any power be disconnected, or any isolation of services done, without prior written approval from the Contracting Authority and an adequate Work Permit issued. Any such disconnections shall be agreed in advance, with the Supplier giving a minimum of 7 days' notice. The Supplier shall allow for all shutdowns to be undertaken to suit the building use activity which may require to be outside the normal daily working hours or even at weekends. No additional costs for such events will be accepted.

Through the course of the contract, every effort is to be undertaken to minimise the impact the works will have on other users of the building and establishment – where disruption occurs every reasonable precaution shall be planned, and provisions made to minimise operations to the business operations from all aspects.

Strict security requirements apply to all aspects of the project information, as well as execution and full observance and adherence of these is essential at all stages of the project.

The contractor will be required to take into account all aspects identified in respect to the site, any restrictions, statutory requirements etc. which will materially affect the design and construction of the building and make due allowance for them in his contract sum. No claim will be entertained for lack of knowledge.

Contractors are required to follow all safe working practice directions required of the site as outlined in individual MoJ workplace assessments.

Covid-19 Management plan: The contractor shall provide a project specific Covid 19 Construction Management plan outlining their procedures and processes in that respect and in compliance with government guidelines and regulations.

2.5 Builders and Civils Work

The Supplier shall be responsible for undertaking all builders and civils work in connection with the PV generation installation.

Holes through building structure for cabling shall be avoided where possible, however where this is impractical, prior to forming any holes, the Supplier shall consult with their appointed structural engineer then submit and agree with the Contracting Authority, the exact location of the penetration, including full weathering & fire stopping details. Holes through walls and/or floors shall be filled, sealed and weatherproofed, with fire barriers added or reinstated. Filling of holes shall be carried out in a neat manner to match the respective surround, e.g. damaged brickwork or cladding, as a consequence of the contract works, and the external facade shall be made good with matching brick or whatever material the existing structure comprises. Decorations shall generally be made good to match existing.

PV modules on flat roofs shall be mounted on sloping frames which can be mounted on free standing frames. PV modules on pitched roofs shall be fixed using appropriate fixing hooks for each site roof type. Refer to installation design for further details.

Trenching and ground works shall be carried out in accordance with standards referenced in this document. Temporary supports and barriers for excavations are to be provided as required under the Construction Design and Management latest Regulations

Hazards associated with PV installation are outlined in the DTI's free manual, 'Photovoltaics in Buildings – Safety and the CDM Regulations. The supplier shall provide full supporting Health and Safety Information with risk assessments and method statements with each proposed installation.

The Supplier shall provide a designer's risk assessment and installation method statements prior to commencement of works on site. The above documentation shall be submitted to the Contracting Authority for comments prior to commencement of the works.

Where a permit to work scheme is in operation at a site, the permit shall be applied for in writing and received comment one week before commencement of the works.

2.6 Supplementary Information to be Provided with PV Generation Proposal

The Supplier shall provide the following information with their priced submission.

- Details of any subcontract or proposed subcontract arrangements
- Name and experience (with CV) of Project Manager
- The proposed company and name of the person (with CV) undertaking the structural / civil inspection and associated calculations.
- Evidence of the personnel required Security Clearances as indicated elsewhere.
- The Client has specific programme reporting requirements that contractors will be required to align to – typical information required will be, how many SMEs are being contracted with, job creation / job retention stats, carbon impact of projects
- The client is to be provided with full efficiency predictions by both *kWh displaced from grid* and *carbon emissions avoided*. All assumptions and data used must be supplied. The client can provide actual costs of electricity and UK Government conversion factors for greenhouse gas emissions that are to be used.

2.7 Photovoltaic Generation Hardware, Accessories, Key Requirements and Functionalities

The supplier is to be responsible for the *s*upply & installation of all necessary hardware and accessories needed for a fully operational photovoltaic generation system.

The installed generation power for each site is specified elsewhere.

The equipment shall meet the following minimum requirements:

- Panel efficiency minimum is to be 22%. The type and manufacturer of the photovoltaic panels is the responsibility of the supplier submitting the tender.
- The proposed configuration of the system must be clearly stated - the number of arrays and panels per array
- Inverter with a manufacturer’s warranty of not less than 10 years.
- A multifunction sub-meter to measure the output of the array shall be provided. The meter shall be digital with a readily available and easy to operate human interface. The meter shall provide an input into the Building Management System. Allow for the meter to be BACnet protocol compatible.
- A data logger with a GPRS modem for remote performance monitoring.
- Adequate on-site sensors or satellite-based data for irradiance and temperature.
- Maintain a measured annual Performance Ratio higher than 90% of the Predicted Performance Ratio.
- Meet all of the requirements set by the manufacturers of the Goods Warranted by a Manufacturer.
- Install PV modules in a shade-free environment which also mitigates the risk of shading from future growth of vegetation (as reasonably foreseeable at the time of the installation).
- The installed panels with the proposed fixing system to the roofs will have to protrude less than 20 cm in order to not exceed permitted development criteria.
- The plant shall be designed and installed to minimise the cost of electricity generation over the plant lifetime, also commonly known as Levelised Cost Of Electricity (LCOE); compatibly with any relevant H&S, structural, planning constraints.
- PV electricity shall have priority over CHP electricity, where a CHP is installed.
- Individual string and inverter monitoring.

- GPRS to comply with Cellular Data Network Radio Equipment Directive.
- TCP/IP 2 way communication with secure central server. With network security to HTTPS, 128 bit encryption.

2.8 Practical Completion & Handover

The supplier is to be responsible for the design and installation of the infrastructure and associated equipment, including all necessary electrical engineering and construction activities.

The supplier is to liaise with the Distribution Network Operator (DNO) to agree all relevant permission for a parallel power generation to a grid-connected site, if required.

Government Soft Landings approach to project delivery must be adopted and a comprehensive handover is an essential part of project scope and delivery; handover must include provision of user guides and onsite training with ENGIE, FM, Building Champions and all other personnel who may use the systems, to ensure correct system operations.

The supplier will be fully responsible under the CDM Regulations for undertaking the role of Principle Designer and Principle Contractor.

Furthermore, the following will apply:

- Practical completion for the site shall be granted when the PV generation installation work is fully completed as defined in the tender documents, inspected and accepted by the Contracting Authority.
- All installation certification is provided and accepted by the Contracting Authority.
- Each location's DNO approval has been received and invoices have been paid in full.
- Each installation has been demonstrated as working correctly including online monitoring and metering.
- Training to MoJ Personnel on each installation location has been given, including the Contracting Authority's technical staff.
- Structural / civil calculations received & Contracting Authority's comments incorporated in the calculations.
- A full O&M manual and record drawings issued for each location of installation.

3. PV Generation Proposals

3.1 Site Survey

The Supplier shall undertake detailed non-intrusive surveys at site. The survey(s) shall confirm the PV panels point fixing arrangements and any possible issues such as existing underground services, ground conditions and disruption to services.

For roof mounted PV panels, the supplier shall determine the capability of the existing building structure to withstand the imposed loads of the system, including snow and wind loading.

The Supplier shall provide a detailed proposal following the desk top survey proving viability.

This proposal shall be based on information gathered during the onsite non-intrusive survey and provide full scope of works involved should the PV generation be taken to installation stage.

The proposal shall identify the electrical distribution connection points cable routes, internal and external to the building, identifying surfaces that shall be disturbed during installation to enable Asbestos surveys to be commissioned.

If the building is fitted with a lightning protection system, the Supplier shall allow to electrically bond any steelwork supports/fixings etc. associated with the PV generation installation to the termination network. Verification for SPD (Surge Protection Devices) shall be carried out and evidenced in the proposal for works.

Where the building has no lightning protection system, the Supplier shall assess and report on any remedial works he feels necessary, to reduce or mitigate the risks associated with a lightning strike, i.e., installation of SPD's to protect the electronics of the inverters and / or additional Earthing System within the PV panels locations.

The Supplier shall undertake a structural and ground survey of each site, providing a written report for each site, to be included in the proposal.

3.2 PV Generation Installation Design

The Supplier shall undertake, as part of the proposal, the design of the complete PV generation and associated groundwork / infrastructure associated with the site(s).

The supplier shall include in their design:

- Detailed PV panels installation layouts and inverter locations
- PV panels mounting details
- All electrical cable procurement, installation and calculations
- Full electrical schematic including all switching and protection type interfaces
- Proof of maintaining any existing guarantee or warranty on existing wall cladding / building footings, roof coverings, surfaces and finishing's
- Drawings indicating the proposed BWIC (excavation, back filling, plinth construction etc.) and weathering details
- Layout drawings indicating the outdoor / indoor proposed cable routes and the internal new equipment layout
- Manufacturers details of equipment
- Data sheets for all selected equipment
- Method statements and risks assessments for delivery and storage at site of materials
- Method statements and risks assessments for the PV panels
- Voltage Surges Risk Assessment and mitigating remedies
- Method statements and risk assessments for working in occupied buildings and electrical shutdowns
- Method Statements for preserving the required level of Security within the worked-upon premises
- Agreement of labelling strategy and installation
- Signage as required

PV Panels Mounted on the Ground

Standard solar panel ground mounts shall be utilised. Mounts shall be specifically designed to support PV panels and have a guaranty equal or exceeding the PV panels guaranty itself.

Panel shall be oriented facing South or in Southward direction when South is not possible, and their pitch shall be selected to maximise power generation.

Spacing between rows of panels is to be allowed to minimise shading.

PV Panels Mounted on Roofs (general)

Solar PV panel mounting structures shall be constructed of material made of lightweight, anti-rusting with minimum aluminium grade AL6005-T5, stainless-steel SUS304 grade (bolts and nut), and water resistant EPDM rubber.

The mounting structure should include the wind and snow loads to be expected and calculated in accordance with Eurocode-1 (BSEN 1991-1), for UK & Europe.

Clipping/Clamping mount must be fitted to roof profile without penetrating the roof structure.

Pressing, lifting and friction force Test calculations shall be produced by a structural engineer.

Inner clamp load test ≥ 8.5 kN and end clamp load test ≥ 11.5 kN as a minimum shall be provided, or as agreed with the appointed structural engineer.

International standard of 96 hours salt spray test is required for the proposed mounting structure.

PV frame clamping system with integrated earthing/grounding system with proven testing result shall be provided.

Rail connections shall have a joint length ≥200 mm to prevent any sagging effect of the panels.

Material and PV mounting system warranty period is required to be ≥10 years for each store.

Manufacturing standards of ISO9001 and ISO 14001 are required.

Mounting equipment and installation shall follow manufacturer's instructions.

PV Panels Mounted on Flat Roofs

PV modules on flat roofs shall be mounted on sloping frames which can be mounted on free standing frames/bases loaded with additional ballast or fixed directly to the roof structure and incorporated into the roof waterproofing system. PV Modules and especially ballasted systems will further increase the dead loads on the roof; an assessment of the structural adequacy of the roof structure shall be made by the supplier.

Where freestanding ballasted systems are used any ballast shall be contained within suitable containers that are not subject to UV degradation or rotting due to advance weather conditions.

The supplier shall ensure that the installation of the PV array on the roof does not invalidate any guarantee that may exist on the existing roof.

Penetrations:

The only sources of rain leakage with these systems are where there are penetrations through the roof waterproofing layer. The supplier shall avoid such penetrations as far as practicably possible, as they are generally hard to seal, and inspection is often difficult.

Ponding:

The installation of the PV array on the roof shall be designed such that the array will not compress the roof covering to form ponding and suitable supports such as 'Big Foot' shall be utilised to prevent this affect.

Rainwater run off: Beneath the bottom edge of large arrays of PV modules, high levels of run-off rainwater from the modules can be concentrated. It is important to ensure that there is sufficient gap between the system and the roof covering to allow for free drainage of the rainwater.

PV Panels Mounted on Pitched Roofs

Fixings for above-roof PV systems are in three main types: hook fixings which penetrate between the tiles and fix to rafters or occasionally to the battens; proprietary tiles or slates with built-in fixing points; bolt through fixings which penetrate through the tiles (generally used with double lap tiles and slates).

PV Modules will further increase the dead loads on the roof and an assessment of the structural adequacy of the roof structure shall be made by the supplier.

Hook Fixings for Pitched Roofs: The European Standard BS EN 517:2006 for roof safety hooks and should be adopted for hook fixings used with PV systems. This Standard gives information on materials and methods for fixing hooks to the roof structure as well as test methods for static, dynamic and fatigue loading. It is likely that much of this Standard will be applicable to the design of hook fixings used with above-roof PV systems.

The supplier shall provide an adequate design and installation which will not cause the roof to leak, particularly caused by hooks which deflect under wind load, lifting surrounding roofing elements, hooks which increase the gap between tiles and hooks which interfere with the adjacent tiles causing them to break under wind or snow loads or from workers walking on the roof.

Where hooks are used with an interlocking tile roof, the lap tile is to be lifted to allow the hook to be installed, using a standard roof hook for interlocking tiles.

Particular care shall be taken when hook fixings are installed with double lapped tiles (plain tiles) and slates since the underlying roof structure is not exposed by lifting the top tile or slate. Hook fixings can be used with double lapped roof elements although this will require the roof elements to be cut to accommodate the hook and an appropriate flashing installed to ensure the fixing is weather tight.

The supplier shall use stainless steel hooks (e.g. stainless steel number 1.4301 or 1.4401 to BS EN10088-1) (with a minimum thickness of 5 to 6 mm) for corrosion resistance and to avoid excessive deflection under wind action. On profiled tiles, hooks should usually be installed in the tile trough and notched to avoid increasing the tile gapping. The size of the notch should not create excessive gaps larger than those that naturally exist between tiles.

Roof hooks for use in mainland Europe often have fixing holes designed to suit the larger rafters common in these countries. These hooks might not fit the narrower roof timbers generally used in the UK without modification. Another consideration with some hooks is that they are designed for use with large screw fixings in excess of 8 mm diameter. BS 5268-2[21] specifies that the minimum distance from predrilled holes to the edge of the timber is five screw diameters. Typical UK rafters are 35 to 50 mm wide which could preclude the use of such large fixings or could require evidence that the fixings are adequate. A common solution to this problem is to use noggins – timber cross members fixed between the rafters.

Solar Support Tiles for Pitched Roofs: Proprietary fixing systems are available for mounting PV (and solar thermal systems) on to tile or slated roofs. These systems shall be securely fixed back to the roof structure and sealed with a flashing panel designed to seal around the support post and integrate with the surrounding roof tiles. These systems can be universal systems designed to fit a range of tiles or products designed to fit specific tile types. These systems can provide a robust and weather tight solution which does not create gaps or lift the surrounding roof tiles under wind loading. Purpose designed tiles shall be used to provide a weather tight entry for power cables.

Through Fixings for Pitched Roofs: Bolt-through fixings are not recommended because they can damage or weaken the roof tiles or slates, they can increase the loads on the roof covering, and they are difficult to seal.

Roof Penetrations

Any penetrations through the roof envelope or walls, such as fixings or cables and pipes should be sealed using appropriate standard or custom-made flashings or kits where appropriate supplied by and/or approved by the roof covering specialist. Sealants or mastic alone shall not be used. Where tiles are cut or trimmed, for example, to allow installation of a roof hook, the gaps around the hook should be no larger than those naturally occurring between the roof tiles.

Inverters

The inverters must carry a Type Test Certificate to ENA Engineering Recommendation G99 or G98 (as applicable), manufactured in accordance IEC 62109 and carry a CE mark (European).

The supplier should quote the options of installing string inverters or micro inverters on the PV array.

The inverters must be mounted in accordance to the manufacturer's requirements, not be installed in direct sunlight or in rooms with high ambient temperatures and mounted on non-flammable material.

Arc fault detection should be provided to UL 1699B. If not available within the inverter, it should be installed either as a combined circuit breaker or separately and work together with the circuit breaker. Upon activation, the device should have visible indication of operation, automatically disconnect the equipment and require manual reset.

Inverters shall be provided with separate isolators so allow ease of maintenance.

Connection of the strings must be by a proprietary plug connector – see section 'DC Connectors'.

Inverters should be correctly sized to match the PV array in order to maximise efficiencies in the system.

Have the following characteristics:

- Synchronization with the grid, adhere to local grid operating frequency and be capable of producing 50 Hz ±1%
- DC voltage input ≤ 1000V
- Automatic disconnection including DC isolation of the PV panels in case of fault or absence of grid i.e.no islanding allowed
- Automatic connection and disconnection of the installation
- Protection against overload and short circuits
- A low rate of harmonic distortion (3 % Total Harmonic Distortion (THD))
- No electromagnetic disturbance
- High efficiency: greater than or equal to 98 % at nominal power; >90 % from 10 % of nominal entry power.
- All inverters should be produced by a single manufacturer.
- Number Independent MPPT (Maximum Power Point Tracking) inputs - at least 2 inputs

- Inverter operating temperature up to 60°C
- At least 'IP 65' according to IEC 60529 standard or equivalent.
- Inverter product warranty for minimum 10 years. (warranty options to be provided)
- Have remote interrogation and alarm connection – insulation resistance etc
- Have fault detection circuitry & capable of raising an alarm to a remote monitoring house
- Regulate output to the grid as input alters
- Optimization of system to ensure low output panels do not affect the remainder of the string.

Inverters for all sites will be from the same manufacturer to allow access to one web portal for monitoring purposes.

Inverters shall be labelled with the following – "Inverter – isolate ac and dc before carrying out work" Labels shall be of the fixed traffolyte type.

Inverters and switchgear should be located in a single designated area, with restricted access.

Inverters shall be mounted on fire retardant surface and in a weatherproof environment which is suitably ventilated in accordance with manufacturer's guidelines to avoid overheating.

Where electrical switchgear and equipment is present, insulated rubber matting shall be provided.

The building fire protection system shall be suitably extended / modified.

When mounted internally:

- Inverter room illuminance level ≥ 200 Lux, 0.4 Uniformity plus emergency lighting. This requirement should be agreed and arranged in cooperation with GFSL. The supplier will be responsible for any upgrade to lighting to meet this minimum Lux requirement.
- Provide a minimum of two twin switched socket outlets within the space.

Complete specifications, data and drawings covering all materials and equipment shall be submitted for approval before installation.

Direct Current

DC cabling:

The Supplier shall ensure that all DC cables used in the array string cabling are certified in accordance with BS EN 50618 and/or certified to TUV PV1-F standard and be of the LSZH type, cross linked double insulated type. Positive cables must be coloured red and negative cables coloured black

During installation the supplier must run string pairs of the positive and negative conductors adjacently to eliminate loops.

All cables shall be run on galvanised steel cable tray or trunking, suitable for the environment they are installed in.

DC string cables should also be sized to prevent fire risk when in overload or have excessive module reverse currents.

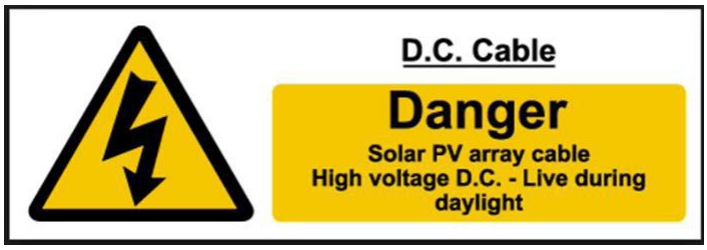
DC cables should not be concealed. If they are then they should be routed in steel conduit or trunking or be steel wire armoured.

The cable must UV protected.

The cable must have minimum temperature rating -40°C to +120°C.

Labels should be provided to all runs of d.c. cabling, fixed every 5-10 m for straight runs where a clear view is available. Where a clear view is not available, labels should be installed in visible locations more frequently. Labels shall be of the fixed traffolyte type.

Labels should be yellow in colour as per the following in local language:



DC Junction Boxes:

String cables are to be run directly into the inverters or to junction boxes and terminated into a DIN mounted terminal of adequate current and voltage rating for the connected string. Entry to the junction box shall be by compression gland. Between the junction box and inverter, a single multi-core SWA LSZH cable shall be run on cable tray or ladder rack to the inverter location. The cables must be secured to the containment with stainless steel cable ties.

One junction box per inverter shall be used per inverter

The junction box shall be IP66 rated as a minimum and from the Fibox Arca range or equivalent and approved.

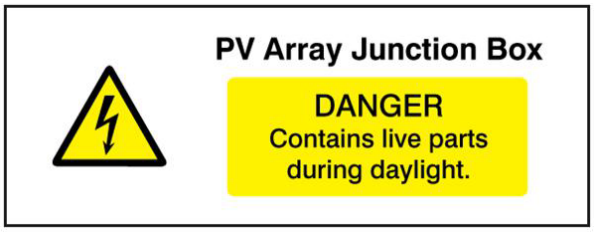
The junction must be labelled up with the corresponding inverter number and the string cables entering the junction box must be labelled with a string reference relating to an As Built string drawing.

The junction boxes must be positioned where they can be easily accessed but in close proximity to the connected strings

A suitably sized surge protection Surge Protective Device (SPD) shall be installed in the DC junction box.

Cables and junction boxes should be designed to provide suitable short circuit protection, ensuring adequate separation of positive and negative busbars via an insulating plate or separate junction boxes.

Junction boxes shall be provided with a label - “PV array d.c. junction box. Danger, contains live parts during daylight”.



DC Connectors:

DC connections in solar arrays are a significant hazard if not designed or installed correctly and particular care and attention is required of the supplier to ensure that the correct materials and methods are used in the installation of this part of the system

The Supplier shall ensure that all DC connectors used in the array string cabling are certified in accordance with BS EN 50521. The use of connectors from different manufacturers should not be used.

The Supplier shall demonstrate that they have the correct tools to achieve the assembly of the connectors in accordance with the relevant manufacturer’s instructions. Care shall be taken when terminating DC cables into plug connectors or any termination to ensure that the termination is secure, and all cable strands are properly terminated. MC-4 connector shall be IP67 waterproof and dust proof safe electrical connection. The quality of a connection shall not deteriorate over a time span of 25 years.

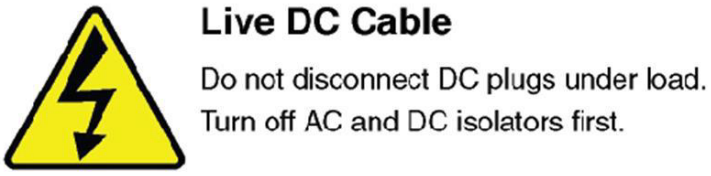
D.C. plug and socket connector halves should be from the same manufacturer. Different manufacturers will not be permitted.

Connectors shall comply with BSEN 50521 - Connectors for photovoltaic systems. Safety requirements and tests and must be rated for the calculated voltages and currents under normal and fault conditions.

If connectors are located in an accessible position for unauthorized personnel, they should be of the locking type, requiring a tool or required to have two separate actions to disconnect.

All connectors shall be provided with a sign “Do not disconnect dc plugs and sockets under load”. Labels shall be of the fixed traffolyte type.

DC connectors shall be labelled with the following warning notice:



DC switchgear:

The Supplier shall ensure that all DC isolation devices are certified to BS EN 60947-1 and be adequate for the voltage and currents present in accordance with section 5.2.2 of the IET ‘Code of Practice for Grid Connected Solar Photovoltaic Systems’

Where the string terminations to an inverter are not by plug connectors separate DC isolators must be used regardless of whether the inverter has a built in DC isolator.

DC isolators shall be separate to the inverters.

Cable Installation

All cables shall be installed on or in containment for its entire length, selected, rated and sized for its location and intended use.

All metallic containment shall be earthed

The requirements of BS 7671 should be applied to all cable containment and particular attention should be made to cable containment in publicly accessible locations to provide mechanical protection and protection against tampering.

Main Switch Board

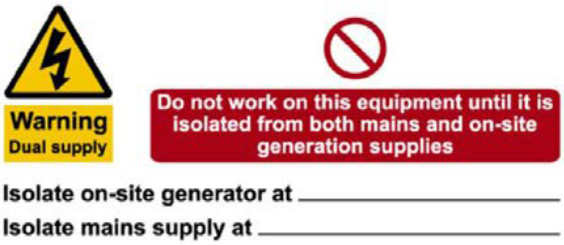
The PV Generation shall be connected to the building's main switch board utilising an MCCB breaker.

Where a single inverter is in use, it shall be connected directly to the main switch board. Where multiple inverters are in use, a three phase distribution board shall be installed to connect them, and this distribution board shall be connected to the main switch board.

The PV supplier will be responsible for all DC and AC wiring between the PV panels, inverters, meters and the main switch board.

The supplier will allow to automatically disconnect the PV System from the main switchboard when the mains are out and reconnect the PV system when mains power is restored.

The PV system main isolator and the main switch board shall be appropriately labelled to identify dual supply labelling, as per the pictures below, using fixed traffolyte type.



Isolation

Isolation shall be provided throughout the system to ensure compliance with local standards and to provide safe maintenance regimes.

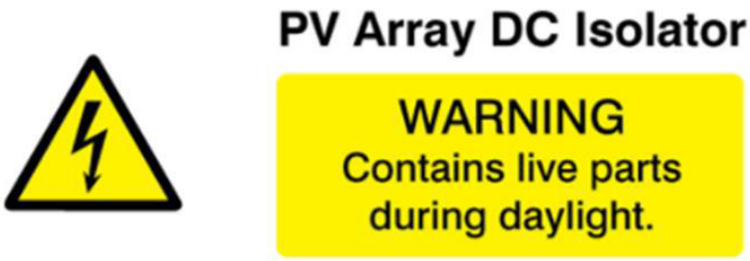
All main isolation devices shall be capable of being "locked off" to prevent unauthorized tampering.

All isolator casings shall be rated for the environment they are situated in. They should not be mounted on flammable surfaces and cable entries shall be provided with correctly sealed cable glands, mounted under the isolators. No more than one cable per gland shall be used.

The inverter shall be provided with external isolation for both ac and dc sides via means of switch disconnector. The device should switch all live conductors and should be able to be locked off. Internal isolation for the DC disconnect or AC isolator is not permitted.

All isolators shall be labelled with fixed traffolyte labels, identifying the purpose of the isolator i.e. PV array isolator, and be provided with electrical warning notice in local language.

DC connectors shall be labelled with the following warning notice:



AC connectors shall be labelled with the following warning notice:

All AC and DC isolators shall be provided with labels on their enclosure, detailing their make and model of switch used.

In the event of fire, the system should automatically disconnect and switch off DC voltage at module level and within the DC cabling.

The inverters must carry a Type Test Certificate to ENA Engineering Recommendation G99 or G98 (as applicable), manufactured in accordance IEC 62109 and carry a CE mark (European).

Grid Connection (if required)

The Supplier shall be responsible for supplying and installing of all equipment required for connection of the PV generation to each site's electrical system and where necessary, any additional connection devices required by the Local Distribution Network Operator.

MoJ will initiate the grid connection application for the installation. Further liaison and approvals with the Local Distribution Network Operator shall be completed by the supplier and shall follow the approval route as detailed by the Local Distribution Network Operator. This shall include all application forms, design approvals and approvals for connection and commissioning.

Allow to provide synchronisation equipment within the PV system to synchronise with the mains, with any generator on site and with the combination of mains and generator.

Lightning Protection

On roof mounted PV installations, where a lightning protection system is already present, the supplier shall main bond the array frame to the main earthing terminal or the lightning tape. Where a lightning protection system is present, the PV system components should be mounted away from lightning rods and down leads. Long leads, for example dc main cables connecting the array to the inverter that are over 50m in length, should be installed in earthed metal conduit or trunking.

Surge Protection

The Supplier shall fit a Surge Protection Device to each string on the array side of the inverter. It is acceptable for this to be built into the inverter. Type of device shall be suitably selected for the risk associated.
The surge protection equipment shall conform to IEC61643-1, IEC61643-11 standard.

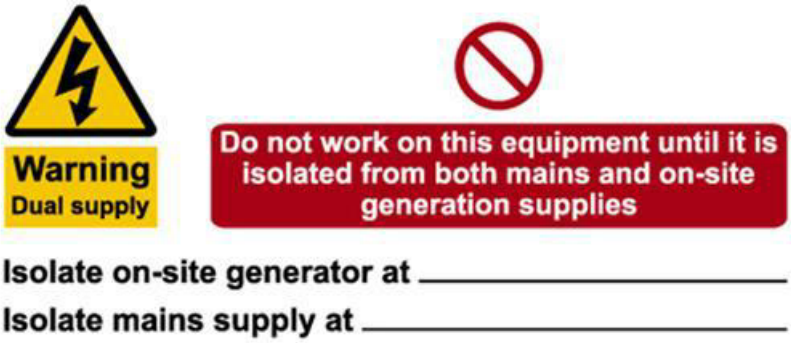
Labelling

As the PV system, which is used as an additional source of supply is connected in parallel with another source, warning notices should be affixed, as a minimum at the following locations in the installation:

- At the origin of the installation
- At the meter position, if remote from the origin
- At the distribution board to which the generating set is connected
- At all points of isolation of both sources of supply

An example of notice is given below:

Labels shall be of the fixed traffolyte type.
A warning notice should also be provided next to the main incoming electrical switch position, the main fire alarm panel and any other repeater panels to advise any fire service attendance of the presence of the solar PV system. Labels shall be of the fixed traffolyte type. An example of notice is given below;



Roof Access

This paragraph sets out the guiding principles underpinning the design of a safe roof environment, which must be suitable for the type and frequency of maintenance activities planned during the O&M phase.

The site-specific roof access proposal, submitted by the plant supplier and reviewed by the Principal Designer under CDM regulations, describes the permanent design elements the supplier will install at each particular site, which will complement what MoJ has already implemented or plans to implement at that site as part of MoJ's Roof Safety Improvement Programme.

Work at height

The minimum requirement is to keep a safe distance from the roof edge and provide clear demarcation on the route to use and suitable safe system of work, provided this is compatible with the supplier's maintenance activities (type and frequency). Collective measures such as handrail are preferable.

Previously non-accessed roofs, which will need future access because of the solar PV installation, will require safe access and height protection provisions adequate to the type and frequency of the expected maintenance activities.

Slips & trips & access surface

The access path on the roof is provided to ensure safe access from a slip and trip hazard and to provide mechanical protection to the roof surface. Based on this, any design assessment should consider:

- Future operation and repair of the PV panels. For example, whether access will be needed at critical time or the supplier will be able to select prime access conditions when undertaking future maintenance and repairs (access put off until access path is dry, daylight, free from frost, etc.).
- Subject to a suitable safe system of work and training reflecting this, existing paths may be considered adequate for access to PV panel runs. Any pathways obstructed by the install of PV panels is likely to require a re-assessment and alterations.
- The profile and gradient of the roof surface will need to be taken into account and may require a suitable flat pathway to minimise the risk of trips or a surface to minimise slips on steep gradients.
- Items of the PV system subject to regular access such as inverters and main pathways around Concept Store upper roof are likely to be required to minimise the risk of damage to the roof surface and potential for subsequent roof leaks. On some occasions, such as Havant, these may already be in place.

Fire Safety

Fire alarm audibility needs to be verified for the purpose of the construction phase (2-3 weeks on site, rather than short periodic maintenance access). A suitable solution would consist of an audibility check and the installation of additional sounders prior to start of construction work. Escape routes should be equipped with appropriate signage.

During construction and installation, suitable edge protection may be necessary, e.g. scaffolding, to ensure a safe working environment.
It is the supplier's responsibility to provide all necessary safety equipment and they must provide method statements and risks assessments for approval, prior to commencing with their works.

Roof Structure

To comply with operations and maintenance, the supplier shall supply all civil and structural materials to support the PV module and system, service platform, and safe and compliant access to the PV equipment and system.
The supplier shall determine the capability of the existing building structure to withstand the imposed loads of the system, including snow and wind loading.
PV mounting systems that require roof penetration are not allowed, unless otherwise agreed with MoJ project team.
Pre and post condition surveys of the roof are to be completed by the Supplier on the areas where the plant has been installed and any working area utilised during the construction phase.

4. PV Panels Installation - Structural / Civil Engineering Requirements

It is the Suppliers responsibility to ensure that the structural & civil engineering design and integrity of the proposal and installation is safe, sound and correct. This confirmation is relevant to the installation work and for the life cycle of the installation on the PV panels.

The information to be provided with the initial proposals shall be relevant to each of the sites worked upon and be correct and concise. The Supplier is responsible for the correctness and suitability of all installations. All reports and references are to be communicated in plain English.

4.1 Groundwork Survey

For all civils works the Supplier shall allow to undertake a full survey of each location to be excavated for the proposed PV panels. The Supplier shall complete the surveys including a photographic condition assessment and provide a written report on his findings enclosing the condition assessment. Asbestos surveys shall be required for each location of works.

4.2 Structural / Civils Drawings

The Supplier shall provide drawings to support the proposals which indicate the following minimum information;

4.3 Trenching

Provide drawings showing depth of trenching for cable ducts including sand, tape, tile and backfilling. Other services local to the trench shall also be identified.

4.4 Proposed Layout

Provide Plan drawings showing the proposed PV panels layout per each location.

4.5 Break through into existing building

Provide plans and elevations showing proposed entrance into existing buildings on each location and the weather proofing details. These are to include prevention of rising ground water and damp.

4.6 Proposed layout / connection to electrical infrastructure

Provide plans and sectional drawings showing the route through the sites to connect into each existing electrical system.
Care is needed in the identification of asbestos containing materials within the work area.

4.7 Structural / Civil Calculations

The Supplier shall provide structural / civils calculations to support the PV generation installation proposals and which proves that the ground and bases will support the PV panels. In addition, where penetrations are required through existing structures the Structural Engineer shall provide evidence that the proposed works do not compromise the structure in any way. Information shall be presented in plain English and all calculations shall be fully referenced and assumptions detailed and quantified.

5. Detailing Concrete Plinth Base and Trenching works

The Supplier shall provide where required details, drawings and sketches for the proposed base(s) for supporting the PV panels.

5.1 Standard plinth detail

The base size and type calculations shall in all cases consider the existing ground ‘make up’ and conditions within any structural design proposal.

Electrical cables passages and ducts shall be evidenced, and sizes shown, including radius bends for cable pulling.

5.2 Typical Trench detail

The Supplier shall evidence a standard trenching detail, including ductworks, backfilling and distance from services.

The Supplier shall be detailing layouts and depths of incoming utility supplies, where applicable.

5.3 External cable routes

The Supplier shall be responsible for the correct measurement on site of the cable lengths required, and they shall be installed in one continuous length without joints.
Where cables are laid in the ground the Supplier shall ensure that trenches, pits and ducts are to the typical standard details.

5.4 Excavation Works

Care shall be taken when excavating the trenches to avoid damage to other services. Reference shall be made to any site drawings showing services to ascertain the possible locations of other services. The Supplier shall liaise with the Local Services Providers to obtain maps of their Services within the locations to be excavated prior excavations starts. Should any damage occur to existing services, the Contracting Authority shall be informed immediately. The responsibility for repairs of damaged existing services will stay with the Supplier.

5.5 Cable Laying

Allowance for changes in level and deviations required by following the building profile shall be included in the information package.

The Supplier shall be responsible for the correct measurement on site of the cable lengths required, and they shall be installed in one continuous length without any through joints. Where cables are laid in the ground the Supplier shall ensure that trenches, pits and ducts are installed in accordance with this documentation and all relevant Standards as applicable. Other services and cables that have been uncovered during excavation shall be adequately supported and protected. Cables buried in the ground shall be laid in properly excavated trenches. The trenches shall be evenly graded, clear of loose stones and coved with a 75mm layer of sand or sifted soil. The cables shall be carefully laid in the trench being spaced apart where there is more than one and a 75mm layer of sand or sifted soil placed over the cables before the trench is back filled. A yellow safety tape with black writing reading “CAUTION! ELECTRIC CABLE BELOW” shall be installed 200mm above the new cables for all the length of the underground cable.

Cable trenches for Low Voltage, Earthing System and Data cabling installation shall be at least 600mm (2’ – two feet) deep. If Fibre cables are used, then Polyduct of 60mm diameter minimum shall be protecting the Fibre cables. When crossing roads, car parks or vehicles passages, the cables shall be installed in heavy duty Polyducts of adequate diameter. The ends of the polyducts shall be sealed against water penetration, rodents, insects and vegetation roots.

The Electricity Safety, Quality and Continuity Regulations 2002 – Part IV – Underground Cables and Equipment – shall be fully adhered to.

5.6 Cable Identification

Buried cables shall be identified in accordance with the standards set out.

5.7 Cable Ducts

Additional cable ducts shall be installed in accordance with the standards set out and as agreed with the Contracting Authority.

5.8 Reinstating Ground Works

All trenching, reinstatement, supply of sand, ducts and installation of ducts shall be carried out by the Supplier and shall be to match existing and good standard or better upon completion.
If there is presence of water in the trenches, backfilling should not start until, and unless, the water has been taken out.
The backfilling shall be sufficiently compacted to ensure that the reinstated surface of the trenches will not collapse in future.
Surface finishing shall match, or better, the existing.

5.9 Record information

A plan drawing depicting accurately the position of all the external cable runs, ducts and trenches shall be supplied upon completion of the works for submission into the Operating & Maintenance manuals. The drawing shall also indicate the location and depth of each service discovered during excavation.

6. Groundworks on Site

6.1 Excavation and grounds work

The Supplier shall use appropriate barriers to make safe the groundworks area. Supplier shall liaise with the appointed local building managers at all times to ensure that staff and members of the public are kept safe.

6.2 Temporary support and shoring

The Supplier shall allow, where necessary, for temporary support and shoring to excavation / trenching activity.

6.3 Safety General

Excavating in the street is dangerous work: damage to underground services can cause fatal or severe injury. The activity of excavating in the streets needs to be addressed in a safe manner – see HSE publication HSG47 *Avoiding dangers from underground services*.

The Supplier shall provide Personal Protective Equipment to all workers associated with the works. The Supplier shall carry out the works employing only suitably qualified and experienced persons. The Supplier shall ensure that each worker has been provided with the relevant safety training for the works. Full details of training and qualifications appropriate to each worker shall be provided prior to their commencing work on site.

6.4 Delivery of Materials to Site

The Supplier shall include for the safe delivery to site of all materials and equipment for the installation of the complete System.
Where necessary this shall include for crane lifts, temporary material lifts, road closures and anything else to enable the works to be carried out including any local authority charges.

The Supplier shall note that there may be no on-site storage facilities available, if equipment/materials needs to be stored, then the storage facilities shall be provided by the

Supplier within his own warehouses or in agreed locations. The security of the storage facilities and the materials contained within them shall be the responsibility of the Supplier.

The storage and site compound shall be maintained in clean& tidy order throughout the container. Storage areas shall be reinstated to existing and good condition upon completion.

The Supplier shall provide within the method statement per each working location how the materials are to be delivered to site and any temporary storage facilities proposed. At all times the Supplier shall understand, consider and respect the delivery constraints and timings for each individual site, location and Contracting Authority's requirements.

7. PV Generation Infrastructure Electrical System requirements

7.1 AC Circuit Installation

All persons working on the cabling of an PV panels, inverters and associated equipment shall be experienced / competent, fully trained in working with such systems and fully acquainted with the risks that voltages present on that system. Works shall be carried out using qualified electricians complying with the electricity at work Regulations (EAW). These are to be read in conjunction with HSE guidance memorandum of guidance on EAW regulations 1989, HS R 25 and the 18th Edition of the IET Wiring Regulations.

7.2 Live Working

Working on live electrical circuits will not be permitted. If it is unavoidable to work in any enclosure or situation featuring simultaneously accessible live electrical parts, this shall be raised with the Contracting Authority.

7.3 Earth Bonding

All equipment, apparatus and metal work shall be effectively bonded to provide a continuous earth path back to the feeding distribution board / feeder pillar. This shall not absolve the Supplier from bonding other equipment, apparatus or metal work which is necessary to comply with the BS 7671:2018+A1:2020.

8. Performance Monitoring and Reporting

The Supplier will collect performance information of the Solar PV Installation on a daily basis through the transmission of data from the Meters, Inverters and Irradiance Sensors to the relevant online data monitoring system.

SFTP with Key File Authentication as a data transfer type for the data to be put into MoJ C3 central database is required.

The Supplier will analyse and interpret the information obtained from the performance monitoring systems to identify any performance issues and / or equipment failures. The supplier will need to react to any metering issues to rectify and ensure accuracy and quality of consumption data feeds.

The Supplier shall fit a monitoring system which provides the following:
- Inverter and string level monitoring information
- Electricity generated by the plant
- Performance Ratio, including weather correction

All sites shall be visible on one single combined web portal platform provided by the inverter manufacturers with a log in for access by all parties.

8.1 Energy Metering and Data Collection

The generation meter must be in accordance with the metering legislation as defined in the latest version of Ofgem's Guidance for Renewable Installations.
The supplier shall remotely monitor the plant for diagnostic and energy data collection via a data logger with GPRS communication. These will be within a tampered proof box with no signal of containing a GPRS device.
The supplier will need to react to any metering issues to rectify and ensure accuracy and quality of consumption data feeds are ongoing.
All metering consumption data must be made available for MoJ and GFSL for the duration of the Operation and Maintenance period. Data must be available on a “day+1” basis and with half-hourly granularity. Data must be made available as “.csv” file as a minimum, FTP data delivery is preferable. MoJ and GFSL can configure their system to accept different data layouts used in the .csv file itself.

8.2 Reports

The following performance tests/reviews shall be carried out by the Supplier.

- Preliminary Acceptance Test (PAT)
- Monthly Performance Reviews (MPRs)
- Annual Performance Reviews (APRs)

If the Performance Ratio (‘PR’) -calculated in the PAT, MPR or APR- is equal to or higher than 90% of the Predicted PR then the performance of the Plant is deemed to be ‘Acceptable’.
If the Performance Ratio -calculated for the PAT, MPR or APR- is lower than 90% of the Predicted PR then the performance of the Plant is deemed to be ‘Insufficient’.
The Predicted PR is the predicted Performance Ratio. It is site/plant specific, it is based on design stage data and its value relative to a full year is stated in the Investment Grade Proposal (and the Power Purchase Agreement, where applicable).

8.3 Performance Calculation Methodology

For each of the performance tests the PR will be calculated as described in Appendix 1.
Preliminary Acceptance Test

The Preliminary Acceptance Test shall be carried out following the general Performance Calculation Methodology detailed in the Appendix 1 and the specific conditions detailed below.

Duration and conditions

a) The Preliminary Acceptance Test shall begin after the visual inspection and functional testing as part of the commissioning and works completion process. The site visit shall be scheduled between the Supplier and MoJ and shall not be unreasonably postponed.
b) The duration of the Preliminary Acceptance Test shall be ten (15) full days in total (Test Operation Period), for the whole plant.
c) On each day of the test, the test will be deemed to have commenced at the earlier of commencement of inverter operation or 50 W/m2 irradiance measured in the plane-of-array, as applicable.
d) The following irradiation conditions apply: (i) For the period from the start of April to the end of September the test shall be undertaken so that for a period of no less than 2h of the testing time, the modules shall be exposed to an irradiance of 500 W/m2 or greater.
   i. For the period from the start of October to the end of March the test shall be undertaken so that for a period of no less than 2h of the testing time, the modules shall be exposed to an irradiance of 300 W/m2 or greater.

ii. Pyranometers shall be calibrated according to ISO 9874 and calibration protocols shall be made available by the Supplier.
iii. In the case of one sensor reading more than 5% difference to the other sensor, the higher of the two readings will be used.
e) (e) The sampling period each day will cease when no further energy from the inverters is being received and irradiance is below 50W/m2.
f) (f) Each sampling period, j, will be 30 min. i.e. Ts = 30 min.

Where:

$$Availability = \frac{T_{Energy\ output}}{T_{Total\ test\ time}}$$

$T_{Energy\ Output}$ = total time in which inverters are operating (minutes)
$T_{Total\ test\ time}$ = total time in which either the inverters are operating, or plane of array pyranometer or satellite data irradiance reading is ≥50W/m2, (minutes)

Preliminary Acceptance Test PR result (PRPAT)

The result of this adjustment is the Preliminary Acceptance Test PR result.

$PR_{PAT} = PR_{overall} / MCF$

8.4 Monthly Performance Review

The Monthly Performance Review shall be carried out following the general Performance Calculation Methodology detailed in the preceding paragraphs and the specific conditions detailed below.

Duration and conditions
a) The Monthly Performance Review shall begin on the 1st day of each month and last during the whole month.
b) On each day of the test, the test will be deemed to have commenced at the earlier of commencement of inverter operation or 50 W/m2 irradiance measured by the plane-of-array pyranometers or the satellite data, as applicable.
c) The following irradiation conditions apply:
i. Pyranometers shall be calibrated according to ISO 9874 and calibration protocols shall be made available by the Supplier.
ii. In the case of one sensor reading more than 5% difference to the other sensor, the higher of the two readings will be used.
d) The sampling period each day will cease when no further energy from the inverters is being received and irradiance is below 50W/m2.
e) Each sampling period, j, will be 30 min. i.e. Ts = 30 min.

Monthly Performance Review PR result (PRMPR)

The result of this adjustment is the Monthly Performance Review PR result.

$PR_{MPR} = PR_{overall} / MCF$

8.5 Annual Performance Review

The Annual Performance Review shall be carried out following the general Performance Calculation Methodology detailed in the preceding paragraphs and the specific conditions detailed below.
Duration and conditions

a) The Annual Performance Review shall begin the day after the PAT test and at each anniversary subsequently) and last for one full calendar year.
b) On each day of the test, the test will be deemed to have commenced at the earlier of commencement of inverter operation or 50 W/m2 irradiance measured by the plane-of-array pyranometers or the satellite data, as applicable.
c) The following irradiation conditions apply:

i. Pyranometers shall be calibrated according to ISO 9874 and calibration protocols shall be made available by the Supplier.
ii. In the case of one sensor reading more than 5% difference to the other sensor, the higher of the two readings will be used.

d) The sampling period each day will cease when no further energy from the inverters is being received and irradiance is below 50W/m2.
e) Each sampling period, j, will be 30 min. i.e. Ts = 30 min.

Annual Performance Review PR result (PRAPR)
The result of this adjustment is the Annual Performance Review PR.(PRAPR)

$PR_{APR} = PR_{overall} /MCF$

9. Inspection, Testing and Commissioning

The Employer shall be provided with the information as described in BS EN 62446 Grid Connected Photovoltaic systems — Minimum requirements for system documentation, commissioning tests and inspection. Inspection and testing of the completed system to the requirements of BS 7671 shall be carried out and documented.

The inspection and test documentation is based on three distinctive phases of inspection, testing and commissioning;

1. Check sheets - construction inspection check sheets to cover inspection of construction and installation including insulation resistance tests.
2. Functional tests - functional test sheet to cover the detail electrical testing prior to and including first electrical energizing.
3. Energizing system check sheets - energized system test procedure to cover electrical proving tests of equipment and systems under energized conditions.

Inspection and testing documentation for the a.c. side shall comprise the following as a minimum:

- Electrical installation certificate,
- Schedule of items inspected
- Schedule of test results

The inspection and testing of the dc side of the PV system shall be in accordance with the requirements of BS 7671 and also BS EN 62446 Grid connected photovoltaic systems Minimum requirements for system documentation, commissioning tests and inspection.
The verification sequence contained within BS EN 62446 includes:

- Inspection schedule
- Continuity test of protective earthing and/or equipotential bonding conductors (if fitted)
- Polarity test

- String open circuit voltage test
- String short circuit current test
- Functional tests
- Insulation resistance of the dc circuits

These tests shall be recorded on a PV array test report which shall be appended to the ac documents listed above.
The Contracting Authority shall witness and sign-off these tests.
The energized systems check sheets will be completed by the commissioning engineer. The Supplier will provide copies of the relevant check and functional test sheets.
No item of electrical equipment shall be energized until fully tested in accordance with relevant section of this specification.
Any system, plant and/or appliance which is not signed-off confirming that the appropriate testing, commissioning and demonstration activities have been fully witnessed, shall prevent practical completion being agreed.

9.1 Functional Testing

Functional testing shall be completed when the Solar PV Installation is complete to verify that the installation is being completed according to the design and specification to confirm;
• The proper operation of disconnecting devices and component connection and disconnection sequences.
• Interactive inverters and AC modules de-energize their output to site electrical system upon loss of its voltage.
• Interactive inverters automatically reconnect to their output to Owner's electrical system once the voltage has been restored for at least five (5) minutes
• Proper Grid voltage and frequency to operate inverters, including evaluating voltage drop between the inverter AC output and point of connection to Owner's Electrical System
• Testing shall include Witness Testing of the G99 Mains Protection for the DNO
• Testing of the DC aspects of the system shall be according to BS EN 62446

9.2 Operation and Maintenance Information (O&M)

The Supplier shall demonstrate to the client team that all pats of the installations are fully accessible for the purposes of planned and reactive maintenance.

The Supplier shall provide an Operating and Maintenance Manual for each location installation. The Supplier shall provide one copy of a basic, typical manual for comment to the Contracting Authority, and once approved the Supplier shall provide per each side one hard copy, and two electronic combined PDF & Word versions with electronic copies of all drawings in DWG format related to each PV Generation Location.

The Supplier shall provide a simple and concise step by step guide, user interface and operation, shutdown procedure, interfaces and alarms. This guide shall be included within the front of each site Manual.

The client shall be provided as a minimum, the information as required in of BS EN 62446 Grid connected photovoltaic systems — Minimum requirements for system documentation, commissioning tests and inspection. The following provides a summary of the information required:

Basic system information (parts used, rated power, installation dates etc)

- System designer information

- System installer information
  - Wiring diagram, to include information on module type & quantities
  - String configurations
  - Cable specifications – size and type.
  - Over-current protective device specifications (where fitted) - type and ratings.
  - Array junction box locations (where applicable).
  - d.c. isolator type, location and rating
  - Array over-current protective devices (where applicable) – type, location and rating
  - Details of all earth / bonding conductors – size and connection points.
  - Details of any connections to an existing Lightning Protection System (LPS).
  - Details of any surge protection device installed (both on AC and DC lines) to include location, type and rating.
  - AC isolator location, type and rating.
  - AC overcurrent protective device location, type and rating.
  - Residual current device location, type and rating (where fitted).
- Module datasheets
- Inverter datasheets
- Mounting system datasheet
- Metering datasheets
- Sensor datasheets

Operation and maintenance information, to include:

- Procedures for verifying correct system operation.
- A checklist of what to do in case of a system failure.
- Emergency shutdown / isolation procedures.
- Maintenance and cleaning recommendations (if any).
- Considerations for any future building works related to the PV array (e.g. roof works).
- Warranty documentation for PV modules and inverters - to include starting date of warranty and period of warranty.
- Documentation on any applicable workmanship or weather-tightness warranties.
- Test results and commissioning data
- **list above has been taken from the MCS Guide to the installation of PV Systems*

Note: Testing and Commissioning prior Provisional Acceptance Testing shall meet IEC 62446-1:2016 IEC 62446: Grid connected photovoltaic systems – Minimum requirements for system documentation, commissioning tests and inspection;
All documents are to be stored on site. A digital copy would be required.

9.3 Operation and Maintenance Services

In performing the Operation & Maintenance Services the Supplier will provide a full preventative and reactive service as detailed in this technical specification.

The Supplier will be responsible for ensuring that the Solar PV Installation meets or exceeds the requirements set out in this technical specification.

The Supplier will prepare a programme of Planned Maintenance with a view to minimising the level of Unplanned Maintenance required.

In performing the Operation & Maintenance Services the Supplier will clean up the site after any maintenance visit and shall remove any of the supplier's equipment or waste from the site.

In performing the Operation & Maintenance Services, the Solar PV supplier's staff will at all times act courteously and professionally keeping appointments and being punctual, being smartly dressed in accordance with GFSL H&S policies.
The Supplier will ensure that all accessible components in the Solar PV Installation, including the Solar PV Cells, Environmental Sensors and Inverter Air Filters will be thoroughly cleaned in accordance with the manufacturer's guidelines, taking into account each site-specific conditions.

The Supplier will be responsible for cleaning the solar panels. The decision to clean the solar panels would be made on the basis of the impact on system output, product warranty, manufacturer's guidelines and health and safety.

A call-out protocol shall be completed prior to practical completion and submitted to the Contracting Authority at the same time as submitting the draft O&M manuals.

Minimum annual visit requirements;

- To complete O&M services in line with manufacturers recommendations.
- Check plant and equipment for visible signs of corrosion, damage and defects.
- Check correct functioning and operation of plant and equipment.
- Check equipment connections, screw connections and Electrical safety.
- Check functionality of all equipment.
- Check safety of the installation and general cleanliness
- Cleaning of solar PV panels, if deemed necessary.
- Monitor all junction boxes and connections and inverters with IP camera for unusual hot spots.
- Report findings to MoJ.
- Correct any faults, prioritising any H&S issues which arise.
- Complete work in line with GFSL H&S policy and the HSAWA .

10. Planning and Permitted Development

The Supplier shall assess the schemes during the site surveys and advise if they require full planning permission or they can be delivered under of permitted development laws.

In roof mounted PV panels the permitted development/planning conditions are as follows:

Up to 50kW total generation - Permitted Development applies with the following conditions:

a) Pitched roof – must not protrude more than 0.2m beyond the plane of the roof slope when measured from the perpendicular with the external surface of the roof slope;
b) Flat roof – the highest part of the solar PV equipment must not be higher than 1 meter above the highest part of the roof (excluding any chimney);
c) Must not be installed within 1 meter of the external edge of that roof;
d) In the case of a building on an Area of Natural Beauty, National Park etc - the solar PV equipment must not be installed on a roof slope which fronts a highway;
e) Must not be installed on a site designated as a scheduled monument;
f) Must not be installed on a listed building or on a building within the curtilage of a listed building
g) The panels must be designed and located so far as practical to minimise any effect on the external appearance of the building and the amenity of the area
h) The panels must be removed as soon as reasonably practicable when no longer needed.

Above 50 kilowatts but below 1 megawatt total generation - prior approval is required :

a) The same conditions as for Permitted Development apply

The prior approval application will be determined based on the design and/or external appearance of the development, in particular the impact of glare on occupiers of neighbouring land.

The application must be accompanied by:

- A written description of the proposed development
- A plan indicating the site and showing the proposed development
- The developers contact address and email address
- The application fee

The prior approval process takes 56 days, on the expiry of 56 days if no written notice has been given that prior approval is required or that prior approval is granted/ refused then the works can be undertaken.
If the conditions for prior approval/ permitted development cannot be met then a full planning application is required.

In either case, the Supplier shall make full allowances for obtaining all necessary planning approvals and shall include for preparing all necessary applications, documentation, paying all fees and attending all necessary meetings to complete the task.

11. Plant or System Changed or Newly Installed

Appendix 2 – Plant change form. The plant change form is relevant for all new buildings or sites to be maintained or existing buildings currently being maintained by the Contracting Authority. The Supplier shall complete the form prior to practical completion of each installation and submit this to the Contracting Authority at the same time as submitting the draft operation & maintenance manuals. The plant change form shall be accompanied by a copy of the testing and commissioning certificates held in the O&M Manual.

Appendix 1

Performance Calculation Methodology

PR calculation methodology

The performance ratio (PR) is a measure of the quality of the design, components and installation of the Photovoltaic System. It is the relationship between the actual energy produced, i.e. the energy measured at the appropriate meter (being the generation meter) and the energy theoretically produced by the PV Modules (before any losses):

PRj = Eprod_j/EPV_j

Where:

PRj	Is the performance ratio calculated over time period "j" where the inverter has been operational for the full 30 min
Eprod_j	Is the sum of all available energy (kWh) produced by the plant at the accredited generation meter in timeframe j.
EPV_j	Energy theoretically produced by the PV modules (kWh) in timeframe j.

$$E_{PV\_j} = P_{nom} * \left(\frac{H_j}{G}\right) * (1-d)^k$$

Where:

Pnom	Is the nameplate or datasheet capacity of the modules in kWp
Hj	Is the average of the irradiation hitting the PV Modules in timeframe j, either based on the pyranometers installed or from the satellite data, as applicable (kWh / m2)
G	Is the irradiance under Standard Test Conditions = 1,000 W / m2
d	Is the agreed degradation (0.4% p.a.)
k	Is the year following the PAT test

For the purpose of calculating the PRPAT k will be 1.
For each test a single PR figure will then be generated by using the following equation.

PRoverall	Single PR value for all valid readings over the performance testing period for the whole plant.

$$PR_{overall} = \frac{\sum_{j=1}^{Z} E_{prod\_j}}{\sum_{j=1}^{Z} E_{PV\_j}}$$

Where:

Z	Is the number of sampling periods (j) in the total performance test duration

Model Correction Factor

Should the performance test not be carried out during a whole calendar year, for comparison against the Guaranteed PR, the PRoverall value from the test must be adjusted to account for variations between seasonal and annual conditions using the Monthly

Correction Factor (MCF) described below, where the Guaranteed PR is per the definition outlined above

Month	MCF
January	TBC
February	TBC
March	TBC
April	TBC
May	TBC
June	TBC
July	TBC
August	TBC
September	TBC
October	TBC
November	TBC
December	TBC

[NOTE: Correction Factor details to be added per project once the as-built design has been modelled]

The MCF adjustment will be weighted to take account of the number of days of the test that fall in each month e.g. if 2 days of the test fell in June and 3 days in July the MCF would be (0.4 x June MCF) + (0.6 x July MCF).

Data Format

Processed data shall be prepared in an Excel spreadsheet on a half hourly basis with the following columns:

a) Time and date
b) All pyranometer readings, if applicable
c) Pyranometer average, if applicable
d) Pyranometer deviation range, if applicable
e) Satellite data, if applicable
f) Reference cell data, if applicable
g) Ambient temperature
h) Each string inverter or string combiner box power
i) Total inverter power
j) Availability
k) Expected production
l) Generation meter energy output
m) Export meter energy output
n) Energy consumed by the Customer

o) PR

The test results shall be readable by GFSL for the purposes of auditing. In order to facilitate this requirement the client will need the flexibility to request a bespoke version of the report where they can pick the 'data columns' required, to ensure that only the data we needed for input into the central database (hence the requirement for into C3 and that the process is as fluid as possible (hence the request for SFTP with Key File Authentication as a data transfer type).

Check of Data Quality

The Supplier will supply raw data before any manipulation and highlight any gaps in the data to GFSL. All recorded data shall be checked for consistency and gaps to identify obvious anomalies before any detailed analysis is conducted. A reasonable set of limits shall be defined for each recorded parameter, based on the known characteristics of the parameter, the Photovoltaic System and the environment.

Safety during testing

The Supplier shall be responsible for safely conducting all Tests. The Supplier shall provide a safety briefing for all personnel on the Site who will be involved in or witnessing any Tests and shall ensure that such personnel comply with all applicable safety procedures at all times during performance of the Tests. The Supplier shall discontinue performance of any Tests in the event of any unsafe conditions.

Procedures for Stopping and Restarting Testing

(a) If an event beyond the control of and not the fault or responsibility of the Supplier causes the Photovoltaic System or a part thereof to stop operating or to be disconnected temporarily, then the Test Operation Period shall be suspended during the period of non-operation and, following restoration of operation, the Test Operation Period for the Photovoltaic System shall resume for the remaining period until the Test Operation Period has run for ten (10) days. The Supplier shall maintain a log of any such event, including the cause, duration and times at which the performance testing was suspended and resumed.
(b) The Supplier shall provide written notice to GFSL within twenty-four (24) hours following each such test suspension and resumption. The Tests may be resumed if the Test pre-requisites still remain.
If the Supplier determines that it is unlikely to pass a Test, the Supplier shall notify GFSL and may discontinue performing such Test. The Supplier may subsequently commence a new Test, subject to compliance with the procedures in this section.

Downtime during testing

(a) In calculations for the Performance Tests/Reviews of the Photovoltaic Systems, any period of downtime or reduced operation of the Photovoltaic Systems should be excluded, resulting from:

i. unavailability of the local grid (to be documented, if possible, by way of monitoring the G99 relay in the DNO substation showing an error message of loss of mains for a grid failure or by written or verbal confirmation from the DNO to the plant Operator);

ii. unavailability of the MoJ's electrical infrastructure due to MoJ or a third party not under the control or influence of the Supplier;
iii. any act of MoJ or any other third party, birds or animals which adversely affects or limits the performance of the Photovoltaic System;
iv. export limitations imposed by the DNO to manage export at the Property, in which case the exclusion shall apply only to the extent the export limitation applies;
v. occurrence of a Force Majeure Event which prevents the Supplier from reacting to a reduction in performance of the Photovoltaic System;
vi. coverage of the PV modules by ice and/or snow that limits the performance of the Photovoltaic System;
vii. spares stock or replacement parts not being available, and the Supplier has ordered all necessary spare parts;
viii. any maintenance, repairs, additions, costs necessitated due to a change in law;
ix. any maintenance of the Photovoltaic System carried out in accordance with the maintenance contract or as agreed between the Parties if such maintenance leads to a loss of generation of electricity.

Appendix 2 – Plant or System changed or new installed

Property Address:		Electrical Services Installation Supplier:	
Property Number:		Maintenance Supplier:	
Practical Completion date:		End of Defects date:	
Project Engineer		TMS Code	

This is relevant for all new buildings to be maintained or existing buildings currently being maintained by The Contracting Authority.

The Contracting Authority shall complete the form prior to practical completion and submit this to the CA at the same time as submitting the draft operation & maintenance manuals.

SUMMARY OF NEW PLANT/SYSTEMS INSTALLED			
Description	Location	Reference	Comment

NEW PLANT/SYSTEM DETAILS					
PLANT/SYSTEM	Qty	Fitted (Y?N)	Monitoring Co. Name	Maintenance Contract (Y/N)	Maintenance Contract Expiry (date)
			Is written scheme prepared?	Yes No	
			Has plant been added to Insurance schedule?	Yes No	

COMMENTS			
Date:		*Completed by:*	