

Minimum technical requirements for photovoltaic power plants up to 5MW (PV-L projects)

Minimum technical requirements

1. Codes and standards

The developer shall ensure that the engineering, design, construction, testing, etc. of the plant complies with internationally recognized standards and regulations, in their latest edition, and follow all applicable requirements of national and local regulations.

The local building regulations of Armenia shall apply to construction works and buildings. The latest editions of the standards, codes, regulations, recommendations and instructions issued by the following organizations shall be applied, as a minimum requirement, for the design, construction, testing, commissioning, operation and maintenance of the plant.

Compliance with individual standards does not guarantee a fit-for-purpose integrated solution. It is therefore the responsibility of the developer to propose and implement a solution that is appropriate to the site conditions and requirements.

International standards (prevail)

ISO International Organization for Standardization
IEC International Electrotechnical Commission

National standards

ANSI American National Standards Institute
BSI British Standards Institute
DIN German Institute for Standardization
EN European standards

Suggestions

ASTM American Society for Testing Materials
IBC International Building Code
IEEE Institute of Electrical and Electronics Engineers
UBC Institute of Electrical and Electronics Engineers
VDE German Association of Electrical Engineers

The design of the plant must comply with all the requirements of the latest version of the Armenian Distribution Network and Electricity Transmission Regulations.

Deviation from the **codes and standards** in this section, as well as the use of any regulations and standards not published by any of the organizations listed above, is not acceptable.

Among others, the following international standards shall be applied for the installation, testing and operation of the substation and switching system. The latest versions of relevant documents (requirements) shall be taken into account. Developers shall take into account, without limitation, the following rules and standards, including all other referenced rules and standards specified in those rules (normative references):

General

- IEC TS 63049:2017, Terrestrial Photovoltaic (PV) Systems: Guidelines for Effective Quality Assurance in the Installation, Operation and Maintenance of PV Systems
- IEC 60364:2021, (all applicable parts), low voltage electrical installations
- IEC 61936-1:2021+AM1:2014 CSV, Power plants with a capacity exceeding 1 kV alternating current – Part 1: general rules
- IEC 60071:2022, (all applicable parts), in the isolation system
- IEC 60068:2022 (all applicable parts), environmental testing

PV system installation

- IEC 60364-7-712:2017 RLV, Electrical installations of buildings - Part 7-712: Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems
- IEC 62852:2014+AMD:1:2020, Connectors for direct current applications in photovoltaic systems: safety requirements and tests
- IEC 60228:2023, 60364-1, 60332-1-2, 60754-1 and -2, 61034-1 and -2
- EN 50618:2020, Electrical cables for photovoltaic systems
- IEC 62548:2023, Photovoltaic (PV) systems: design requirements
- IEC 62894:2014+A1:2016, Photovoltaic inverters: technical data sheet and nameplate
- IEC TS 62910:2015, Grid-connected photovoltaic inverters: Low voltage breakdown measurement test procedure
- IEC 62109-1:2010, Safety of power converters used in photovoltaic energy systems - Part 1: General requirements
- IEC 62109-2:2011, Safety of power converters used in photovoltaic energy systems - Part 2: Specific requirements for converters
- IEC 62109-3:2014, Safety of power converters used in photovoltaic energy systems - Part 3: Specific requirements for transformerless converters
- IEC 61727:2021, Photovoltaic (PV) systems: system interface characteristics
- IEC 61683:2016, Photovoltaic systems - Power converters - Efficiency measurement procedure

PV modules

- IEC TS 62804-1:2015, Photovoltaic (PV) modules - Test methods for the detection of potential induced degradation - Part 1: Crystalline silicon

- IEC 61215-1:2021, (all applicable parts), terrestrial photovoltaic (PV) modules - Design qualification and type approval
- IEC 61215-2:2021, Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 2: Test procedures
- IEC 61701:2011, Salt fog corrosion testing of photovoltaic (PV) modules
- IEC 60068-2-68:2012, Environmental exposure testing – Part 2-68: Tests – Test L: Dust and sand
- IEC TS 62782:2016, Photovoltaic (PV) modules - Cyclic (dynamic) mechanical load testing

Implementation and documentation

- IEC 60364-6:2016, Low-voltage electrical installations – Part 6: Inspection
- IEC 62446-1:2021, Photovoltaic (PV) systems - Testing, documentation and maintenance requirements - Part 1: Grid-connected systems - Documentation, commissioning tests and verification

Power transformers

- IEC 60076:2021 (all the applicable parts), power transformers

High voltage and medium voltage distribution equipment

- IEC 62271:2021 (all applicable parts), High voltage switchgear and controlgear
- IEC 60376:2018 Specification for technical grade sulfur hexafluoride (SF6) for use in electrical equipment

High voltage and medium voltage cable

- IEC 60183:2015, Selection guide for high voltage alternating current cable systems
- IEC 60287:2015, (all applicable parts), Electrical cables
- IEC 60502:2020 (all applicable parts), Power cables with extruded insulation and their accessories for rated voltages from 1 kV ($U_m = 1.2$ kV) to 30 kV ($U_m = 36$ kV)
- IEC 60840:2011 RLV, Power cables with extruded insulation for voltages above 30 kV ($U_m = 36$ kV) and above ($U_m = 170$ kV) and their accessories - Test methods and requirements
- IEC 62067:2011 RLV, Power cables with extruded insulation for rated voltages above 150 kV ($U_m = 170$ kV) ($U_m = 550$ kV) up to and including 500 kV ($U_m = 550$ kV) and their accessories - Test methods and requirements

Low voltage system

- IEC 61439:2020, Low-voltage switchgear and controlgear assemblies
- IEC 60947-1:2020, Low-voltage switchgear and controlgear – Part 1: General rules

Grounding and lightning protection

- IEC 60364-4-41:2015+AMD1:2017 CSV, Low-voltage electrical installations - Part 4-41: Safety protection - Protection against electric shock

- IEC 60364-5-54:2011, Low-voltage electrical installations - Part 5-54: Selection and erection of electrical equipment - Earthing systems and protective conductors
 - IEC 61140:2016, Protection against electric shock - General aspects for installation and equipment
 - IEC 61936-1:2010+AMD1:2014 CSV, Alternating current power installations with voltages exceeding 1 kV - Part 1. General rules
 - IEC 62305:2022 (all applicable parts), Protection against lightning
 - IEC 60099:2022 (all applicable parts), Surge arresters
- IEC 61000:2022 (all applicable parts), Electromagnetic compatibility (EMC)

Buildings and hulls, inverter protection

- IEC 60721-3-3:2018, Classification of environmental conditions - Classification of groups of environmental parameters and their degrees of severity - Stationary use in locations protected from weather conditions
- IEC 60721-3-4:2018, Classification of environmental conditions - Classification of groups of environmental parameters and their degrees of severity - Stationary use in locations not protected from weather conditions

Control and management systems

- ISO/IEC 27000:2018-02, Information technology - Security techniques - Information security management systems - General information and vocabulary
- IEC 62443:2022, Industrial communication networks - Network and system security
- IEC 62351:2018, SER Power system management and related information exchange - Data and communication security (all parts)
- ISO 9060:2018, Solar energy - Specification and classification of instruments for measuring hemispherical solar radiation and direct solar radiation
- IEC 62443-3-3:2013, Industrial communication networks - Network and system security - Part 3-3: System security requirements and security levels
- IEC 61850-90-7:2013, Power automation communication networks and systems - Part 90-7: Object models for photovoltaic, storage and other distributed energy resource (DER) inverters

2. Program

2.1. General requirements

A photovoltaic plant shall be designed to efficiently and competitively supply solar energy and maximize energy production from a given surface area. All parts of the photovoltaic plant must be compatible with the climatic conditions of the location.

The plant's equipment and systems must be constructed according to the Armenian and internationally recognized standards and comply with all applicable national regulations and legislative requirements.

An approved classification and identification system shall be used at all stages of the PV plant design. The international SI system of units shall be used for design, drawings, diagrams, instruments and all technical documentation. All warning and safety labels and signs shall be in Armenian and English.

The PV plant must be designed to operate in the climatic conditions prevailing in the area throughout the entire design life of the plant.

The PV plant shall be operated in full compliance with all technical and environmental requirements and local regulations.

All the structures and equipment of a PV plant must be arranged and located at a sufficient distance from each other to ensure regular and sufficient operation and maintenance.

The PV station shall be equipped with the necessary means to manage and transmit all the necessary measurements and data via communication channels between the PV station and the Dispatch Center.

The PV plant must be equipped with an emergency (backup) power supply to ensure safe and controlled operation and shutdown of the plant in the event of a failure of all power supply sources without damaging any equipment.

The PV plant shall meet the following plant operating requirements:

- The photovoltaic plant shall be able to maintain zero reactive power transfer at the transmission input point at all active power output levels under constant voltage conditions.
- The rated output power of the generating unit shall be available for a power factor of 0.95 (lagging) to 0.95 (leading) according to the points mentioned below.
- A continuously operating automatic control system is required to ensure voltage control at the connection point, without instability, throughout the entire operating range of the PV plant.

The developer shall optimize the plant layout and detailed plant and operational settings to achieve the agreed minimum power output.

The load factor (the ratio of the total power of the modules [kW] to the total power of the inverters [kVA] in each subsystem) shall not exceed 1.2. The rated power [MVA] for each transformer must be equal to the rated power of the inverters.

The general plan should show the implementation of all the components and infrastructure of the photovoltaic power plant (excluding solar panels), taking into account local conditions, existing infrastructure structures and units, long-term operation and necessary on-site maintenance work.

In addition, detailed design drawings shall be developed, showing sections at various scales and, where necessary, supplemented with appropriate details, as well as schemes developed for infrastructural, civil, mechanical, electrical and other specialized areas of design and construction.

It is planned that temporary structures and storage platforms will be located on the construction site (object). Labor camps must comply with the technical requirements and local regulations of the Republic of Armenia.

The developer is free to optimize the design of the PV plant system as it deems most appropriate to competitively maximize solar energy production in the proposed area.

2.2. Environmental, social, health and safety requirements

The Developer shall design, construct, operate, maintain and maintain the PV Plant in accordance with all applicable environmental regulations and standards of the Republic of Armenia, as well as comprehensive and preventive health, safety and environmental procedures, according to which the Developer shall include in the design and construction processes of the PV Plant such equipment, processes and structures that will contribute to the operation of the PV Plant in accordance with environmentally safe and sustainable policies, practices and procedures. The developer shall demonstrate during the design and construction phase, as well as during the testing and operation phase, that the PV plant can comply with all the applicable environmental regulations and standards.

The developer shall demonstrate during the design and construction phase, as well as during the testing and operation phase, that the PV plant can comply with all applicable environmental regulations and standards.

According to the current requirements of the Republic of Armenia, an Environmental Impact Assessment (EIA) shall be carried out, including the development of appropriate environmental management plans for the construction and operational phases, if applicable by law.

If the project is subject to EIA according to the RA legislation, a situation is possible when, at the application stage, the Investor has not yet received **a positive conclusion on the EIA** issued by the relevant state body. In that case, the EIA-RE team will begin processing the application received from the investor if the latter can demonstrate that the EIA report is in the evaluation phase by the relevant state body and that the Conclusion is pending. The conclusion must be submitted to the GCF-RE team as soon as it is available and, in any case, before the final monitoring is organized by the GCF-RE team. Failure to submit a positive conclusion **before the final monitoring** may result in a loan recall procedure by the GCF.

The developer must also consider and ensure compliance with all applicable health, safety and environmental regulations and guidelines, including the availability of personal protective equipment, ensuring site cleanliness and other requirements for workers and visitors during the construction and operation of the PV plant.

In addition to the requirements of the Republic of Armenia, the plant must be classified according to the KfW Sustainability Guideline 2021, and an impact assessment and management appropriate to the assigned category must be carried out.

The environmental impact category of a project is determined by the category of its most environmentally sensitive component, including direct, indirect, induced, and cumulative impacts. Each proposed project is carefully examined in terms of its type, location, scale, sensitivity, and magnitude of potential environmental impacts. The level of detail and comprehensiveness of the environmental and social impact assessment is appropriate to the significance of the potential impacts and risks. The environmental impact classification in the KfW Sustainability Guide 2024 is defined as follows:

- **Category A (high risk):** A proposed project is classified as Category A if it is likely to have significant adverse environmental impacts and risks that are irreversible, diverse, or unprecedented. A proposed project is classified as Category A if it is likely to have significant adverse environmental impacts and risks that are irreversible, diverse, or unprecedented. These impacts may affect an area larger than the physical sites or facilities subject to the works. An Environmental and Social Impact Assessment (ESIA), including an Environmental and Social Management Plan (ESMP), is required.
- **Category B+ (significant risk):** If a Category B project is predicted to have significant adverse environmental and social impacts and risks, it is included under Category B+. An ESIA and ESIA are required. (Հաշվան ռիսկ).
- **Category B (medium risk):** The proposed project is classified as Category B if its potential adverse environmental and social risks and impacts are less adverse than those of Category A projects. These impacts are site-specific, largely reversible, and can usually be mitigated through standard, best available mitigation approaches. The need for, scope, priorities, and depth of an ESIA are determined on a case-by-case basis.
- **Category C (low risk):** A proposed project is classified as Category C if it is likely to have minimal or no adverse environmental impacts. An environmental assessment is not required, although the environmental implications should be studied. The classification of projects in terms of impact magnitude will be assessed based on environmental and social impact indicators, if any.

Environmental, social, health and safety management

The developer shall prepare and implement a comprehensive ESHS (environmental, social, health and safety) standards policy and accompanying procedures that will govern the actions of the contractor responsible for design, supply and construction and the operator during the design and construction of the PV plant, as well as during the operational phase of the PV plant.

In addition to other requirements regarding the standards to be adopted by the Developer in the overall design of the PV plant, the Developer shall submit a detailed Environmental, Social, Health and Safety Construction Plan and a detailed Environmental, Social, Health and Safety Operation Plan, which shall demonstrate the Developer's commitment to the highest standards of personnel and general safety, as well as health and occupational health standards during the construction and operation of the PV plant, as well as to the concept of an accident and injury-free project.

All guidelines and restrictions specified in the Environmental, Social, Health and Safety Plans must be carefully considered for all activities of the PV plant project.

Requirements for warning and safety signs

The PV station must be equipped with comprehensive information, warning and safety signs according to the following requirements:

Language requirements: All signs, labels and markings shall be in Armenian and English. The text shall be clearly legible. Pictograms and symbols shall comply with IEC 60417 and ISO 3864, where applicable.

Mandatory safety signs: High voltage warning signs on all electrical equipment above 50 V DC or 30 V AC. Arc flash warning labels on all electrical enclosures and switchgear. Electric shock warning signs at PV installation sites with the words “DANGER - ELECTRIC SHOCK HAZARD - PHOTOVOLTAIC EQUIPMENT”. Access restriction signs in electrical equipment areas. Emergency shutdown procedure signs in control rooms and main electrical areas.

Identification and information labels (markings): Equipment identification labels and nameplates that indicate the name of the equipment, voltage, rated electrical current, and date of commissioning. Circuit identification labels for all DC and AC circuits. Grounding point identification markers. Emergency contact information should be prominently displayed near the main entrance to the construction site and in the control buildings.

Durability and installation requirements All the signs must be weatherproof and UV-resistant for outdoor use. Labels should be made of materials appropriate for the expected service life of the equipment (at least 25 years for permanent installation). Signs must be securely mounted and clearly visible under normal lighting conditions. Signs must be mounted so that they are clearly visible to personnel during normal operation and maintenance activities.

Compliance and standards: All the signs must comply with Armenian national safety regulations and international standards, including IEC 61936-1, IEC 60364 series, and ISO 3864. Color coding must comply with IEC 60073 safety color standards (red for prohibition/danger, yellow for caution, green for safety/emergency escape).

2.3. Main components

PV modules

The PV plant should be constructed with PV modules of proven technology, as described in more details below. The PV modules should be selected according to the following minimum requirements:

PV modules can be either crystalline silicon (including TOPCon, HJT, PERC or other advanced cell technologies) or thin-film. Efficiency calculations must accurately model bifacial modules using the correct bifaciality factors.



A maximum of 3 different module power classes, with a maximum of two different module brands, can be used for each project.

The design of a typical PV power plant connected to a low/medium voltage transformer substation with one type of PV module must have the same inverter and mounting structure type. Further combinations of PV modules, inverters and mounting structures are not permitted. All photovoltaic modules must be manufactured by one manufacturer.

The selected PV module model or series must have been installed and successfully operated at least one (1) year prior to the date of proposal submission in at least two (2) PV plants, each with a minimum installed capacity of 10 MW (DC) and must have a total installed capacity of at least 50 MW (DC).

Information on referral programs must contain at least the following information:

- name
- quantity
- owner and
- date of commercial operation of the project.

Prior to the issuance of a purchase order for PV modules, a confirmation letter from the module manufacturer must be provided for the proposed PV modules, confirming that the PV modules shall comply with the latest version of the following IEC standards, including valid certificates issued by accredited testing facilities in accordance with valid IEC and other standards, including but not limited to:

- IEC 61215 (all applicable parts): Terrestrial photovoltaic (PV) modules - Design qualification and type approval
- IEC 61730-1, -2. Photovoltaic (PV) module safety qualification, Part 1: Construction requirements, Part 2: Testing requirements
- IEC 60068-2-68. Environmental exposure testing - Part 2-68: Tests - Test L: Dust and sand
- IEC TS 62804-1. Potential Induced Degradation (PID) Free Testing of Crystalline Silicon Based Modules
- IEC 61701. Salt spray corrosion testing of photovoltaic (PV) modules
- IEC TS 62782. Photovoltaic (PV) modules - Cyclic (dynamic) mechanical load testing
- IEC TS 60904-1-2. Measurement of current-voltage characteristics of bifacial photovoltaic (PV) devices
- IEC 61853-4. Photovoltaic (PV) module performance testing and energy rating - Part 4: Standard reference climate profiles and their application

The selected PV module must have the following minimum guarantees, starting from the date of commercial operation of the project:

- product quality guarantee is at least 10 years,

- Output power guarantee for 30 years of service life based on nominal peak power and annual linear power reduction guarantee with a maximum output power reduction of 20% (from the initial nominal output power of the module under standard test conditions) over 30 years.

All the modules shall have only positive power deviations (-0% / +5%). PV modules for new projects that were not yet in operation must have at least 22% efficiency under standard test conditions at the time of application. For bifacial modules, this efficiency requirement refers to the measurement of the front side of the module under standard test conditions, where the additional energy from the back side production must be properly accounted for in the efficiency calculations. The PV module efficiency of projects in operation at the time of application submission must be no less than 20%.

DC power cables

DC cables (main and branch) must be selected and installed to withstand the external influences on site, such as temperature, ultraviolet radiation, wind, sand, tension and any other mechanical loads. All DC cables must be single-core and double insulated.

All cables shall be installed according to the manufacturer's recommendations. The cable shall not be permanently submerged in water, and the cable conduit should be properly sealed. The ends of the conduit, connectors, and terminals should be out of the way of water accumulation.

In all cases of outdoor cable installation, it is necessary to use UV-resistant cable and conduit, provide effective protection against rodents, ensure safe and adequate cable fastening, and maintain the allowable bending radius. All the pipes must be properly insulated from the ingress of water, dust, insects, etc. to maintain the integrity of the system.

DC connectors

DC connectors for string/chain connections must be of the same brand and type as those used by the PV module manufacturer. DC connectors of different brands or types must not be mated in the same connection (male-female).

DC junction boxes

The DC junction box shall meet the following requirements:

- PV wire/cable protection: DC fuses on each pole. The maximum fuse rating should not exceed the PV module fuse or the maximum reverse current rating.
- A multi-pole circuit breaker with sufficient DC load capacity must be provided to disconnect all PV module wires/cables under load conditions.
- Overvoltage and lightning protection.
- DC junction boxes must be protected from direct sunlight or appropriate measures must be taken to ensure the functionality of the DC junction during the design operating period.

Inverters

Inverters must be suitable for the site conditions of the PV plant, have a proven history of regular operation in PV plants, and be purchased from reliable suppliers with appropriate banking references. Inverters can be of the string or central inverter type. The inverter manufacturer and the inverters shall meet the following requirements:

Inverters:

- Shall be adapted to the climatic conditions of the PV plant location, or a housing or cover must be provided to maintain the inverters within the permissible temperature range at all times;
- Shall have proven experience of successful operation in industrial scale PV plants;
- Shall have at least 96% (central inverters) and 97% (linear inverters) Euro (California Energy Commission) efficiency.
- All the inverters must be of the same type and from the same manufacturer,
- Outdoor central inverters shall have at least IP 54 class with sufficient cooling capabilities;
- Inverters installed inside a compact station with a minimum protection class of IP 54 shall have at least IP 20 and must provide sufficient active or passive cooling. String inverters shall be IP 65.
- Shall be designed to operate in all local conditions, such as high temperatures, soil or dusty atmospheres, and heavy rainfall. Inverters shall be equipped with a temperature controller, and in the case of central inverters, a humidity controller.
- The inverter shall allow system configurations with functional grounding of the negative poles of the PV cables to combat potential induced degradation (PID). In this case, safety requirements shall not be compromised at any time, and insulation resistance monitoring shall be possible in an automated manner in accordance with parts 1 and 2 of the IEC 62109 standard. This applies particularly to the possibility of automatic disconnection from the earthing network and the possibility of checking the insulation resistance before starting daily operation of the inverter (IEC 62109-2; 4.8), as well as any other requirements regarding electrical safety described in this standard.
- Even if the system design does not provide for grounding the negative pole of the wires, the inverters shall have the necessary features to perform grounding and install an automatic insulation resistance meter if necessary in the future.
- The inverter shall have a product warranty of at least five (5) years.
- Inverters shall have advanced grid support functions, including voltage regulation, frequency support, and reactive power management, in accordance with the latest requirements of the RA Grid Code.
- Inverters shall include cybersecurity features that comply with the IEC 62443 industrial cybersecurity standards.

PV system mounting (supporting) structures

The developer is free to choose fixed-tilt and/or sun-tracking PV mounting structures. If the mounting structures are to be based on column foundations (pre-drilled and concreted or plugged), in order to perform the analysis (measurement) of the strength of the foundations, it is necessary to conduct on-site column tests in a sufficient number, but not less than four (4) per MW (direct current), sufficient for the analysis of the strength of the foundations. The column tests shall be carried out for axial and lateral forces, including bending moments.

The developer shall conduct soil surveys and collect all the information necessary for the project in sufficient detail to ensure that all foundations are most suitable and safe and are properly designed according to the soil conditions of the PV plant site.

The design and construction shall include appropriate measures against strong (high-speed) winds and, where necessary, protect the structure(s) and foundation from corrosion due to corrosive soil conditions, salt air, dust and chemical aggression during the expected life of the plant.

The developer shall be aware of and take into account possible corrosion on site due to adverse weather conditions, especially for equipment installed outdoors and underground.

As part of the detailed design, the Developer is required to provide a detailed corrosion protection concept for all the structures and facilities installed on the construction site before the construction begins.

The concept shall include the corrosion protection measures and details required for the project, as well as the maintenance programs required throughout the design life of the plant.

Mounting structures shall be made of construction-grade aluminum alloy or stainless or galvanized steel, with a product warranty of at least 25 years in appropriate climatic conditions (RA Construction Standard 22-01-2024)¹:

The mounting structures used must be well-known and well-established products on the market, designed for use in PV solar plants with proven experience;

- The mounting structure shall be compatible with the PV modules. The PV module manufacturer is required to confirm the compatibility of its modules with the mounting system (fixed or trailing).
- The manufacturer of mounting structures shall have mounting structures designed for a total power of at least 500 MW (direct current).

For tracked systems, the tracking algorithm should include weather-adaptive positioning and feedback tracking capabilities to optimize energy production and protect against high wind conditions.

Regardless of the system chosen, the Developer should consider the following:

- The site for the PV plant shall be prepared (leveling, compacting and grading as necessary) taking into account hydrological and geological studies to ensure the necessary bearing capacity.
- The preferred foundation solution(s) shall be verified by local tests before construction begins. The test procedure shall be planned in close agreement with the results and limits established in the structural calculations and geological surveys. The test loads shall be defined taking into account

¹ <https://www.arlis.am/hy/acts/188846>

sufficient safety factors for impact loads as well as for the resistance of the foundation. The same applies to the limits of deflection and deformation.

Emergency diesel generator

Emergency diesel generator(s) shall be provided to provide essential services to the PV plant, including heating, ventilation and air conditioning. Essential services shall include:

- Switchgear control and protection
- Communication and monitoring systems
- Digital control system
- Surveillance and security systems
- Water supply and sewage systems
- Fire extinguishing systems
- Operation rooms and buildings
- Gatehouse
- Any other consumer or structure that the Developer considers important (essential) for the safe and reliable operation of the plant.

Emergency diesel generators must be of protection class IP 54 and shall be installed indoors. Emergency diesel generators must be designed for class F insulation and shall operate with a class B temperature rise.

Grounding and lightning protection system

The grounding system must be designed in accordance with IEC, VDE or IEEE standards.

Pairing dissimilar metals should be avoided.

Requirements for control and measurement systems

This specification does not relieve the Developer of the responsibility for the basic design and implementation of the measurement and control system. Good service practice and relevant approved standards and regulations must be followed.

No failure of the measurement and control system shall:

- Cause any danger to personnel or the station.
- Cancellation protection by suspending the shutdown.
- Turn off the main device of more than one station.
- Simultaneously turn off the equipment item and cancel its automatic switching.

A consistent measurement and control philosophy should be applied throughout the PV plant, implemented with equipment characterized by a minimum variety of types and manufacturers. The

goal should be to standardize all measurement and control equipment throughout the PV plant to rationalize operation and maintenance and reduce the number of spare parts.

Each safety-related link must be tested in accordance with IEC 61508, IEC 61511 to ensure that the required and necessary Safety Integrity Level is met for each link. The developer must assess all safety-related links to ensure compliance with the requirements and must provide a record of these studies.

Measuring and control equipment shall have high immunity to electromagnetic and radio frequency interference and must not be affected by mobile radio transmitters operating in the vicinity of the equipment. Any limitations shall be noted.

All measuring and control equipment shall have an enclosure classification of at least IP 54 when installed indoors and IP 65 when installed outdoors, in accordance with IEC 60529. Control cabinets installed in air-conditioned rooms shall have at least IP 32 classification.

Measurement and control systems shall include:

- Cybersecurity measures comply with IEC 62443 series standards
- Remote diagnostic capabilities with secure virtual private network (VPN) access

Sun protection measures shall be provided for all outdoor cabins, and all cabins must be adequately ventilated or, if necessary, air-conditioned for operation.

Digital Control System (DCS) / Supervisory Control and Data Acquisition (SCADA)

IEC 61724 should be considered as a guide for measurement, data exchange and analysis.

IEC 61446 shall be considered as a minimum requirement for system documentation, commissioning testing, and verification.

The IEC 61850-7-420 communication standard for distributed energy resources should be considered. Based on the requirements for availability, reliability and functionality, the tasks of controlling and monitoring the main processes of the plant shall be carried out by a modern control system.

The digital management system shall perform all of the following functions:

- data acquisition with real-time performance monitoring
- management systems, including predictive maintenance algorithms
- human-machine interface with mobile access
- alarm signaling system with automated notification systems
- sequential recording of events
- historical data archive with cloud backup capabilities and
- management reporting with automated performance analysis.

To provide real-time performance monitoring according to the IEC 61724-1:2017 standard, a meteorological station must include the following main components:

- At least two solar radiation sensors: one for global horizontal irradiance and one for plane-of-array irradiance measurements.
- At least two temperature sensors: one for ambient air temperature and one for module temperature.
- Wind speed and direction sensors.

To ensure high availability and reliability of the plant, the control system also requires high availability. This should be achieved through a single-fault tolerant design for centralized components, and critical sensors that can affect plant availability in the event of a fault or be used for protection should be provided in a redundant configuration.

System configuration should be simple and flexible, allowing for changes in ring configurations and display formats to meet changing operational requirements. System software security, including database configuration and administrator ring configuration settings, should be password-protected.

All the systems shall require minimal maintenance and have comprehensive self-testing and self-diagnostic capabilities, including self-test failure alarms, etc.

The PV plant should be designed in such a way that it is possible to manage and monitor the PV from the Armenian dispatch center, including automatic generation control.

Studies

As a design basis, at least the following studies should be completed on time:

- Study of soil conditions, study of geological formations and seismic conditions of the area.
- Investigation of obstacles at and near the PV plant site, such as medium/high voltage overhead lines or underground cables.
- Topographic survey.
- Solar resource and productivity studies based on validation of multi-year satellite data.
- Drainage and water resources management, including the concept of rainwater, fresh and wastewater, and the management of oily and environmentally harmful liquids.
- If required by RA regulations, the Developer shall conduct an Environmental Impact Assessment (EIA) in accordance with relevant requirements, and develop appropriate environmental management plans for the construction and operation phases.

Documenting and information

The developer or its contractor responsible for design, supply and construction shall complete all technical data sheets and forms contained in the request for proposal for the plant. The technical data sheets should be supplemented with additional descriptions, technical specifications, drawings and all other information necessary for a clear understanding of the proposal, so that the consultants can carry out the necessary assessment, evaluation and verification of the technical and performance characteristics of the proposal.

Technical concept of the station

Description of the main equipment and systems, etc., including their auxiliary devices, such as:

- a) General concept of the station
- b) Main components: PV modules, inverters, inverter stations, transformers, mounting system
- c) Description of interfaces
 - Power system philosophy (PV field, medium voltage systems, up to the interconnection point)
 - Main electrical equipment, including auxiliary systems
 - Electrical single-line diagrams of PV plant and subsystems
 - Electrical system calculations
- d) Measurement and control systems:
 - General description of the management system
 - Billing metering system (for own consumption)
 - Description of meteorological stations and sensors
- e) Project plans and diagrams, such as:
 - Site plan, general plan of on-site and off-site structures, marking of fenced areas.
 - Layout plan of the PV plant area, including cable routing.
 - PV plant layout plan, including access road, security fence, buildings, technical equipment, roads, as well as a proposal for cable routing to the switching station connection.
 - General plan
- f) Production reports

The developer is required to submit productivity reports for the plant, including a productivity model and hourly production values, along with its proposal. Productivity reports shall be prepared by experienced independent technical consultants.

Performance reports shall be submitted along with PVsyst specific simulation files (export data with all source files used in the simulations). Performance reports must include:

- P50, P75 and P90 power generation scenarios
- Uncertainty analysis with detailed analysis of contributing factors
- Assessment of the indicative impact of climate change on long-term performance.