

## **Technical Requirements and recommendations for the implementation of ground-mounted and rooftop PV systems for own consumption over 150 kW up to 500 kW**

The technical requirements and recommendations for the implementation of ground-mounted and rooftop PV-systems from 150 kW up to 500 kW will be checked based on the checklist provided below by the loan officer of the PFI and by the subcontractor of “Fichtner GmbH & Co KG” Renewable Resources and Energy Efficiency Fund of Armenia (R2E2). The results of the technical assessment will be summarized in the last column of the attached checklist as well as in a summary report, which should include:

- Short Project Description (location, installed capacity, financial volume, pictures of project area, name of ESCO company, and module producer)
- Analysis of checklist
- Summary of the site visit
- Conclusion and Recommendations

The completed checklist and report will be provided to “Fichtner GmbH & Co KG” in Armenian and English for approval. Based on the conclusion provided, a decision on the financing of the PV system will be made. A negative assessment/conclusion could lead to a rejection of the project. Such cases will be discussed between GAF PMU and “Fichtner GmbH & Co KG” before deciding on the financing of the project.

The technical assessment will be performed according to the requirements as follows.

### **Requirements**

#### **General**

- The capacity of the solar PV plant should not exceed the consumption needs of the customer.
- Grid connection and evacuation of electricity are assured.
- Overbuilt (ratio of total module power to total inverter power in each sub-system) should not be higher than 1.2.
- According to local standards, justification of structural design for foundations and module mounting structures, especially considering wind loads and snow loads, shall be provided.
- Comprehensive and complete grounding.
- Adequate corrosion protection for all installed systems.
- All combiner boxes are adequately closed with all cable glands sealed
- Adequate labeling of module rows, combiner boxes, and cables

- Commissioning tests must be passed on system- and component level (factory acceptance tests, site acceptance tests)
- Engineering, procurement, and construction of systems by a company that is certified in accordance with ISO 9001, ISO 14001, and OHSAS 18001 or a national license to operate as an ESCO.
- Only use of UV-resistant cables and cable-ducts and sufficient protection for cables from vermin for all outdoor installation of cables, adequate fixing of cables, observation of permissible bending radius and sufficient strain relief of all wires, adequate sealing of cable ducts.
- Connection to the grid shall be done respecting the relevant IEC norms, especially if the PV Plant shall be connected to the medium voltage grid at a voltage level between 1 and 52 kV<sub>AC</sub>.
- Operation and maintenance (O&M) contract to include an O&M plan including work instructions or adequate staff, quality manual and qualification requirements of staff, and stating warranties to achieve specific key performance indicators such as availability, regular cleaning of air filters, the limit on reaction times, etc. O&M planning shall be based on IEC 62446: Grid-connected photovoltaic systems - Minimum requirements for system documentation, commissioning tests, and inspection. If regular module cleaning is conducted, the impact and required frequency of module cleaning are to be evaluated at least once a year.

## Modules

- Solar modules with a linear performance guarantee of at least 25 years. Standard crystalline or thin-film modules shall be installed. Modules shall be certified for snow loads of 5400 Pascal.
- The PV modules shall have valid certifications issued by a reputable testing institution according to IEC/EN standards as follows:
  - Design qualification and the type approval following the IEC/EN 61215 requirements
  - Testing for Potential Induced Degradation (PID) by the draft standard IEC TS 62804-1.
  - PV module electrical safety IEC 61730 tests and certification
- The PV modules shall have a minimum efficiency at Standard Test Conditions of **21.0%**
- The degradation warranty of the modules shall be less than 20% in 25 years and less than 10% in the first 10 years. All modules shall have only positive power tolerances (-0% / +5%)
- All PV modules shall be of the same type and from a single manufacturer.

## **Inverters**

- Standard inverters shall be installed. Inverter types shall comply with the relevant IEC standards (e.g., IEC 62109-1/2: Safety of power converters for use in photovoltaic power systems) and national regulations. Especially the local standards and requirements of the grid operator for grid connection (e.g., grid code) must be met.
- The inverters must have a minimum Euro (CEC) efficiency of 96%. All inverters shall be of the same type and from a single manufacturer.
- The inverters must have a product warranty period of at least five years.

## **PV DC cable certificate**

IEC Standard for DC cables for PV systems is recommended. DC cables should comply with the EN50618/TUV 2Pfg 1169/09/07 or IEC62930 and the national regulations.

## **Mounting structures**

- Mounting structures shall be made of aluminum alloys, such as AlMgSi (IADS 6061, 6063, 6082) or AlMg (IADS 5052, 5083, 5754), stainless steel, hot-dip galvanized steel or steel with an equivalent corrosion protection system such as Magnelis®, with a product warranty of at least 25 years in the relevant climatic conditions (RA Construction Standard II-7.01-2011). The mounting structures used shall be products well established on the market, designed for use in PV solar plants with a proven track record.
- Module layout and mounting structure design shall consider higher wind loads in the roof edges and corners and keep appropriate clearance. In any case, PV modules cannot be installed overhanging to roof ridge or verges.
- When installing modules in parallel on the roof, walkways for proper access for module maintenance and cleaning according to the operation and maintenance plan shall be considered.
- Mounting structures should comply with international and local standards.

## Grid Connection

For a safe electrical installation of the grid connection of the PV plants, the relevant standards depending on the connection point shall be met. These include

- IEC 62271 Standards for high-voltage switchgear and controlgear),
- IEC 60298 high voltage switchgear in metallic enclosure,
- IEC 60076 Power transformers for medium voltage,
- IEC 60726 Dry type power transformers,
- IEC 60183 Guide to the selection of high voltage cables, IEC 60502 Power cables with extruded insulation and their accessories for rated voltages from 1 kV up to 30 kV.

In particular, the following requirements shall be fulfilled:

### **Equipment Requirements** (Responsibility of Equipment Manufacturer)

- **Isolation and Protection**
  - Equipment must provide effective isolation between components carrying different electrical potentials
- **Earthing and Bonding**
  - Equipment must include provisions for proper earthing, ensuring a low impedance path for fault currents
- **Temperature and Overload Protection**
  - Components should incorporate thermal and overload protection mechanisms to prevent overheating and potential fire hazards
- **Ingress Protection**
  - Equipment installed outdoors or in harsh environments must have appropriate IP (Ingress Protection) ratings to prevent the entry of moisture, dust, and other contaminants

## **Installation Requirements (Responsibility of Installer)**

- **Proper Mounting and Positioning**
  - Equipment should be securely mounted and positioned to prevent physical damage and ensure ease of maintenance
  - Sufficient space must be provided around equipment for safe operation and access
- **Electrical Connections**
  - All connections, including busbars, cables, terminals and lugs must be properly tightened to ensure low-resistance paths and prevent overheating
- **Earthing and Grounding**
  - Adequate grounding and earthing systems should be established, complying with local electrical codes and standards
  - Equipotential bonding must be established to avoid potential differences within the installation
  - Earth resistance should be measured and maintained within acceptable limits
- **Insulation and Enclosure**
  - All busbars, terminals, and conductive parts must be adequately insulated to prevent accidental contact
  - Exposed live parts must be shielded or enclosed to prevent inadvertent access
  - Outdoor installations must include weatherproof enclosures to protect against environmental elements
- **Clear Markings and Labels**
  - Equipment must have clear and durable markings indicating live parts, warning signs, and safety instructions
  - Labels should be placed in easily visible locations for maintenance and operation personnel
- **Testing and Commissioning**
  - All equipment and connections must undergo thorough testing before commissioning to verify proper functionality and safety
  - Insulation resistance, continuity, and earth resistance tests should be performed and documented

## **Installation and commissioning**

- For a safe electrical installation of the system, IEC 60364 shall be met; for the DC installation, especially IEC 60364 –7–712.
- For commissioning and testing, IEC 62446 applies. The corresponding commissioning and safety tests shall be documented and stored according to the standard.

### **Interim and final monitoring**

At the request of GAF, the Fund will carry out at least one interim and one final monitoring visit to inspect the progress and quality of construction works. The outcomes will be submitted to “Fichtner GmbH & Co KG” in the scope of a short-form Monitoring report.

Investor shall comply and follow through with all conditions stipulated in the TA Report and Monitoring Reports issued by the Fund on the terms as defined as follows:

- max. 6 weeks to fix defects that involve only the investor / developer / EPC Contractor
- max. 12 weeks to fix defects that involve third party (grid operator or any other public authority)
- no Final Monitoring when defects identified during intermediate monitoring are not yet fixed

Failure to comply with the above may result in a loan-call-back procedure by GAF.

Investor can apply to extend the 12-week deadline, providing a written justification including the detailed reasons for the delay, validity of which will be assessed and decided by the Fund and GAF ultimately.

### **Warranties**

- Minimum 5 years of warranty for all components, the complete installation including quality for replacements or repair.
- Minimum five years of warranty for inverters.
- For PV modules, a product warranty for at least 10 years as well as a linear performance warranty guaranteeing a minimum output of 80% after 25 years.

### **Recommendations**

- Cleaning of modules: provide a clear plan for water supply for module cleaning to ensure efficient maintenance and optimal system performance
- Monitoring system/SCADA including irradiance measurement on module plane, ambient and module temperature measurement, string-monitoring by sensors installed in the DC combiner boxes or at the string inverter input.

## Environmental Health and Safety Requirements

- If an Environmental and Social Impact Assessment (ESIA) is required<sup>1</sup>, it should be provided by the owner of the land (customer). It ensures the following standards:
  - No use of lands within settlements, on agricultural land, or within protected areas
  - Land ownership certificate by the investor
  - No land that contains unique archaeological, historical, and/or cultural value/heritage
  - No land with a significant number of trees and/or forestation/vegetation. The logging of trees requires acceptable compensation measures (e.g., planting of new trees)
- When no ESIA is available as not needed for the project, the following information must be provided:
  - Current land use status as well as prior to project development.
  - Land/Property ownership certificate by the investor
  - Stakeholder awareness to project (nearest neighbors have been informed and relevant authorities).
- EHS during construction and operation, in particular, safe working conditions with electrical systems according to national norms and standards. This includes specific safety provisions such as safe and secure scaffolding, working platforms, fall protection, rubber mats, electric shock chart, first aid box, fire extinguishers, sand buckets, waste management for hazardous waste, transformers, and batteries. All personnel deployed are provided with basic training in first aid and firefighting.
- Complaint mechanism during construction, and for stakeholders.

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<sup>1</sup> While, according to current legislation, an ESIA is typically required only for projects with a size and land use greater than 500 kW, it is the applicant's responsibility to confirm whether or not an ESIA is required.

**Checklist of received documents**

Name of PV plant \_\_\_\_\_

N	Name of document	Received	Comments	Checked	Comments/remarks
1	Land coordinates	<input type="checkbox"/>		<input type="checkbox"/>	
2	Land privatization certificate for ground-based projects or rental agreement with permission to install the project of the landowner / Permission for rooftop installation	<input type="checkbox"/>		<input type="checkbox"/>	
3	1. Energy yield forecast / PVsyst or equivalent commercial simulation software. 2. Monthly load profile of own consumption based on existing data on demand (e.g., electricity bills) and / or plausible assumptions for new buildings / enterprises.	<input type="checkbox"/>		<input type="checkbox"/>	
4	Project description of the layout, civil structures, electrical and mechanical equipment	<input type="checkbox"/>		<input type="checkbox"/>	
5	Justification of structural design for foundations / rooftop installation and respective module mounting structures for the wind and snow resistance in the corresponding area/roof.	<input type="checkbox"/>		<input type="checkbox"/>	
6	Electrical single line diagram for DC single line, protections, switches, circuit breakers, cable specifications	<input type="checkbox"/>		<input type="checkbox"/>	



N	Name of document	Received	Comments	Checked	Comments/remarks
7	Technical details of the connection with the network, electrical single line diagram for AC single line, protections, switches, circuit breakers, cable specifications	<input type="checkbox"/>		<input type="checkbox"/>	
8	Technical specifications for PV modules (including PV module certificates)	<input type="checkbox"/>		<input type="checkbox"/>	
9	Technical specifications for Inverters (including Inverter certificates)	<input type="checkbox"/>		<input type="checkbox"/>	
10	PV DC cable certificates	<input type="checkbox"/>		<input type="checkbox"/>	
11	Official document from the distribution network operator or authority granting the connection to the network	<input type="checkbox"/>		<input type="checkbox"/>	
12	Cost Estimation	<input type="checkbox"/>		<input type="checkbox"/>	
13	Implementation Schedule	<input type="checkbox"/>		<input type="checkbox"/>	
14	Photos concerning the site and other structures	<input type="checkbox"/>		<input type="checkbox"/>	
15	O&M concept/budget	<input type="checkbox"/>		<input type="checkbox"/>	
16	Information on-site security (fence, security cameras, etc.)	<input type="checkbox"/>		<input type="checkbox"/>	
17	Information on Operation monitoring scheme	<input type="checkbox"/>		<input type="checkbox"/>	
18	Conclusion on the technical condition and durability of the roof	<input type="checkbox"/>		<input type="checkbox"/>	

