

## EMPLOYER REQUIREMENTS

"CONSTRUIRE PARC FOTOVOLTAIC, IMPREJMUIRE,  
BRANSAMENT ENERGIE ELECTRICA SI RACORDARE LA  
S.E.N."

ENGINEERING, PROCUREMENT AND CONSTRUCTION (EPC)  
FOR PHOTOVOLTAIC POWER PLANT

Project name: Turda Photovoltaic Power Plant

Project location: Turda, Cluj County, Romania

Beneficiary: RES INVEST SOUTH EAST EUROPE S.R.L.

Document version: 1.0

## GENERAL PROJECT INFORMATION

RES INVEST SOUTH EAST EUROPE SRL intends to build a grid-connected photovoltaic power plant on a land area located near the city of Turda. The Beneficiary has secured non-reimbursable funding covering part of the investment associated with this project under the *Modernisation Fund Programme*.

### 1 SCOPE OF WORK

#### 1.1 Scope of work

The scope of work consists of the turnkey construction of a photovoltaic plant with a total installed capacity of **minimum 50 MWp DC** and its Operation and Maintenance (O&M) for 2 years until the issuance of the Performance Certificate.

The installed alternating current (AC) capacity (in inverters and in transformer substations) is **29.4 MW (nominal value)** and **shall not be exceeded**.

The maximum power that can be injected into the Distribution Grid (RED) is limited to **29.4 MW**, in accordance with the provisions of the Technical Connection Approval (ATR) no. 6010221033781 dated 05.12.2023.

Due to the land category on which the PV project will be constructed (pasture), the project will have a dual use, combining electricity generation and grazing of sheep. The Employer provides a general layout as a starting point for the proposal, which may be optimized to achieve the best technical and energy performance.

The plant shall be designed, built and operated in a way to achieve the **maximum energy production**, and the best performance and reliability. The turnkey construction of the PV Plant and its Operation and Maintenance during the Defect Notification Period, will include:

##### EPC

- Complete PV System and Project Design and Construction
- Assistance to the Employer for any possible permit
- Mobilization
- Hydrogeological works
- Supply of all the components
- Civil & Infrastructure Design & Construction
- Mechanical Design & installations
- Electrical Design & installations
- Supply and installation of the Monitoring and SCADA systems
- Supply and installation of the Security and CCTV systems
- Testing, Commissioning, Operating and Maintaining the PV System and Project
- De-mobilization after completion of the Works as per the contract

The battery limit includes the PV plant, MV transformer stations, and medium voltage cables up to the Delivery Station. The 20/110kV Delivery Station itself is outside the EPC scope.

##### O&M

The scope of work of the O&M will be the proper functioning of the system as a whole, by ensuring:

- The guaranteed level of production, Performance Ratio and Availability;
- The preventive maintenance activities to be carried out in accordance with the Operation & Maintenance plan;
- The corrective maintenance including all the necessary components and labour to repair or replace any defective parts, and in general to ensure the correct operation of the PV Plant according to the guaranteed reaction plan;

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- The supply of all the components necessary for the proper maintenance of the PV plant;
  - The supervision and control of the system through remote monitoring and the reporting activity;
  - The landscaping maintenance;
  - The cleaning of the PV modules, at least 2 per year, during the Operation and Maintenance (O&M) Period (2 years until the issuance of the Performance Certificate;
  - Remote security service, based on video monitoring and sensors, with reporting and alarm in case of incident;
  - The assistance to the Employer in relation to any possible insurance and warranty claims.

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## 2 SITE

### 2.1 Site

The project site is located in the eastern part of Turda Municipality, Cluj County, Romania, between the cities of Turda and Câmpia Turzii. The land is situated within the administrative boundaries of Turda.

### 2.2 Access to the site

Access to the site is provided from the national road DN15, via Street Luncii, a local public road that leads directly to the project area. This access route ensures connectivity with major transportation infrastructure, facilitating the movement of construction equipment and materials during the implementation phase.

### 2.3 Soil erosion

The stability of the structures must be ensured for the entire lifetime of the PV plant. Also the good conditions of the soil have to be maintained during the project's lifetime, with particular attention to the drainage system of surface water that has to be designed and realized in order to avoid soil erosion and damages to the PV module structures. Water drainage works will be implemented as per the approved drawings.

## 3 TECHNICAL REQUIREMENTS

The section contains the technical requirements for the main installations and components. The quality of all the proposed components shall reflect the expectations of the Employer to reach a "best in class" photovoltaic plant.

IMPORTANT. The Contractor shall be responsible for the design, supply and installation of the MV equipment (transformer stations, MV and optical fibre cables), up to the connection interface inside the 20/110 kV substation, including the termination of the cables and their connection to the dedicated bay, in compliance with the applicable Romanian and EU regulatory requirements. In case these regulatory requirements differ from the technical specifications defined in this section, the applicable legal and regulatory provisions shall prevail. The Contractor shall prepare the necessary documentation to ensure full compliance with these regulations and avoid any issues or delays related to future grid connection procedures.

### 3.1 Civil works

#### Mobilization

The Contractor shall install all the temporary facilities needed for the construction period including:

- Temporary internal roads
- The own site office, adequately fitted for the operational work of their site management and supervision teams. The furnishing and internal setup of the Contractor's office shall be at their own discretion, according to their operational needs
- A separate site office container for the Employer, fully equipped and furnished, including Wi-Fi, a refrigerator, and a meeting table with chairs for at least 8 participants, to be used by the Employer during the construction period

- Toilets
- Kitchenette
- Infirmary
- Waste containers
- Storage containers

The space allocation of the facilities shall be defined in a specific drawing and approved.  
All temporary facilities are to be removed promptly after completion of the works.

#### Soil Preparation and earthworks

Before starting any activities on the site, it will be necessary to conduct a soil preparation in order to make the PV Area ready for the installation of the components, which basically consist of:

- Cleaning of the PV Field from existing obstructions, including rocks stones, vegetation (grass, trees and bushes);
- Levelling the PV Field in order to remove possible ground drifts, ditches and bumps that may create obstacle in the construction phase and if requested to design and built retaining walls
- Realization of water drainage system sufficient to avoid the soil erosion and to protect the modules structure, as per the approved drawings included in the Contractor's Tender
- All debris whether resulting from Construction or existing site debris, is to be loaded and removed away from the site.

#### Fencing

In order to ensure security all around the site and limit the possible vandalism acts, the Contractor will design, supply and install fences and gates with the following characteristics:

- Tubular profile poles 2 inches in diameter, pre bent, hot-dip galvanized steel mounted at a distance of max 3 m
- Foundations made in situ with holes filled with concrete diameter min30 cm, with a minimum depth of 60 cm or more if dictated by the soil investigation.
- Type of mesh: hot-dip galvanized steel.
- 3 rows of barbed wire in the upper side.
- Height: 2,5 m high;
- Lifetime: 20 years;
- Installation according with the local codes, anti-fire codes and insurance requirements;

The access to the PV field shall be ensured by gates positioned to allow entry into each of the three fenced areas of the site as in the provided layout, with openings of minimum 6 meters to facilitate the movement of construction and operational vehicles. The gates shall also allow internal circulation between the plots. A properly sized foundation for the gate's poles is required for stability.

The Contractor's design will ensure that fence and gates will limit as much as possible the shading of the modules.

#### Internal roads

- The PV plant will be equipped with a single type of internal road infrastructure, properly dimensioned and constructed to allow the transit of trucks and utility vehicles (max load 40 tons). These roads will ensure access between the gates serving each of the three fenced areas, as well as direct connection to the transformer stations and the delivery substation, supporting both construction and long-term operation activities.

#### Cable trenches

Electrical cables will be accommodated in special trenches, made as follows:

- Excavation of the trench, laying of the grounding cable and laying of a minimum of 15 cm of sand bed
- Trenches may have combined layers for MV, LV, (AC and DC) and data cables. MV cables shall lay at the bottom of the trench; on a minimum depth of 80 cm. LV cables shall be at minimum 25 cm above the MV cables, Data cables shall be at least 25 cm distance from the LV cables.
- The depth of the least profound cable shall be minimum 50 cm.
- Solar cables will be directly buried on a sand bed as described above.
- All cables can be directly buried, subject to the following conditions: (i) the cables are of armoured type, (ii) specifically manufactured and certified for direct burial, (iii) for each solar cable route, a spare conduit (empty pipe) shall be installed in parallel for possible future replacements.
- All buried cables, except for the grounding cable, shall be covered with a minimum of 10 cm of sand after installation, before any additional protective layers or backfilling.
- Backfilling of the trench shall include installation of a warning tape at least 20 cm above the sand covering the uppermost cable, extending across the full width of the trench. Compaction till the existing ground level. Trenches shall be **accurately** free of stones.

#### Cabin foundations

In the defined location for the Transformer Cabins, the Spare Part Container and the O&M Building, the following activities are required:

- Specific ground levelling of the designated areas in order to have a complete flat area;
- Verification of the soil resistance in order to assure the required loads of the Cabins (minimum 750 kg/sqm)
- Concrete foundation slab with steel mesh.

#### O&M Building Requirements

The O&M Building shall be adequately designed and constructed to reflect the surrounding architecture. It shall be a permanent masonry building of at least 40 sqm, accommodating the required operation and maintenance functions of the PV plant.

The building shall include at minimum:

- 1 control room for SCADA, monitoring and alarm systems;
- 1 office for O&M staff;
- 1 toilet with sanitary installation.

The Contractor shall also provide the necessary furniture and equipment for office and control activities (desks, chairs, cabinets, desktop computers). A UPS system shall be installed in the control room to ensure safe operation and shutdown of monitoring and alarm systems (minimum 60 minutes autonomy).

The building shall be provided with:

- Electrical connection of at least 32A at 230V AC;
- Electrical heating and cooling system;
- Water supply with a 1 m<sup>3</sup> reserve tank and a 2 m<sup>3</sup> septic tank;
- One dome camera integrated in the CCTV system;
- One desktop (connected to UPS, min. 60') to control all alarm and monitoring signals;
- One desktop for performance monitoring;
- Proper thermal and sound insulation.

All designs, calculations and shop drawing are to be submitted for approval.

### 3.2 PV Modules

The Contractor shall select the optimal variant of photovoltaic modules that would provide a reliable service of electricity generation for at least 30 years. The photovoltaic modules shall also be able to withstand local climatic and environmental conditions.

The following are the minimum requirements for the photovoltaic modules:

- The offered panels must be manufactured by a company included in the **Tier 1 list published by Bloomberg New Energy Finance (BNEF)** in at least one of the last three most recent quarterly reports available at the date of submission .
- **Power/capacity warranty:** minimum twenty-five (25) years from the warranty start date, at which time the actual power shall not be lower than 87.0% of the nominal power.
- **Module efficiency:** minimum 22.4%.
- **Product warranty:** minimum 12 years.
- **Nominal unit capacity of the photovoltaic modules:** 710 Wp or higher.
- **Type of photovoltaic panel:** bifacial.
- **Maximum Power Tolerance of the modules:** only positive tolerance for maximum module power is accepted, maximum +10 W or +3%, with a measurement tolerance of maximum  $\pm 3.0\%$ .
- **Module glass:** tempered glass, with a thickness of minimum 2.0 mm for both front and back sides, with anti-reflective coating.
- Compliance with at least **EN61215, EN61730 or equivalent** standards.
- **Ingress protection rating:** minimum IP67.
- **Shading resistance:** modules with at least three bypass diodes.
- **Fire protection class:** minimum fire protection class C is permitted, but offers with modules of fire protection class A will receive additional points in the technical evaluation. For class C modules, bidders shall include in their offer measures to compensate for the difference in risk and potential impact compared to class A configuration modules, based on a fire protection plan to be prepared by authorized third parties during the design phase.

Regarding the fire protection class, the classification shall be according to **IEC 61730-2 (or equivalent)**. In case the related certification is not available at the time of bidding, an alternative option can be accepted, namely that, at the time of submission, self-declarations shall be provided both by the Bidder and by the Manufacturer regarding the fire protection class, with the obligation that within a maximum of 10 calendar days from the bid submission deadline, the Bidder shall provide the Beneficiary with the required documents certifying the fire protection class, issued by an authorized certification body.

The following specifications of the photovoltaic modules must be indicated in the technical offer:

- Manufacturer of the photovoltaic panels
- Model and type of the photovoltaic module (bifacial)
- Maximum nominal/peak power of the photovoltaic panel
- Type and quality testing certificate of the panels (issued by an independent body), including the year of issue and the certifying entity
- Country of origin
- Datasheet of the photovoltaic panels attached to the offer

## Installation of PV Modules

The PV module installation manual will be provided by the manufacturer. The manual shall include all necessary requirements and specifications to ensure correct and safe module installation, including but not limited to:

- Types of mounting, with detailed physical requirements for securing mechanisms (e.g., anti-theft screws, clamps, dimensions, tightening torque, and specific locations), along with useful information such as:
  - recommended mounting types;
  - recommended spacing to ensure adequate air circulation;
  - Environmental restrictions or limitations, if any.
- Mechanical and electrical module configuration guidelines, covering aspects such as orientation (landscape or portrait), string and array sizing, grounding requirements, and others as applicable.
- In case special requirements in inverter selection and PV array groundings, these must be clearly specified within the installation manual.

The Contractor shall strictly adhere to the module's manufacturer concerning the installation and maintenance as detailed in the installation manual.

### 3.3 Inverters

The total installed power in the inverters shall be **29.4 MW (nominal value)** and shall not be exceeded, as it is limited by the ATR (Technical Connection Approval).

#### Minimum requirements for inverters

- **Product warranty:** minimum 5 years;
  - **Certification / accreditation requirements:** the inverter type must be accredited / certified by the relevant grid operators (the inverter models shall be included in the list of inverters published by the DSO DEER) in accordance with the applicable regulations;
  - **Service:** support/service team available in Romania;
  - **Efficiency:** minimum 98%;
  - **IP class:** at least IP65;
  - **Overvoltage protection:** at least category/type 2 surge protection on both the direct current (DC) and alternating current (AC) side;
  - **Operating conditions:** operating temperature range from -20 to +60/70 °C.
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- The inverters supplier has to approve the stringing chosen for the project. In some cases, special requirements related to the inverter (grounding, number of connected strings, number of modules per string, or other configuration constraints) are requested by the PV module manufacturers. If such case occurs, the Contractor has the responsibility to notify the Employer and to ensure that the special requirements are understood and satisfied. Inverters should comply with applicable international standards, safety regulations, Romanian and EU regulatory requirements, and any other local grid codes if applicable.
  - The inverters will be installed outdoors. The Contractor shall ensure proper protection against weather conditions by either: installing the inverters under dedicated canopies (roof structures) provided and dimensioned according to the manufacturer's recommendations or mounting the inverters at the end of PV rows, directly under the PV modules, ensuring adequate shading and protection from direct sun and rain exposure.



- A thermal analysis shall be performed to ensure that the chosen installation method maintains the inverter's operating temperature within acceptable limits as defined in the technical specifications.
- The installation must also guarantee easy access for maintenance and safe clearances for ventilation and cable management. Compatibility with transformer sizing must be ensured.
- The Contractor shall supply inverters with an extended manufacturer warranty of minimum 5 years. Proof of warranty and the scope of coverage must be included with the technical offer.

### 3.4 Mounting Structure

The metallic structure supporting the photovoltaic panels must meet the following requirements:

- **System type:** fixed-tilt mounting system Est-West;
- **Product warranty:** minimum 10 years provided by the mounting structure manufacturer;
- Design lifetime: the technical conditions used as input data for the sizing/design of the mounting structure shall ensure a minimum lifetime of 30 years.
- It will be made of steel using the hot-dip galvanizing process for anti-corrosion protection. The covering system must have a lifespan greater than 15 years, in accordance with Table 5.5 of GP121-2013.
- Corrosion protection class shall be selected according to the local environmental zone.
- Connections between aluminum and galvanized steel must be protected against galvanic corrosion.
- The foundations, the metal support structure for the panels, and all other civil works shall comply with the applicable Romanian technical legislation (laws, norms, and regulations) in force at the time of contract signing. If Romanian standards are insufficiently detailed, relevant international standards such as ISO may be used.
- The Contractor is free to define an adequate foundation system for the mounting structure. The foundations shall be designed in accordance with local construction standards, site-specific geotechnical conditions, and local snow and wind loads. The structural evaluation shall include the selection of permanent loads, snow and wind loads, seismic loads, structural dimensioning, foundation checks, member sizing, connection integrity, and temperature effects, all in compliance with applicable Laws and Standards.
- The mounting system must fully comply with the module manufacturer's specifications, including clamp size, torque values, and installation method.
- All cable contact points with the metallic structure shall be protected by edge-protection elements to prevent mechanical damage.
- The minimum clearance between ground level and the lower edge of the PV modules shall be **1.0 m**, +/-0.2m depending on local ground elevation (levellings). This clearance must ensure uniformity across rows, facilitate maintenance access, allow for proper ventilation, and comply with drainage and terrain requirements.
- Materials must be accompanied by the following documentation: Declaration of Performance, Declaration of Conformity, and relevant Technical Approvals.
- Product certificates must be submitted as part of the delivery documentation, which must also include the installation manual, mechanical tolerances, and recommendations for operation and maintenance.

### 3.5 Monitoring System

The monitoring system shall provide constant and full evidence of the plant's performances in order to optimize the energy output, detecting abnormal losses, and planning the preventive maintenance

actions. The Contractor shall provide a web-based monitoring system that complies with the requirements set below. The main standard applicable is the IEC 61724 .

#### General requirements

The monitoring system is in charge of recording meteorological and electrical parameters and status of the PV plant components. Continuous monitoring is required. The norm specifies that the sampling frequency has to be at least one minute for the parameters varying directly with the sunlight; up to 10 minutes is allowed for other parameters (e.g. temperatures, wind). The minimum data to be monitored are:

- DC current and voltage at least every 2 strings or as provided by inverter monitoring capabilities
- Inverters behaviour for each inverter:
  - DC current and voltage input
  - Output active and reactive power
  - Phase voltage and current
  - Energy output
  - Alarms and faults
- Meteorological data
- Energy output at the meter
- Status of the equipment (protection devices, inverters)
- Any other information which would be required by the laws and norms and grid code

#### Meteorological stations

The Contractor shall be responsible to erect at least one permanent meteorological stations for each 15 MWp, each in a different adequate position within the PV-plant's limits.

Meteorological station shall allow the measurement of parameters for a Class A system according to up to date specific IEC norms.

All type of meteorological variables, data processing and storage, has to provide versatility for communications, local and remote configuration and programming. Accordingly, open communication protocol shall be provided.

Station will be specially designed for outdoors installation.

Meteorological station shall accept signal from instruments in the following type:

- 0/4-20 mA current signal.
- 0-24 VDC digital input or output.
- Resistance and thermocouple signals.
- At least following interfaces and communication protocols shall be supported:
  - RS232
  - RS485
  - GSM/GPRS
  - TCP/IP
  - Modbus

The Contractor will provide and install the calibrated meteorological sensors according to the client's requirements which are:

- Ambient temperature

- Module temperature
- Solar radiation/ irradiation (tilt and horizontal)
- Wind speed

The Contractor has to provide the data logger and the installation of the interface to the Contractor's SCADA software system.

The client will receive an installation report of the data logger including the transfer function (only calibration parameters) of all meteorological sensors, programmed in the logger.

The client or an independent expert provided by Contractor, if requested by Beneficiary, has the right to check the programming of these parameters and provide a report regarding complete functioning of the meteo station and interconnection with SCADA system.

The Contractor's data logger and system must be able to communicate real-time data to the client for purposes of forecasting energy production and determination of compensation in case of disruption of energy delivery by either party.

#### Irradiance sensors (pyranometers)

The pyranometers will be installed in the plane of the modules, in a non-shaded area. Irradiance in the horizontal plane shall be measured as well. The uncertainties on the measurement (including signal treatment) should be at maximum +/-3% for hourly values and +/-2% for daily totals. The non-linearity error (sensitivity variation versus irradiation) shall not exceed 0.2%. Only measurements using pyranometers are accepted as reference sources. The pyranometers shall have at least the characteristics of a Class A pyranometer under **ISO 9060:2018**. The Contractor should provide the Employer with a calibration certificate from an independent laboratory for each sensor (as part of the as-built files). If signal cables of more than 50 meters have to be used, an adequate IP66 signal amplifier is required. This amplifier shall allow voltage input between -12 to +150 mV and current output between 4 to 20 mA. Signal accuracy shall be at minimum +/- 10  $\mu$ V. Pyranometers shall be secured with levelling screws or mounting rod to a SS-metal support with a good earth connection (e.g. by using a lightning conductor). The following minimal pyranometer's parameters shall be respected:

- Spectral range: 285 to 2800 nm
- Sensitivity: 7 to 14  $\mu$ V/W/m<sup>2</sup>
- Response time: < 5 s
- Directional error (up to 80 ° with 1000 W/m<sup>2</sup> beam): < 10 W/m<sup>2</sup>
- Temperature dependence of sensitivity (-10 °C to +40 °C): < 1 %
- Operating temperature range: -40 °C to +80 °C
- Field of view: 180 °
- Protection: IP67
- Non-linearity (sensitivity variation vs. irradiance): < 0.2%
- Non-stability (variation sensitivity/year): < 0.5%

#### Ambient and Module Temperature Measurement

Ambient air temperature has to be measured with a sensor having an accuracy of at least +/-1K (including signal treatment). The sensor shall be protected from direct sunlight to avoid over-heating effect that can influence the measurement accuracy. The sensor to measure the PV modules temperature shall be located at the back of a module, complying with the installation manual of the manufacturer. The uncertainties should not be more than +/-1K (signal treatment included). PT100 or PT1000 temperature sensors with a silicon body and auto adhesive are recommended. Temperature

range should be  $-50^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ . The location of the temperature sensors needs to comply with the installation manual of the manufacturer and the data should be transferred to the data logger. The installer shall provide the client with a calibration certificate from an independent laboratory for each sensor (as part of the as-built files).

#### Wind speed measurement (anemometer)

Wind speed shall be measured by an anemometer. The uncertainties of the measurement have to be less than 0.5m/s for wind speed up to 5m/s; for higher wind speeds, the uncertainties are to be at maximum  $\pm 10\%$  of the reading. The anemometer should be placed in accordance with the installation manual of the manufacturer. The Contractor shall provide the client with a calibration certificate from an independent laboratory (as part of the as-built files).

#### Datalogger

The datalogger collects the data from the photovoltaic installation. Fixed IP address making the datalogger permanently accessible from remote is preferred. In case of a dynamic IP address, the monitoring system should be combined with a Dynamic DNS (Domain Name Service). The Contractor is responsible for the synchronisation between the permanently accessible fixed domain and the updates of the network router. No land line is available on site. Therefore, the monitoring system is to be connected using a satellite link or 5G connection. The Contractor has to provide a complete folder for approval containing all the information and parameters such as proposed system schematic, technical characteristics devices, tools, software, access frequency and duration, security protocols, etc.). Data should be accessible 24hour/7day all year around remotely via a server. There should be redundancy in terms of communication lines and server, one being used as a backup if the main one fails. The data transmission has to be secured using a firewall or a SFTP server. The datalogger memory should allow the storage of 1 month of data.

#### Data recording and transmission

The format should be consistent with the norm IEC 61724, with numerical data written in single-byte ASCII code.

#### Data Treatment

Data measured and calculated have to be sent every 10 to 15 minutes to an FTP or SFTP server where they will be accessible. The time of the end of each period should be available and should refer to the local or universal time rather than solar time. Data quality has to be checked by comparing it to admissible maximum and minimum values. A variety of values can be calculated from the measured parameters as described in the norm IEC 61724.

The data is to be set available in the O&M Building as well as through an online platform, which can be accessed remotely at the offices of the Employer, on-site and by the O&M operators. The data is also to be available through mobile services (e.g. app for smartphones). The transfer of data is to be made using standardized protocols. The Contractor should take into account that appropriate training is to be provided to the representatives of the Employer in order to facilitate the use of the online platform to be able to collect the desired information.

#### Log Book

Documents specifying any event, incident, component replacement, calibration, maintenance actions, cleaning... shall be kept updated. The logbook shall be kept electronically and shall be remotely accessible from the Employer.

#### IT-Infrastructure

Contractor will deliver, install and put in service a desktop computer in the O&M Building to run the necessary software for the monitoring and the site surveillance as well as for the data storage.

### 3.6 Cables

#### General

The cables used in the photovoltaic power plant shall be designed and installed to ensure reliability and safety throughout the entire lifetime of the plant. They must:

- Withstand severe environmental conditions, including high temperatures, pre-clamping stress, and ultraviolet radiation;
- Be rated for the system voltage and comply with the applicable standards;
- Be installed strictly in accordance with the manufacturer's requirements and the design conditions used in the sizing calculations;
- Be dimensioned so that the combined DC and AC cable losses do not exceed **2.5%** of the transmitted energy.

#### DC cables

The DC cabling of the photovoltaic plant shall comply with all applicable IEC/EN standards and ensure reliable operation over the full lifetime of the plant. Minimum requirements are:

- **Voltage and insulation:**
  - The maximum DC system voltage shall not exceed the cable's rated DC voltage (1.5 kV DC in accordance with IEC 62930;
  - Cables shall have double or reinforced insulation (Class II) in accordance with SR HD 60364-712;
  - Flame retardant according to IEC 60332-3-24.
- **Environmental resistance:**
  - Designed to withstand temperatures from -40°C to +90°C;
  - UV and ozone resistant (HD 605/A1);
  - Minimum service life of 25 years.
- **Design characteristics:**
  - Copper conductors with minimum cross-section of 6 mm<sup>2</sup>;
  - Copper, class 5 flexible conductors per IEC 60228
  - Nominal voltage rating of 1.5 kV;
  - Minimum bending radius four times the cable diameter (or manufacturer's specification).
- **Installation requirements:**
  - DC cables shall be used for:
    - Interconnecting PV modules;
    - Connections from PV modules to inverters.
  - Installed in conduits and protected cable trays, with return paths routed together to avoid induction loops;
  - Losses in DC cabling shall not exceed **1%** at 80% I<sub>sc</sub>.
  - Cables and connectors shall be TÜV-certified and fully compatible with the proposed PV modules and connectors (IEC 62852)

#### DC connector type

The DC connectors shall comply with **IEC 62852 (MC4 type or fully compatible)**, ensuring safe and reliable connection of the DC circuits.

Connectors shall be **UV- and ozone-resistant**, rated for at least the same operating temperature range as the connected cables ( $-40^{\circ}\text{C}$  to  $+90^{\circ}\text{C}$ ), and shall provide a **minimum ingress protection of IP67**. All connectors shall include a **mechanical locking system** preventing accidental or unintended disconnection during operation or maintenance.

The use of mixed connector brands is not permitted unless certified compatibility is provided by the manufacturer.

#### AC cables

All AC cables shall comply with the relevant IEC/EN standards and shall be suitable for direct burial or ducted installation, depending on the final design.

They shall be designed to ensure long-term operational reliability and minimize energy losses.

The alternating current cables will be used for:

- connections between the inverters and the LV/MV transformer stations,
- connections between the transformer stations and the 20/110kV Delivery Substation,
- power supply for outdoor lighting and auxiliary equipment, depending on the final design.

#### Low Voltage (LV) Cables

- LV cables shall be aluminium or copper conductors, with XLPE insulation and PVC sheath, reinforced, and with delayed flame propagation.
- LV cables shall be terminated using proprietary crimped lugs compliant with IEC 61238-1.
- LV cables shall comply with IEC 60502-1 and relevant IEC/EN standards.

#### Medium Voltage (MV) Cables

- MV cables shall be single-core aluminium or copper conductors, with XLPE insulation, copper wire screen, and PE outer sheath, flame-retardant and suitable for direct burial.
- Rated voltage: 12/20 (24) kV ( $U_0/U_n/U_{max}$ ).
- MV cables shall be delivered in one continuous length without joints, unless otherwise approved.
- MV cables shall comply with IEC 60502-2 and with all applicable Romanian standards and regulations in force.
- Each cable type shall be factory-tested in accordance with IEC 60502-2 (routine, sample, and type tests)

#### General Requirements

- All AC cables shall be installed underground, in direct burial or protective conduits, depending on design.
- **Backfill material** shall be free of sharp stones and compacted to prevent settlement
- **Warning tape** shall be laid above buried cables at approximately 30 cm above the cable crown
- The combined AC cable losses (LV and MV together) shall not exceed 1.5% of transmitted power.

#### Cables identification

All cables, including DC, LV, MV, and control cables, shall be assigned a unique identification number. Each cable reference shall appear in the Cable Schedule and on the Single Line Diagrams.

Cables shall be clearly identified at both ends with robust, UV-resistant and weatherproof identification tags, showing the cable reference number.

Tags shall be installed at each termination and, for underground routes, at intermediate points (every 10 m or at each junction box).

For multi-core cables, each core shall be individually identified and labelled.

All phase conductors shall be colour-coded and identified at each end in accordance with IEC 60446 / HD 308.

## Cables implementation

The Contractor shall install all cables in accordance with the approved Cable Route Layouts and Method Statement for Cable Laying, ensuring protection against mechanical, thermal and environmental stress for the entire service life of the plant.

- Cable entries to all external equipment shall be through weatherproof glands (minimum IP67) suitable for the specific cable diameter and material.
- Conductors with a cross-section larger than 1.5 mm<sup>2</sup> shall be stranded copper or aluminium in accordance with IEC 60228 (Class 2 or 5).
- All cables shall be properly supported, restrained and protected to prevent mechanical or thermal damage.
- Segregation between power and control cables shall be maintained at a minimum distance of 250 mm, unless separated by metallic partitions or conduits.
- All ducts shall be sealed after installation with expanding or fire-rated materials to prevent ingress of water, dust, gas, or vermin.
- Cable entries through building walls shall be made using proprietary cable transit systems (e.g. Rextec, Hilti, or equivalent), fully sealed after installation.
- Buried cables shall comply with local regulations regarding trench depth, warning tape, protective layers and mechanical protection. Unless otherwise specified, minimum cover depth shall be 800 mm with a warning tape at 300 mm above cable crown.
- The Contractor shall ensure full compliance with IEC 60364-5-52, EN 50565, and national standards for underground electrical installations.

## Signal List

The Contractor shall be responsible for preparing and submitting the complete signal list for all interfaces between the Photovoltaic Power Plant and the Substation SCADA system. The signal list shall include all analogue, digital, and status signals required by the Network Operator and shall be prepared in coordination with the Employer and the Substation EPC Contractor/owner.

- The signal list shall be delivered in tabular format (Excel or CSV) and include at least: Signal name, type, direction, origin/destination device, protocol, scaling, and alarm classification.
- All proposed signals shall be reviewed and approved by the Employer prior to commissioning.
- Analogue signal cables shall have each pair individually screened and an overall outer screen.
- Digital signal cables shall have an overall screen only.
- Screens shall be connected to earth at one end only (normally the SCADA/control building side).
- Control and signal cables shall comply with IEC 60332-1, with flame-retardant, halogen-free sheath.
- All signal wiring and terminals shall be clearly identified and referenced to the approved Signal Mapping Matrix.

## 3.7 Transformer stations

The Contractor shall supply, install, test and commission the transformer units (stations) completely equipped with:

- Power transformers(20/LV kV)
- Auxiliary services panel
- LV Electrical Panel for inverter connection
- RMU
- Auxiliary transformer of xxx kVA, LV/0,4 kV, dry type;
- UPS -230 Vac/48 Vdc;



- Dataloggers;
- RTU/PLC and communication system equipment for integration into SCADA
- Surge arresters and earthing bar for connection to the site grounding system.

The MV units of the transformers will be equipped with numerical terminals that meet the functions of command, control, protection (TNP&CC) and which will be integrated in SCADA.

The station shall provide individual disconnection capabilities for both RMU incoming lines as well as the MV power transmission line, overcurrent and short circuit protection as well as grounding facilities.

The equipment shall meet following requirements as a minimum:

- Meeting the local and international requirements for over-current protection, over and under voltage protection, short circuit protection, earth leakage protection, circuit breaker and AC fuses
- Meeting the requirements of grid operator according to low/medium voltage guidelines.
- The product certificates must be submitted as part of the delivery documentation which also include the installation manual and recommendations for operation and maintenance.
- Comply with IEC 60076, IEC 62271-200, IEC 60529, and other relevant local standards.

The following documents shall be submitted as part of the delivery package:

- Type Test and Routine Test Certificates for all major equipment (transformer, RMU, LV panel, UPS, etc.);
- Product data sheets and certification of conformity;
- Installation, operation and maintenance manuals (in English and local language);
- Factory Acceptance Test (FAT) and Site Acceptance Test (SAT) procedures and reports.

### 3.8 CCTV, Alarm System and Lighting

In order to strengthen the security on site, a fence intrusion protection system or IR or radar protection system and a video-surveillance system, all accessible and controllable via internet is required. Signals generated by the fence protection, the IR or radar system, the video surveillance and intrusion systems will be processed by a central controller generating alerts, alarms, acoustic messages, site lighting activation, alarm messages to the security intervention team.

Following are the requirements for the security system:

#### Video surveillance

The video-surveillance system provider must be able to provide maintenance (to the video surveillance system) and caretaking contracts. The Contractor should ensure a 24hour/7day all year functioning of the system with an on-call duty for solving issues with the video surveillance equipment. The repair time should be at maximum 1 business day. Maintenance actions have to be carried out regularly depending on the system needs. The Employer is to be informed of the tasks carried out and added to a logbook.

During construction, the Contractor is responsible for on-site security and should take adequate measure to ensure this.

The video surveillance system shall comply with IEC 62676 standards.

#### Lighting



An appropriate fence perimeter LED lighting along the entire perimeter of the fences, the gates and the O&M building is to be installed. The O&M building will be equipped with led lights. The system shall automatic switch on in case of alarm or manually for interventions.

Luminaires shall comply with IEC 60598-2-5, rated IP65 minimum, with colour temperature  $\approx 4000$  K and CRI  $\geq 70$ .

## 4 DOCUMENTATION

The Contractor shall provide a complete set of documents for review covering the design, installation, commissioning, maintenance and operation of the works. The Contractor shall incorporate the Employer's comments into the documents and re-issue where requested. All documentation shall be submitted via a transmittal sheet to record issue and receipt. All documents shall be submitted in Romanian. All documents shall be submitted in hard copy (3 copies) and electronic format. The hard copies shall be sent to the Employer's representative site office. All drawings shall be in Romanian and made in accordance with the IEC/ISO drawing standards. Metric units of measurement (SI) shall be used. Drawings shall be provided in pdf and source format (e.g. AutoCAD). All documents or drawings shall demonstrate clear compliance with the requirements of the Contract. Documentation requested by Authorities will be presented in the local language.

### 4.1 Executive project

Following the signature of the Contract Agreement, the Contractor shall prepare all the designs, calculations, workshop drawings, documents, details, material submittals and samples needed for the installation of the PV Plants and all Civil and Infrastructure items. The documentation required is that described in the table below. Unless otherwise described all submittals shall be in (1) soft & (2) hard copies.

Nr	Name	Type	Description
D1	Layout	Technical drawing	Layout of the PV plant with: <ul style="list-style-type: none"> <li>Unambiguous localisation and labelling of strings, arrays and inverters, wiring, combiner boxes, transformer substations, delivery station etc.</li> <li>Localisation and dimensions of obstacles.</li> </ul>
D2	Single line diagram	Technical drawing	Complete identification of : <ul style="list-style-type: none"> <li>Number of modules per string.</li> <li>Labelling of all strings, arrays, inverters.</li> <li>Earthing, DC and AC cabling and cable conducts: length, cross-section, type.</li> <li>Protection devices, combiner boxes, switches, inverters, transformers.</li> <li>Metering equipment.</li> <li>Monitoring equipment.</li> <li>Security equipment.</li> </ul>
D3	Structural plan	Technical drawing	<ul style="list-style-type: none"> <li>Technical drawings of the structural fastening of the PV modules into the ground/ onto the buildings.</li> <li>Identification of the type of profiles, screws, clamps.</li> <li>Calculation note or analysis of the stability of module mounting structures.</li> </ul>
D4	Product quantification	Bill of materials	Estimated quantities per product.
D5	Product information	Technical data sheets	Technical data sheets are provided for (at least): PV modules, DC cables, protection devices, inverters, MV transformers, switches, monitoring equipment.
D6	Product certification	Certificate	Product certificates are provided for (at least) the PV modules, the inverters and the islanding protection.
D7	Product guarantee	Contract	Definition of product guarantee on (at least) PV modules, inverters, transformers and monitoring equipment

D8	Project plan and organisational chart	Project documentation	<ul style="list-style-type: none"> <li>General description of project management.</li> <li>Identification of project manager (curriculum vitae).</li> <li>Identification of all subcontractors (company presentation).</li> <li>Specific references of project manager and all subcontractors.</li> <li>Gantt chart of the project planning.</li> </ul>
D9	Monitoring plan	Project documentation	Description of the parameters monitored, the monitoring frequency, the storage capacity, the data flow model and the user interface.
D10	Preventive maintenance plan	Project documentation	Description of the preventative maintenance actions foreseen and their frequency.
D11	Corrective maintenance procedures	Project documentation	Description of the corrective maintenance procedure for the most likely random failure.
D12	Design note structural stability	Design documentation	Calculation note with respect to the stability of the structure, on which the installation is built (buildings, land, etc).
D13	Design note PV sizing	Design documentation	Calculation note with respect to PV sizing and expected system yield and performance ratio.

## 4.2 Documentation required prior to the Commencement date

The Contractor shall provide the following documentation:

- Executive design for the project as above described
- Project Baseline Program (including a resource plan with the number and definition of workers, machineries and equipment installed on a weekly basis)
- Health and Safety & Environment Plan
- The QA manual including the project QA / QC Plan
- The Inspection and Test (ITP) plan.
- Proposal for the Weekly report and the Action Plan (for the definition of all actions needed to achieve the weekly goals or to solve topics)
- All needed certifications and permits for the Contractor, Subcontractors and specialised workers to work on the site
- Site Waste Management Plan
- Method Statements for all major activities (civil works, foundations, equipment installation, cabling, testing and commissioning)
- Risk Assessment / Hazard Analysis for site works
- Lifting and Transport Plan for heavy equipment (e.g., transformers, switchgear)
- Commissioning & Testing Procedures, including FAT, SAT and PIF methodologies
- Training Plan for Employer's personnel in operation and maintenance activities
- Emergency Response Plan (fire, oil spill, electrical accident scenarios)
- Document Control Plan, describing the workflow for submission, revision and approval of project documentation

The Contractor shall also submit detailed design, specifications and calculation information for review and approval by the Employer. A design review meeting will be held by the Employer and Contractor to formally review the detailed designs. The documentation for design review shall be made available at least two weeks prior to the design review meeting. The complete list of documents is defined in this section.

## 4.3 Documentation required prior to any inspection at factory or testing on site

No later than prior to any testing on Site, the Contractor shall submit Testing Plans for the works. At least 14 days prior to any factory or witness testing of equipment or systems, the Contractor shall notify the Employer of the time, date and location of the tests and submit the testing procedures. All costs associated with the Contractor's attendance at factory tests shall be borne by the Contractor.

#### 4.4 Documentation required prior to Provisional Performance Test

At least 7 days prior to the requested beginning of the Tests on Completion, the Contractor shall provide draft versions of the following documents for review:

- Safety File
- Operation & Maintenance Manuals
- Maintenance schedule including intervals
- As-Built Drawings
- Site Testing Acceptance reports
- List of PV modules flash test
- Calibration certificates of the meteorological sensors and meters
- Datasheet of the components installed
- Factory Testing of the electrical equipment

The Take Over Certificate will not be issued until final versions of these documents have been received to the satisfaction of the Employer. All as-built documentation submitted by the Contractor shall include a drawing naming and numbering system and title block to the satisfaction of the Employer.

#### 4.5 Documentation required prior to Intermediate Performance Test and Performance Test

At least 14 days prior to the relevant Test date, the Contractor shall provide draft versions of the following documents for review:

- Safety File
- Operation & Maintenance Reports
- Production during the previous year
- Calculation of the PR in the previous year
- Calculation of the availability in the previous year

#### 4.6 Training Requirements

The Contractor shall provide comprehensive training and technical support to the Employer's staff to allow him to adequately operate and maintain the PV Plant. The courses shall be targeted at different levels of personnel, including plant operators and specialist maintenance personnel. Dates for training shall take place prior to Performance Test and every 4 months during the Defect notification period. The training programme shall include:

- Theoretical introduction to commissioning and test programs.
- Practical introduction to the correct use of maintenance manuals.
- Fault finding.
- Safety features of the power plant.
- Safe operation of power plant.
- Protection equipment.
- Theory and practice of electrical power system.
- Operational activity that is permissible by the Employer's personnel, during the warranty period.
- Safe methods of isolation of equipment for maintenance.
- Description of the electrical system including details of MV, LV and data cable routes.
- Location of plant and equipment including points of isolation and earthing.
- Identification of protection relays and equipment.
- Review of protection relay settings.
- Description of interface with any existing substation equipment and with the utility grid.

- Safe operation, safe access, maintenance of nominal and safe performance where special procedures are required which would not be familiar to experienced, qualified/registered personnel.

The Contractor shall provide comprehensive course notes and shall include 'hands-on' practical sessions on the Works. Operating and technical manuals, including drawings shall also be provided to accompany the training. Training manuals shall be provided to all delegates attending training courses. The manuals shall be developed specifically for the Works and shall be specific to the level of training provided to the course delegate. The training manuals shall be developed in sections, reflecting the course structure and shall be developed in a manner that will provide the delegate with a quick reference guide to the various aspects of the system following the course. The Contractor shall provide written certification for personnel who complete the course to the required standard.

## 5 INSPECTIONS AND TESTING

The Contractor shall be responsible for the factory inspections of the Material and for the site testing of the Works supplied under the Contract. A testing plan covering factory inspection and site testing shall be provided by the Contractor detailing all proposed equipment and system testing. The test methodology and parameters shall be clearly defined in the testing plan. Following each test, a report shall be provided confirming that the test was successful and fully detailing the test results. Upon request, Factory Inspection of the components will be organized in presence of the Employer representative. Once the installation is achieved, Pre-Commissioning Test will be carried out. Successful of this initial phase will allow to proceed with the energisation from the Grid of the facility and with the Commissioning Test and with the Trial Operations. This last will be organized as per the guidelines of IEC 62446 and will include a Performance Ratio test for a period of at least 14 days. Tests after Completion procedure also will follow the IEC 62446 and will be divided in 2 stages: the Intermediate Performance Test and the Performance Test. The intermediate Performance Test will involve checking module reliability and defects and an analysis of the Key Performance Indicators (Production, Performance Ratio, Availability) of the first 12 months after Taking Over Certificate. The Performance Test will be implemented 12 months after the conclusion of the Intermediate Test. The Performance Test will include a verification of the Key Performance Indicators on top of any contractual aspect required for an orderly conclusion of the contract. The next paragraphs describe the specific requirements for each test and protocol.

### 5.1 Factory Inspections

#### General

All of the equipment supplied under this contract shall be factory tested prior to shipment. Testing shall be carried out by the Manufacturer in accordance with the relevant IEC standard. Prior to any testing, copies of the proposed test procedure shall be provided by the Contractor for Employer's review. The Employer may elect to attend to have an own representative at the factory testing at no additional cost. No equipment shall be released for shipment to site until all defects identified during the factory test are rectified.

#### PV Modules

Evidence of a recent positive assessment of the PV Modules Manufacturer's Quality System is to be provided by the Contractor. The objective is to evaluate the ability of such manufacturers to produce PV modules of the same quality to those that have been submitted and passed certification and compliance tests. The Contractor will provide an attestation by an independent third party that such

an assessment is or was performed, at max 12 months prior to the prospected delivery date of the modules. The modules supply or purchase agreements (e.g. contract documents) shall contain detailed technical specifications and agreed warranty terms and conditions. The Contractor will provide evidence of such specifications and warranties. Upon delivery of the modules to Site, the Contractor shall submit the flash data for each PV module at STC (flash reports) in electronic format (Excel file). The Contractor shall provide a summary spreadsheet, containing the summary of all the spreadsheets and the full installed capacity. Modules are expected to be packed in vertical to avoid micro-crack damage, during transportation.

Compliances and certifications (e.g. IEC or ISO) themselves are typically not adequate to validate, if a group of PV modules are technically suitable for use in certain PV installations. In order to mitigate the quality risks, additional due diligences are required.

The Employer may require the following due diligence measures to be allowed by a representative of the Employer:

- PV module inspection at manufacturing point: factory inspections at the factory involved in the production of the batch for this project, in order to ensure compliances to good manufacturing practice and quality systems.
- PV module acceptance before shipping:
  - Review of electrical performance IV-flash test data (see below for contents).
  - IV-flash measurement and visual inspection of a randomly sampled small population of the delivered PV modules (test of 200 modules to be foreseen).
  - Small sample tests in accordance to IEC standards' environmental tests (UV-exposure, thermal cycle, damp heat and humidity freeze) and quality inspection (electroluminescence).

The total costs of the audit to make this additional due diligence are at charge of the Contractor.

For each PV module delivered for the projects, a comprehensive IV flash test data collected during the module fabrication (in excel format) must be provided. The data must have the following information:

- Serial number of the tested module, including which modules are in which shipping containers and pallets.
- Power at maximum power point (Pmpp).
- Voltage at MPP (Vmpp).
- Current at MPP (Impp).
- Open circuit voltage (Voc).
- Short circuit current (Isc).

This information shall be provided the latest 2 weeks prior to the arrival of PV modules on the site, in order to enable the Contractor to plan or change the program development and assembly based on the type and quantity of modules, in the containers they are delivered in.

#### Circuit Breakers

Factory testing on circuit-breakers shall include:

- Pressure and tightness test
- Functional check of wiring and auxiliaries
- Adjustment of set points and auxiliaries
- Lowest operating voltage of close and trip coils
- Resistance of the main circuit

- Power frequency withstand test
- Overpressure test on each pole
- Tightness test on each pole
- Mechanical operations test
- Timing test of the main contacts
- Timing test of the auxiliary contacts

#### Voltage

Transformers Factory testing on VTs shall include:

- Pressure and tightness test
- Power frequency withstand test
- Partial discharge test (<5pC)
- Verification of terminal marking
- Determination of Errors

#### Current

Transformers Factory testing on CTs shall include:

- Pressure and tightness test
- Power frequency withstand test
- Partial discharge test (<5pC)
- Capacitance Measurement on Capacitive Tap
- Measurement of Dielectric Dissipation Factor
- Secondary Resistance Measurement
- Inter-turn Overvoltage test
- Verification of terminal marking and turns ratio test
- Determination of Errors
- Verification of secondary EMF
- Secondary magnetizing current characteristic

#### Disconnect and Earthing Switches

Factory testing on outdoor disconnects and earthing switches shall include:

- Functional check of wiring and auxiliaries
- Adjustment of set points and auxiliaries
- Lowest operating voltage of close and open coils
- Resistance of the main circuit
- Power frequency withstand test
- Mechanical operations test

#### Surge Arresters

Factory testing on outdoor surge arresters shall include:

- Measurement of the reference Voltage
- Residual Voltage test
- Partial Discharge test (<5pC)
- Leakage test
- Current distribution test

- Measurement of the continuous current at continuous operating Voltage

#### MV Switchboards & RMUs

Factory testing on Switchgear and RMUs shall include:

- Mechanical functional test of all components including mechanical interlocks.
- Electrical functional test of all control and protection wiring against the approved switchgear schematics.
- Power frequency overvoltage test on the switchgear including circuit-breakers in the test circuit.
- Low resistance conductor test on the switchgear including circuit-breakers in the test circuit.
- Secondary injection test on all protection relays to confirm satisfactory operation of the protection scheme.
- Routine tests for all CTs and VTs including confirmation that ratio and errors are within IEC tolerances.
- Primary injection of all CTs and VTs to confirm ratio and polarity.
- Magnetisation curve tests for all CTs.
- The overvoltage and secondary injection tests shall be repeated once the switchboard has been installed at site.

#### Transformers

The following factory tests shall be undertaken on each of the following type of transformers supplied by the Contractor as part of the Works:

##### Unit Substation Transformers

The testing described below shall be performed, as a minimum. (The Employer may waive the requirement to conduct non-routine tests if the Contractor can provide independently witnessed type test certificates for the exact same tests conducted on an identical design.)

Routine tests as per IEC 60076 including applied and induced overvoltage tests, measurement of no load and load losses, impedance and resistance of the windings, confirmation of the vector group and megger testing (HV-E, LV-E and HV-LV).

##### Auxiliary Transformers

Routine tests as per IEC 60076 including applied and induced overvoltage tests, measurement of no-load and load losses, impedance and resistance of the windings, confirmation of the vector group and insulation resistance testing (HV-E, LV-E and HV-LV).

#### Low Voltage Distribution Boards

Factory testing on distribution boards shall include:

- Mechanical functional test of all components including mechanical interlocks.
- Electrical functional test of all control and protection wiring against the approved switchgear schematics.
- Power frequency overvoltage test (flash test) on the switchgear including circuit-breakers in the test circuit.
- Low resistance conductor test on the switchgear including circuit-breakers in the test circuit.
- Visual inspection.

## 5.2 Tests on Completion

Tests on Completion are formed by:

- Pre-commissioning Tests

- Commissioning Tests
- Trial period

### **Pre-commissioning Test**

Site tests shall be undertaken on all systems and equipment installed as part of the Works. The Contractor shall provide test sheets for each item of equipment/system, for each stage of testing. These sheets shall list all the tests to be undertaken and shall record the results.

### **General Services**

General services shall be tested and certified in accordance with the verification requirements of the Romanian electrical installation regulations. For any aspect not covered by the Romanian regulations, the requirements of IEC 60364 (Low Voltage Electrical Installations) shall be applicable.

### **Earth Resistance**

Following installation of each earth grid, and prior to interconnection to any remote earth conductors, resistance measurements at each grid location shall be conducted. A test method in accordance with the Generator Supplier's requirements is required. Where the Generator Supplier does not specify a particular method, the fall of potential method or slope method shall be used. The Contractor shall submit his proposed test procedure to the Employer for comment at least 14 days prior to the commencement of the tests.

### **Control & Instrumentation**

All control and instrumentation wiring shall be checked against the relevant schematic diagrams. All wiring shall be point to point checked. Insulation resistance tests shall be conducted on important circuits (e.g. CT and VT secondary's, trip circuits, etc.). All signal cabling shall be tested in the signal range expected. No earth faults shall be present on the control and instrumentation cabling following completion of testing.

### **MV Cables**

After installation and termination, and prior to connection to the respective items of equipment and to the unit substation transformers, the following tests shall be conducted:

- Continuity test of conductor and screen.
- Confirmation of phasing.
- A 5 kV Megger insulation resistance test (core to screen/core to earth) on each length of cable with recording of all results including confirmation of cable phasing and continuity of conductor and screen. The minimum acceptable Megger reading is 500 MegaOhm.km.
- A Megger insulation resistance test between screen and earth (sheath test). The test voltage shall be according to the IEC standard or as otherwise agreed with the Employer. The minimum acceptable sheath test reading is 500 MegaOhm.km.

After all MV cables have been terminated, the Contractor shall perform a Very Low Frequency (VLF) over-voltage test on the complete MV system, including the MV cables and the individual unit substation RMUs. The test voltage shall be at least  $2xU_0$  where  $U_0$  is the operating phase to earth voltage of the collector system. Following each high voltage test, verification shall be made that all equipment and cables have been adequately discharged to safe voltage levels.



## LV Cables

After installation and termination, but prior to connection to the respective items of equipment the Contractor shall perform: A conductor continuity and phase identification test. Insulation resistance tests on each length of cable, at the following voltage levels:

Circuit Nominal Voltage	Test Voltage dc (V)	Minimum Insulation Resistance (MΩ)
SELV and PELV	250	0,25
Up to and including 500V, but excluding the above	500	0,5
Above 500V	1.000	100

## MV Switchboards & RMUs

Switchgear commissioning shall include:

- A full mechanical functional test of all components including mechanical interlocks.
- A full electrical functional test of all control and protection wiring against the approved switchgear schematics.
- A power frequency overvoltage test (conducted at 80% of the factory test) on the switchgear including circuit-breakers in the test circuit.
- Insulation resistance test
- Final torquing of the primary circuit, and a low resistance conductor test on the switchgear including circuit-breakers in the test circuit.
- Secondary injection shall be carried out on all protection relays to confirm satisfactory operation of the protection scheme.
- Primary injection of all CTs and VTs to confirm ratio and polarity.
- Injection testing of interface protection witnessed by the appropriate representative from the relevant Grid Company.

## Transformers

Transformer commissioning shall include:

Visual inspection, alignment, earthing, labelling, etc.

- Functional check of all wiring against the approved transformer schematics.
- Testing and calibration of all transformer protection and monitoring devices.
- Insulation resistance test (HV-E, LV-E, HV-LV).
- Functional test of off-circuit tap changer and check of the continuity of all windings.
- Turns Ratio test
- Winding resistance test
- Oil sampling and off site testing of same.

## Circuit Breakers

Site testing on outdoor circuit-breakers shall include:

- Functional check of all wiring, interlocks, auxiliaries and pressure devices
- Timing test and travel curve
- Current profile and minimum operating voltage of open and close coils
- Quality test of insulating gas
- Final adjustment of set points

- Check of all interfaces with substation (control, trips, position indication, etc.)
- Resistance test of primary contacts (conductor test)
- Insulation resistance test
- Visual inspection

#### Voltage Transformers

Site testing on VTs shall include:

- Polarity test
- Ratio test
- Insulation resistance test
- Primary injection
- Secondary injection of secondary circuits
- Visual inspection

#### Current Transformers

Site testing on CT's shall include:

- Magnetisation curve verification
- Ratio test
- Polarity test
- Winding resistance test
- Primary injection
- Secondary injection of secondary circuits
- Visual inspection

#### Disconnect and Earthing Switches

Site testing on outdoor disconnects and earthing switches shall include:

- Functional check of all wiring, interlocks and auxiliaries
- Alignment of primary contacts
- Current profile and minimum operating voltage of open and close coils
- Final adjustment of set points
- Check of all interfaces with substation (control, commands, position indication, etc.)
- Resistance test of primary contacts (conductor test)
- Visual inspection

#### Surge Arresters

Site testing on outdoor surge arresters shall include:

- Insulation resistance test
- Verification of leakage meter/surge counter
- Visual Inspection

Busbars and Supports Site testing on outdoor busbars shall include:

- Insulation resistance test
- Resistance test of all connections (conductor test)

- Check of clearances
- Visual inspection

Relay Testing Site testing on protection relays shall include:

- Secondary injection test using the final protection settings
- Functional test of protection scheme
- Check of tele protection / interface with remote equipment
- Check of interface with SCADA equipment

Distribution Boards Site testing on distribution boards shall include:

- Mechanical functional test of all components including mechanical interlocks.
- Electrical functional test of all control and protection wiring against the approved switchgear schematics.
- Power frequency overvoltage test (flash test) on the switchgear including circuit-breakers in the test circuit.
- Low resistance conductor test on the switchgear including circuit-breakers in the test circuit.
- Visual inspection.

### **Commissioning Test**

Commissioning Tests will be carried out to verify the capacity of the PV plant to inject the energy produced into the grid under several conditions. The test procedure will also be agreed with the constructor of the 110/20 kV Connection Station and the Distribution/Transmission System Operator (only for tests requiring interface with the grid connection)..

#### *Electricity Distribution Grid Code Compliance Tests*

These tests are required to be completed before the power plant can be deemed Grid Code compliant. It is the responsibility of the Contractor to manage the delivery of a Grid Code compliant power plant, including management of the grid code compliance testing process and agreement and provision of any interfaces with the Connection Substation Contractor and the Grid Operator, as applicable. In advance of actual Grid Code compliance testing with the Grid Operator, the Contractor shall complete a series of pre-tests to ensure that Grid Code compliance can be achieved and to avoid any non-compliances during the Grid Operator test. The Works shall be deemed to have passed these tests when written confirmation is received from the Employer based on Grid Operator/Connection Substation Contractor acceptance. These tests shall commence as soon as reasonably practicable after completion of the Works and their successful completion is one of the pre-conditions for the Taking Over.

#### *Operational Tests following the energization of the PV Plant*

Operational Tests following the plant energization will follow IEC 62446 Edition 1.0 2009-05 ("Grid connected photovoltaic systems – Minimum requirements for system documentation, acceptance tests and inspection"), where tests require synchronization with the MV/HV connection substation, the Contractor shall coordinate and align testing procedures with the Connection Substation Contractor.

This standard is based on:

- IEC60364;

- IEC/TR 60755:2008;
- IEC 61557 (all parts);
- IEC 61730-1.

#### Verification

Before the Provisional Performance tests can start, the following steps have to be validated:

- Initial verification to verify that the requirements of IEC60364 are met;
- Inspection according to IEC 60364-6 ("Low-voltage electrical installations – Part 6: verification") including at least :
  - System designed according to IEC 60364-7-712;
  - Class II on DC side;
  - DC components sized for continuous operation at 1.25.Isc and for  $V_{oc} \leq 1500$  V (IEC 60634-7712.433:2002);
  - Double insulated cables so that to achieve IEC 60364-7-712.522.8.1:2002 and to limit earth fault and short-circuits;
  - Wiring part designed to resist to specific environmental requirements (IEC 60 364-7712.522.8.3:2002);
  - Verification of the module overcurrent protection (IEC 60634-7-712.433:2002);
  - Presence of a DC switch connector on the DC side (IEC 60364-7-712.536.2.2.5:2002);
  - Verification of the adequacy of the blocking diodes (IEC 60364-7-712.512.1.1:2002);
  - Verification of the earth connection as in IEC 60364-7-712.312.2:2002;
  - Protection against overvoltage/electric shock;
  - Verification of the AC system;
  - Verification of the labelling and identification.

Verification scope applies to PV plant equipment and cabling up to the delivery point at 20 kV switchgear inside the Connection Substation.

#### Testing

The testing has to be done in accordance to IEC60364-6 and includes:

- Tests of all the AC circuits;
- Verification of the continuity of protective earthing and/or equipotential bonding conductors;
- Polarity tests;
- String open circuit voltage test;
- String short circuit current test;
- Functional tests;
- Insulation resistance of the DC circuit. An IR camera inspection can be carried out to detect potential temperature-related issues in the modules and cabling. It is not mandatory but recommended as it allows detecting at an early stage defects on the materials. Lastly, a Performance and Availability Verification is to be performed according to the procedure for a period of at least 15 consecutive days.

Testing of AC circuits beyond the 20 kV delivery point is excluded and falls under the Connection Substation Contractor's scope.

#### Trial Operations

Once the commissioning tests are complete and the facility is energised through the 110/20 kV Connection Substation, a Trial Period of 14 days will start for the verification of the Performance Ratio and its compliance with the contractually guaranteed PR value (see par. 8.3 for Performance Ratio

measurement and acceptance procedures). Upon positive completion of the Trial Period a Take Over Certificate is released.

### 5.3 Tests after Completion

Once the Taking Over Certificate has been issued, the Defects Notification Period starts. The period ends with the issue of the Performance Certificate. During this period 2 different Tests will be carried out:

- The Intermediate Performance Test will start after the issue of the Taking Over Certificate and will end 12 months after (see par. 8 for performance measurement and acceptance procedures). Upon positive completion, an Intermediate Performance Certificate is released by the Employer.
- The Performance Test will start after the issue of the Intermediate Performance Certificate and will end 12 months after (see par. 8 for performance measurement and acceptance procedures). Upon positive completion, a final Performance Certificate is released by the Employer.

#### Intermediate Performance Test

Production, Performance Ratio and Availability verifications will be performed according to the procedure specified in Chapter 8 at the end of a period of 1 year from the Take-Over Certificate.

A visual inspection of the modules is executed to check for any defects.

A thermal analysis is made for at least 10% of the modules to check for hot spots. If this analysis shows that more than 1% of the panels have an error (non-working cell (s) and/or cell(s) with a hot spot), then the Contractor will organise a new flash test carried out on a number of panels for each type. It is up to the Contractor to determine this number of flash tested panels but the outcome of the statistical sampling must have to demonstrate that the probability of a type I error (the probability to accept the panels on basis of a statistical trial despite that the mean value of the power of the population is lower than the peak power of the panel type) is less than 5%. The peak power will be determined by taking into account a decrease of the power of 0,6%/y. If it appears that the population will not pass the statistical test, the manufacturer will verify by measurement the declared flash value of all panels and non-conforming panels will be replaced at his expenses.

The Intermediate Performance Test scope applies only to the PV Plant. Where verification requires energy injection into the grid, the Contractor shall coordinate with the Connection Substation Contractor.

#### Performance Test

The Performance Test period will start after the issue of the Intermediate Performance Certificate. During the final Performance tests, all remarks made during Provisional and Intermediate Performance tests are verified for the full implementation of the respective corrective actions.

Production, Performance Ratio and Availability verifications as described in the subsequent Chapter 8 will be performed after a period of 1 year from the Intermediate Performance Certificate.

The Performance Test shall cover the PV Plant performance up to the 20 kV delivery point. Coordination with the Connection Substation Contractor is required only for measurements or verifications involving the injection point to the grid.

Minimum requirements for Performance Certificate

The Performance Certificate will not be issued until all of the minimum requirements listed in below have been met:

- Training of Employer's Personnel is completed
- Tests After Completion have been successfully done meeting the minimum Guaranteed Production, Performance Ratio and Availability over the periods of analysis.

## 6 COMPONENTS WARRANTIES

### 6.1 PV Modules

The PV module manufacturers at present day, generally, offer two types of standard warranties: product and power warranty.

Product warranty warrants that the modules are free from defects in materials or workmanship. The definition of defects in materials or workmanships shall be clearly defined. The compensation for defective products shall be clearly defined (replacement, repair or financial compensations). The warranty shall also include the factory-assembled DC connector and cables. A warranty period of at least 12 years is required.

Power warranties guarantee certain percentage of power output during certain period of time. The definition of a reference output power must be clearly defined. The measurement shall be conducted under Standard Test Conditions (STC). A power output warranty, being 92% within 12 years and 85% within 25 years with a linear/yearly degradation, is the minimum required. The date the warranties start and defect notification period are critical and must be defined clearly. The effective start date is usually the date of sales, date of invoices or date of shipment. The Contractor shall ensure that any claims are executed by taking into account the defect notification period. The involvement of an independent test party such as Fraunhofer ISE (Freiburg, Germany), TUV Rheinland (Cologne, Germany), or other international institution in case of technical disputes during the warranty claim is required. The warranties offered by the module manufacturers shall be in the name of the Employer. Other terms and conditions for warranties transferability must be defined clearly. The contract sales agreement with the module manufacturer is expected to define clearly the claiming procedure of defect modules, the required additional specific independent party involvement and any other conditions that might influence the honouring of the warranties. Finally, the conditions which void the warranties shall be clearly stated (e.g. mishandling of modules, etc.).

### 6.2 Inverters

Inverters should have at least a 5-year standard warranty. The contract sales agreement with the inverter manufacturer has to clearly define the claiming procedure of defect inverters or parts, the required additional specific independent party involvement and any other conditions that might influence the honouring of the warranties. Any extension and the full scope of that extension to the standard limited warranty - included in the price - should be indicated. Finally, the conditions which void the warranties shall be clearly stated (e.g. mishandling of inverters, installation in extreme salt conditions etc.).

### 6.3 Other components

The Contractor is expected to provide warranties for all the components provided and for the works. Warranties requested are:

- 10 years for the metal structure
- 20 years for solar cables
- 5 years for the transformers
- 2 years for the rest of the PV components
- 2 years for the installation

The PV plant components manufacturer warranties, and particularly for the PV modules and the inverters shall be in the name of the Employer; defect notification period must be taken into account in the Contractor warranties period determination and will be responsibility of the Contractor; the repair or replacement of any defective PV plant component(s) shall reset the beginning of the Contractor warranty period for the specific component(s).

## 7 YIELD ANALYSIS

The Contractor shall provide a 1-year production estimation – hourly based - assuming an exceedance probability of P95. The meteo data source, must be a source with at least 10 years of relevant data for a location not further than 50 km away from the site or with interpolated values specific to the site. The accuracy of the meteo data source must be proven by literature. The meteo data source must be able to provide an average expected yearly irradiation value and the yearly climate variation or year to year values. The system shall be simulated in PVsyst.

The Contractor is requested to calculate an estimated production forecast for the first year and for the 24 following years, taking into account degradation and availability (both) as guaranteed in the Contract.

The following losses are required for the simulation:

- Far shading loss (horizon line)
- Soiling losses
- Near shading losses (obstacles, buildings, trees, etc.)
- Snow losses
- Reflection
- Irradiance dependencies
- Quality related losses (related to product variance)
- Temperature dependencies
- Spectral dependencies
- Mismatching
- Cabling (DC as well as AC)
- Inverter losses
- Transformer losses
- Auxiliary consumption losses

The analysis shall contain also the calculation of the Performance Ratio (PR) of the PV plant. Production and PR estimated for the first year shall be split by single months.

### 7.1 Degradation

The value of the degradation is set to no more than 0,7% per year.

## 8 GUARANTEED PV PLANT PERFORMANCE

### 8.1 Introduction to the Key Performance Indicators and Acceptance Procedure

The following sections will include the definition of the Acceptance Procedure with the parameters and the formulas that will be used for the measurement of the Performances of the PV Plant and the calculation of the Liquidated Damages in case of Performance Shortfall. The following Performance Indicators will be considered:

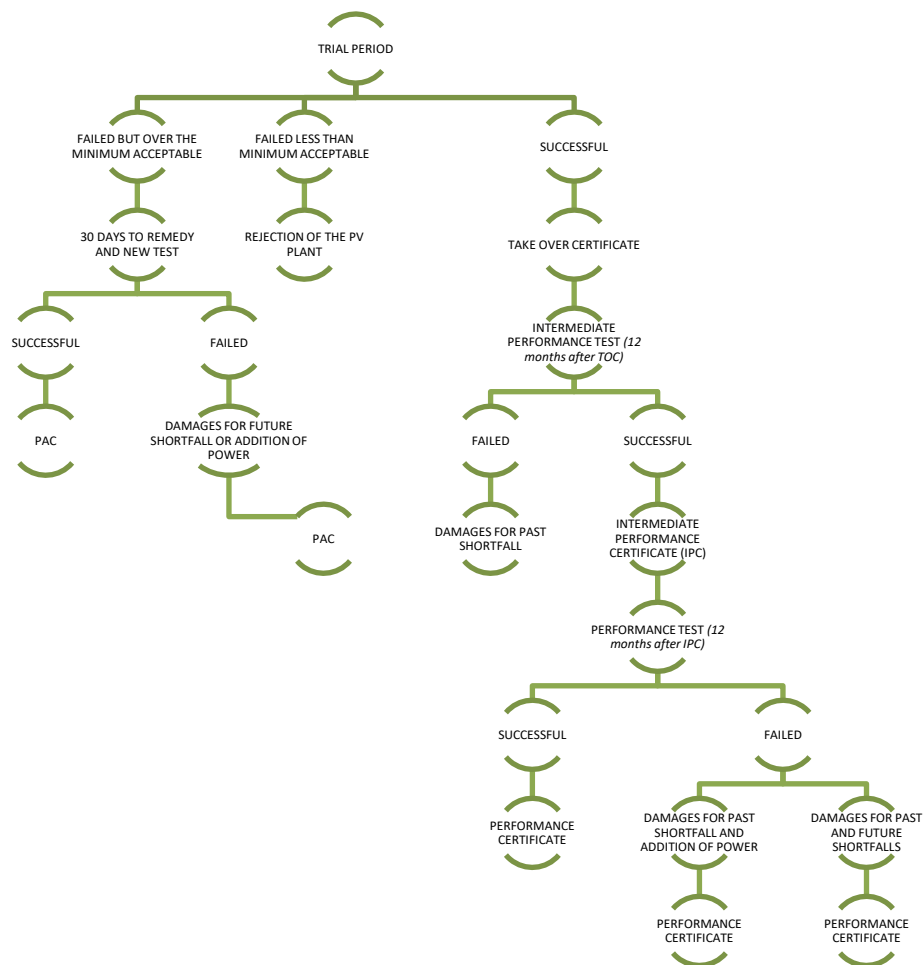
- Production
- Performance Ratio
- Availability

For each of the above and for the different tests where the above will be used, the Contractor commits (see Contractor's Tender) on Minimum Guaranteed Values ( $PROD_{GUAR}$ ,  $PR_{GUAR}$ ,  $AV_{GUAR}$ ) as defined in this document.

For each of the above indicators, Effective Values at any relevant moment will be calculated according to the formulas detailed below ( $PROD_{EFF}$ ,  $PR_{EFF}$ ,  $AV_{EFF}$ ).

At any relevant test, possible Performance Shortfalls ( $SHF_{PROD}$ ,  $SHF_{PR}$ ,  $SHF_{AV}$ ) will be calculated and will be  $>0$  when an Effective Performance for any of the indicators will prove lower than the related minimum guaranteed value. All performance shortfalls will initially be expressed in kWh, resulting from the formulas described in the relevant paragraphs of this chapter.

The value of the Liquidated Damages will be calculated considering only the highest between  $SHF_{PROD}$ ,  $SHF_{PR}$ ,  $SHF_{AVL}$  and associating an economic value to each kWh equal to the average energy price over the previous 12 months on the Day-Ahead Market (DAM), based on published OPCOM data, prior to the date of the relevant test.



## 8.2 Production

### Definition



The Production is defined as the total amount of energy delivered to the 20 kV Delivery Point in 1 year, expressed in kWh, as recorded by the Delivery Point meter at 20 kV.

Minimum Guaranteed Production ( $PROD_{guarYn}$ )

The Minimum Guaranteed Production in the Year N (1, 2) will be equivalent to the result of the following formula:

$$PROD_{GUARYN} = PROD_{YN} - EXCL$$

where:

- **N** = Number of the reference year
- **EXCL** = the hourly generation profile shall be used as reference for the calculation of the kWh to be excluded per each hour of duration of the following:
  - Restriction in grid connection (grid connection injection limitations, failure of the grid, defaults in grid connection point)
  - Force Majeure

Example:

$$PROD_{GUARY2} = 10798000 - 120000 = 10678000 \text{ kWh}$$

Where EXCL in the example above is assumed to be the result of 200 hours of exclusions.

Effective Production ( $PROD_{EFF}$ )

Effective Production will be evaluated against Guaranteed Production at Intermediate Acceptance Test and at Performance Test, subject to the average recorded irradiation of the reference 1 year period being higher than 1300 kWh/m<sup>2</sup>. For the purpose of clarity, the evaluation of the Effective Production against the Guaranteed Production (and consequent possible Performance Shortfall damages) will **NOT** be implemented in the following case:

- Recorded yearly irradiation on the modules plane lower than 1300 kWh/m<sup>2</sup>

For the purpose of the Intermediate Performance Tests, the Effective Production is defined as the total energy expressed in kWh that has been injected into the 20 kV Delivery Point, as recorded by the meter installed in the delivery station in the year elapsing between Take Over Certificate and the Intermediate Performance Test.

For the purpose of the Performance Tests, the Effective Production is defined as the total energy injected into the Delivery Station as measured by the meter at 20kV in the year elapsing between Intermediate Performance Certificate and the Performance Test.

### 8.3 Performance Ratio

Definition

The performance ratio (PR) is defined according to the standard CEI EN 61724 (CEI 82-15) as:

$$PR = \frac{Y_F}{Y_R}$$

The value for  $Y_f$  is calculated by the equation:

$$Y_F = \frac{E}{P_N} \quad (\text{kWh/kWp})$$

where:

- $Y_F$  = final PV System yield
- $E$  = System net AC energy output in kWh as measured by the Delivery Point meter at 20 kV. (if this last is provided by the Contractor)
- $P_N$  = System nominal power in kWp

and:

$$Y_r = \frac{H}{G}$$

where:

- $Y_r$  = reference yield
- $H$  = total in-plane irradiance in kWh/m<sup>2</sup> being the average of the solar irradiance as measured by the pyranometers installed.
- $G$  = reference irradiance (1 kW/m<sup>2</sup>)

At any relevant PR Test, the Guaranteed Performance Ratio (PR<sub>guarYn</sub>) will be calculated according to the following formula:

$$PR_{GUARYN} = (PR_{GUAR} - (100\% - AV)) - EXCL$$

where:

- **EXCL** = 0,0258% per each hour of duration of the following:
  - Restriction in grid connection (grid connection injection limitations, failure of the grid, defaults in grid connection point)
  - Force Majeure

Example;

$$PR_{GUARY2} = (78,7\% - (100\% - 99\%)) - 0 = 78,7\% - 1\% = 77,7\%$$

Minimum Acceptable Performance Ratio ( $PR_{ACC}$ )

The Minimum Acceptable Performance Ratio is the minimum value that has to be achieved at the PAC in order to avoid the rejection of the PV Plant. The value shall be calculated deducting 2.8% from the monthly PR as per the PVSYST table.

Effective Performance Ratio at Trial Period ( $PR_{EFFTP}$ )

During the Trial Period Tests, the effective PR will be measured during a period of consecutive 15 days, subject to:

- at least 9 out of the 15 days resulting in a daily irradiation level > 2300 Wh/m<sup>2</sup>
- no interruption in the regular system functioning

Should the above conditions not be satisfied, the period will be extended to the next days satisfying the conditions until a total of 15 test days will be achieved. The PR at PAC will be computed as follows:

$$PR_{EFFPAC} = \frac{Y_f}{Y_r} \quad (\text{kWh/m}^2)/(\text{kW/m}^2)$$

The  $PR_{EFFPAC}$  must be higher than the reference PR of the month when the test has been performed as per the table included in the PVSYST analysis. In case the average temperature during the test will

differ more than 15% from the temperature of the correspondent month as per the below table, a temperature coefficient to adjust the  $PR_{EFFPAC}$  shall be introduced.

Monthly Reference Temperatures table:

Month	Reference T (°C)
January	-1
February	0
March	5
April	10
May	15
June	20
July	25
August	27
September	22
October	15
November	7
December	2

Effective PR at Intermediate and Final Performance Tests ( $PR_{EFFIAC}$  and  $PR_{EFFAC}$ )

The effective PR at the Intermediate at Final Performance tests is defined as follows:

$$PR_{EFF} = \frac{\frac{E}{P_N}}{\frac{IRR_{AVG}}{G}}$$

where:

- **$IRR_{AVG}$**  = the average value of the solar irradiation measured by the pyranometers installed in the PV Plant during the relevant Test period (1<sup>st</sup> and 2<sup>nd</sup> year after PAC for Intermediate and Performance Tests).  
For the provisional acceptance test  $IRR_{avg}$ =Annual PVsyst reference -2%  
If data from different pyranometers differ >3%, then only the highest value will be considered.

## 8.4 Availability

### Definition

The availability of the system is defined as the total time of proper functioning of the inverters in a given period, expressed as a percentage of the total time when the same inverters should be fully functional within the same period. An inverter is defined as “properly functioning” if its total energy output in a given period is not less than 4% lower of the energy output provided by the highest producing inverter of the same type and model in the same PV Plant. In the Effective Availability formula as described in the relevant section, the specific load of each inverter is taken into the account.

### Minimum Guaranteed Availability

The Minimum Guaranteed Availability is 99,0%.

### Effective Availability

The effective PV Plant availability ( $AV_{eff}$ ) is calculated as follows:

$$AV_{EFF} = \frac{(PROD_{EFF} - INV_{SF})}{PROD_{EFF}}$$

where:

- $INV_{SF}$  = the sum of every production shortfall of any inverter (kWh), when differences with the highest-producing inverter of the same type and model is >4%. Production values from inverters connected to a limited number of PV Modules, and hence connected to a load being lower than their nominal load, will be compared to a fraction of the reference highest production being proportional to the connected load.
- Potential shortfalls to Inverter Production that are created from a cause that can be clearly attributed to the Grid Operator (grid outages, continuous overvoltage or undervoltage incidents, etc) in case they are duly documented and justified will be excluded from the calculation of the  $INV_{SF}$ .
- The Contractor commits to keep a daily record of the production data in kWh of each inverter as shown in the Monitoring System. Such records in the form of a complete yearly report will be provided to the Employer prior to the Intermediate Performance Test and prior to the Performance Tests.
- $PROD_{EFF}$  = Effective Production in the reference year

## 8.5 Performance shortfall

### Production shortfall ( $SHF_{PROD}$ )

Possible performance shortfalls related to Production will be evaluated at the Intermediate Performance Test and at the Final Performance Test. The value of the Shortfall is calculated in kWh according to the formula shown below:

$$SHF_{PROD} = PROD_{GUAR} - PROD_{EFF}$$

### Performance Ratio shortfall ( $SHF_{PR}$ )

Possible Performance Ratio shortfall is calculated according to the following formula:

$$SHF_{PR} = (PR_{GUAR} - PR_{EFF}) * IRR_{AVG}$$

Availability shortfall ( $SHF_{AV}$ )

Possible performance shortfalls are calculated in kWh according to the formula shown below:

$$SHF_{AV} = (AV_{GUAR} - AV_{EFF}) * PROD_{EFF}$$

## 8.6 Liquidated Damages for Performance Shortfalls

Possible Performance Shortfalls related to Performance Ratio will be evaluated during the Trial Period.

Possible Performance Shortfalls related to Production, Performance Ratio, Availability, will be evaluated at the Intermediate Performance Test and at the Performance Test.

In case of multiple Performance Shortfalls in the same Test session, liquidated damages will only apply to the highest Shortfall value. The value of the highest Shortfall expressed in kWh will be multiplied by the corresponding price of the electricity (€/MWh) recorded on the Romanian Day-Ahead Market (OPCOM) during the relevant Test period.

The formulas for the calculation of Liquidated Damages are:

$$LD = SHF_{HI} * EP$$

where:

- $SHF_{HI}$  = the highest SHF (PROD, PR, AV) in kWh
- $EP$  = Average electricity price (€/MWh) on OPCOM DAM during the Test period

At the **Provisional** and at the **Performance Tests** (in this last case as an additional liquidated damage), in case of shortfalls in PR the formula below will apply:

At Provisional Performance Test:

$$LD_{PR25Y} = SHF_{PR} * EP_{AVG} * 25/2$$

At Performance Test:

$$LD_{PR23Y} = SHF_{PR} * EP_{AVG} * 23/2$$

where:

$EP_{AVG}$  = Average of the Electricity Price in the remaining years to get to 25 from Take Over Certificate, calculated with an inflation of 3% (starting from electricity price recorded on the Romanian Day-Ahead Market (OPCOM) during the relevant Test period.

- $/2$  = Actualization

As an alternative to the payment of these last Liquidated Damages, the Employer and the Contractor may agree that additional capacity is installed – sized as deemed necessary to cover the Performance Shortfall – at the expense of the Contractor.

## 9 OPERATION AND MAINTENANCE SERVICES

The following is applicable for the duration of the Defect Notification Period until the issuing of the Performance certificate.

### 9.1 Mobilisation Services

Mobilisation services, to be completed by the time of the Take Over Certificate, shall include:

- Recruitment and training of personnel and subcontractors dedicated to the O&M services;
- Procurement and mobilisation of plant resources and equipment including additional spare parts.
- Observing and assisting with the commissioning and testing of the Plant

### 9.2 Planned Maintenance Services

Prior to Take Over Certificate, the Contractor shall prepare and submit to the Employer for review and approval an Annual Maintenance Plan, which shall detail the Contractor's provision of planned maintenance and a description of the Services to be performed during such planned maintenance, including the dates of the Services planned over the following Year. The Annual Maintenance Plan shall include the minimum activities and related frequencies recommended by the manufacturers in their respective operation and maintenance manuals.

The planned maintenance activities shall include, at a minimum, the following ones:

- Modules cleaning 2 times / year
- Visual inspection of all Modules, to include:
  - Verification of DC current using automated testing and further visual inspections in the field as necessary;
  - Visual search for possible glass breakage or physical damage to modules,
  - Inspections for any deformations or damage of the Module MC4 connectors, due to the high contact resistance caused by poor tightening of an electrical terminal.
  - Check for proper functioning of the fixation to the mounting structure.
- Visual inspection of the electrical connections of the inverters panel cabling to include:
  - Confirmation of the tightening and of the status of the terminals of the inverters panel-connection cables.
- Visual and mechanical inspection of all mounting structures including inverter racks. The Contractor's technician will tour the site looking for issues at least monthly. Inspections will include;
  - Visual search for impacts, corrosion, the condition of the protective paint, the absence of pooled water, etc.
  - Visual and mechanical inspection of the posts, tables, tilt brackets.
  - Visual inspection of the condition of galvanized and/or painted surfaces, and also of the foundation structures and possible deformations of the materials.
  - Verification of cleanliness of the rails and cable trays.
- Maintenance of the Inverters as recommended by the equipment manufacturer to include as appropriate;
  - General observation of the condition and operation of the Inverter.
  - Confirmation of the cabling and the connection of the components.
  - Confirmation that the Inverter is operating properly
  - Confirmation of the operating temperature at normal ambient temperatures.

- Planned change of components as required by Inverter manufacturer specifications and operating manuals.
- Verification of cleanness, ventilation, and cleaning of the air filters (if applicable).
- Inspection and subsequent tightening of the screw joints of all of the components,
- Visual inspection of the grounding contacts, the plates, and the output level control, in relation to electrical erosion and discoloration.
- Reading the loss and failure memory.
- Test of the operation of the input power switch
- Electrical Facilities
  - Confirmation of the electrical protective devices as recommended by the equipment manufacturer
  - Annual confirmation of the mechanical condition of the cables and terminals, plates, junctions, connections, and cleaning (including the grounding infrastructure – wires, test wells, lightning protection and grounding plates).
  - Annual maintenance of the transformer stations, the protection stations, the distribution stations and the medium voltage boards (transformers, boards, circuit breakers, protective devices, fans/extractors, fuses, capacitors, etc.).
- Inspection of the civil works (internal roads, gates, fencing, drainage systems).
- Inspection of any building or similar structure, including the operating and maintenance building.
- Annual maintenance of the safeguard/monitoring, communications, and safety/security systems.
- Annual maintenance of the SCADA/monitoring infrastructure, including PLC (Programmable Logic Controller) panels, all internal structural and support components, power supply, interface, logic and controller devices, monitoring devices and sensors via automated testing.
- Completion of the maintenance activities required by the components' manufacturer
- Maintenance of any emergency batteries that may be present.
- Maintenance of any device compliant with health and safety procedures (fire extinguishers, danger signals).
- Maintenance and calibration of meters as required by Applicable Law.
- Monthly cleaning and maintenance of the weather station – including structural and all power and control wiring, temperature sensors). Should remote analysis highlight a defective or soiled meteorological sensor this will be corrected promptly.

### 9.3 Corrective Maintenance Services

The Contractor shall promptly intervene in case of any fault and/or damage on specific equipment and/or to a combination of equipment in order to solve promptly the fault/damage. Corrective Maintenance shall be performed either during the planned maintenance visits or when the remote monitoring system indicates the existence of a functional problem or when the Contractor will acquire the knowledge of the problem from a different source (the Employer or other). This service will include:

- Analysis of the problem, also through site visit of the Contractor's staff equipped with the adequate tools and test equipment needed. The Contractor shall commence remote investigation of the failure within 24 hours and an initial report should be provided to the Employer as soon as reasonably practical and a detailed root cause analysis report to be provided to the Employer as soon as possible in case of relevant events.
- The removal or elimination of the defective equipment or component, and their reconditioning and return to the manufacturer through the Contractor's staff and/or third-party electrical subcontractors as needed.
- The transport of the corresponding replacement parts, up to and including their installation and assembly, within the times indicated in the following paragraph 9.11 (Response Time)



- The usage of the same equipment or component or equivalent previously installed in the Plant. In case of usage of equivalent equipment or component, a written approval from the Employer is needed, which shall not be unreasonably withheld, the Contractor will provide updated manuals and any modified as built documentation to the Employer as appropriate.
- The Contractor will supply directly, or via third party vendors, spare parts for use at the Plant.

## 9.4 Monitoring Services

### Remote Monitoring

The Contractor shall provide remote monitoring capability on a twenty-four (24) hour a Day, seven (7) Days a week basis via the Data Monitoring System. It being agreed and understood that portions of such remote monitoring will be performed through unmanned computer systems, including near real time: performance and remote event notification, weather conditions, plant equipment performance, electrical generation, operating parameters and other key operating metrics.

### Alarm and Notification Protocol

The Contractor and the Employer shall mutually establish the Employer's alarm and notification protocol, on the basis of the fault codes and the information available via remote monitoring to be agreed, which shall address the Employer's preferences for alarm notifications of its operations personnel, including the best methods for communications (cell phone, email and other means of communication).

### Data Storage

- All performance data retrieved from the Data Acquisition System will be stored and backed up by the Contractor's field data storage warehouse.
- All performance data will be archived by the Contractor for a period commencing on the term of the EPC Contract and ending on the date that is one (1) year from the date of termination or expiration of the EPC Contract.
- Upon request of the Employer, the Contractor will deliver all the archived data in a CSV format.

### Monitoring Systems

The Contractor will ensure that critical field device sensors calibration is performed as required to ensure the integrity of the system data. A backup of all critical site tags (unique field data points) are backed up and maintained on the data warehouse. The Employer has access to key data via the Data Monitoring System.

## 9.5 Plant performance analysis

- The Contractor will ensure a consistent and complete electronic recording of any maintenance, operations or other data in order to allow the full evaluation of the Plant performance (Power production, Performance Ratio, Availability as described in par.8)
- The Contractor shall be responsible for correcting Plant performance issues and directing appropriate actions in relation to troubleshooting issues for the Plant. The Contractor shall execute repairs and troubleshooting in relation to Plant performance issues which are within the scope of the Contract.
- The Contractor shall develop standard operating procedures and safety protocols
- The Contractor will make recommendations as part of the performance reporting process for any changes, adjustments or modifications that should be made to the Plant.

- The Contractor shall provide detailed performance and diagnostics information to aid in the detection and resolution of all performance and/or technical issues.

## 9.6 Reporting

Contractor shall be responsible for the weekly and annual performance reporting for the Plant. Reports shall be generated by Contractor from the Site data residing in Contractor's data storage warehouse.

Content of Report:

- Weekly Report metrics:
  - Weekly actual energy output;
  - Year-to-date actual energy output;
  - Weekly inverter availability;
  - Year-to-date inverter availability;
  - Weekly performance ratio;
  - Weekly actual irradiation on the modules' plane;
  - Year-to-date actual irradiation on the modules' plane;
  - Relevant alarm logs.
  - Weekly Report summaries:
    - Forced outage log and description;
    - Description of major maintenance activities and events including completed work orders;
    - List of Employer's Inventory used;
    - Failure analysis reports, as necessary; and
    - Relevant alarm logs.
- Annual Report
  - A summary of the weekly reports along with annual totals for the performance metrics.

## 9.7 Spare Parts Inventory Management

Employer's Inventory

Contractor shall manage the Employer's Inventory through periodic audits (such periods to be determined by Contractor, but at least quarterly) and shall store such Employer's Inventory at the Employers onsite storage facility.

Contractor's Inventory

In addition to the Employer's Inventory, Contractor may maintain an inventory of any additional spare parts and consumables as necessary or appropriate in Contractor's discretion to facilitate the performance of the Operation and Maintenance Services. Contractor may store such additional inventory of spare parts and consumables at the Employers onsite storage facility or at any other location from which it can service the Site. All such spare parts and consumables, other than the Employer's Inventory, are and shall remain the sole property of Contractor until such time as the same may be incorporated into the Plant.

## 9.8 Other Services

The following are included as Operation and Maintenance Services:

- Cleaning of the array / Modules at least 2 times per year
- Vegetation control at the Site to avoid impact on the electricity production of the Plant and/or on the health and safety conditions of the Plant;
- Pest, rodent and animal control within the Site boundaries;

- Waste, garbage and dumping disposals that is not directly a result of Contractor provided services;
- Maintenance and cleaning of the roads within the Site boundaries in order to maintain functionality;
- Site security;
- Maintenance of the availability of the telecommunications and remote data access systems installed by the Contractor.

### 9.9 Safety Program

The Contractor shall implement an effective and compliant Health, Safety and Environmental (HSE) Program to ensure the safety and integrity of persons and equipment at the Site. Detailed lock out/tag out procedures along with risk analysis and assessment methods shall be developed and implemented for all Site activities.

### 9.10 Provision of Personnel

- The Contractor shall recruit, interview and hire qualified personnel to meet individual plant staffing needs.
- The Contractor shall provide technical training for all staff to ensure that each is competent and qualified to perform as required in their job function.
- The Contractor shall provide all personal protective equipment, tooling and testing equipment needed for each employee to function effectively in their duties.

### 9.11 Response Time

The Contractor shall ensure that any defect, shortcoming and/or fault that occurs to the Plant as a whole during the period of the Operation and Maintenance Services are promptly dealt with and repaired in accordance with the list of reaction/remedy times depending on fault type/equipment stipulated below from the time on which the defect, shortcomings and/or faults occur as communicated to the Contractor by his personnel and/or the Engineer. Below, an indicative list of response times is provided; this list shall be updated and finalized by the Contractor after the completion of the design:

Item	Description	Reaction time
PV Modules	XX	Spare On Site - Renewed - Next Working Day
Inverters	XX	Spare On Site - Renewed - Next Working Day
Mounting Structure	XX	Spare On Site - Renewed - Next Working Day
Inverter Racks	XX	Spare On Site - Renewed - Next Working Day
Earthing	As per Design	Spare On Site - Renewed - Next Working Day
Cables	DC Solar Cables 1x6mm <sup>2</sup>	Spare On Site - Renewed - Next Working Day
	LV Cable	Spare On Site - Renewed - Next 2 Working Day
	MV Cable	Spare On Site - Renewed - Next 2 Working Day
	FO Cable	Spare On Site - Renewed - Next 2 Working Day
	Aux Cable	Spare On Site - Renewed - Next 2 Working Day
	Data Cable	Spare On Site - Renewed - Next 2 Working Day
Comunnication	Scada BoX	Spare On Site - Renewed - Next Working Day
Fence	Fence Mesh, mounting poles, barbed wired, gates and accessories - Depending on the defect	1 Day to 1 Week
CCTV & Security System	Depending on the defect	1 Day to 1 Week
Protective Tubes	Φ50/63/110 - As per Design	Spare On Site - Renewed - Next Working Day
Consumables	MC4 Connectors	Spare On Site - Renewed - Next Working Day
	LV Cable termination	Spare On Site - Renewed - Next Working Day
	MV Cable termination	Renewed - Next 2 Working Day
	LV fuses/Circuit Breackers	Spare On Site - Renewed - Next Working Day
O&M Building	HSE First Aid Kit	1 Week
	Fire Extinguishers	1 Week
	Toilet	1 Week
	Water Tank	1 Week
	Water piping	1 Week
	Septic Tank	1 Week

## 9.12 Spare Parts

The Contractor shall provide the Employer with the spare parts of the components at the expense of the Contractor. Any replacement of the Spare Parts shall be considered included in the O&M Services Fee. Spare parts shall be provided and be available in a container on site before the Provisional Performance Test. Spare parts shall include the components described in the table below. For the avoidance of doubt, any use of any spare parts during the Operation and Maintenance Services shall be replenished prior to the issuance of the Performance Certificate so that the spare parts, consist of the same components listed below.

Component	Description	Stock
Structure	Minimum one set of each type of tabel and Inverter rack	1 set
Modules	Spare PV modules	250 pcs
Inverter	Complete Inverter	5 pcs
DC Equipment	DC connectors (MC4 or equivalent)	100 pcs
Cables	Spare solar DC cables	2000 m
Cables	Spare AC LV cables	500 m
Cables	Spare fibre optic cables (SCADA)	200 m
Earthing	Earthing wires	150m
LV Equipment	LV Connection materials (lugs, Heatshrink, screws, etc)	5 sets
LV Equipment	LV fuses/Circuit Breackers	5 pcs
Scada	Complete Scada box	1 pcs
Weather Station	Spare irradiance sensor	1 pcs
Weather Station	Pyranometer	1 pcs
Weather Station	Spare module temperature sensor	1 pcs
Weather Station	Spare ambient temperature sensor	1 pcs
Weather Station	Spare wind speed sensor	1 pcs
Earthing	General earthing materials (Ex. clamps, screws, lugs, earthing bridges, et.)	5 sets
Spotlight	Perimeter LED lighting	2 pcs
CCTV System	Camera	1 pcs

## 10 FINANCIAL GUARANTEE REQUIREMENTS

### 10.1 Performance Security

The Performance Security to be established at the contract signing stage shall be equal to 10% of the total Contract Price, with validity covering the entire contractual duration, including the 2-year warranty period after the Performance Test Acceptance. The amount of the Performance Security may be reduced from 10% to 5% after successful completion of the Performance Test Acceptance and the Commissioning (subject to successful completion of compliance tests with the relevant Network Operators and obtaining the Compliance Certificate with the technical requirements), and until the expiry of the Contract, namely 24 months corresponding to the warranty period of the PV Plant.

The Performance Security shall be issued in euros in the form of a Performance Bank Guarantee Letter issued by a banking institution, in accordance with the requirements of the model attached as Annex 14.2, and in a form agreed with the Employer. The Performance Security shall remain valid for

at least 30 days after the issuance by the Employer of the Final Acceptance Certificate and full completion of the EPC Contractor's services.

Proceeds from the Performance Security shall be payable to the Employer as compensation for any contractual penalties or damages for any loss/harm resulting from the EPC Contractor's failure to fulfil its contractual obligations. In the event that the Employer executes partially or fully the Bank Guarantee Letter (Performance Security), the Contractor shall be obliged to reinstate the available value of the Performance Security up to the level of 10% of the Contract Price until Commissioning and, respectively, 5% during the 2-year warranty period. The total maximum cumulative amount of the Performance Security, after reinstatement(s), shall remain within the contractual liability limit agreed by the Parties.

**Conditions for the issuers of guarantee instruments (for the Performance Bank Guarantee Letter):**

- The issuer must be a banking credit institution;
- The issuer or its parent company must hold valid external ratings;
- The rating issuer mentioned above must be, as applicable, one of Fitch, Standard & Poor's, or Moody's;
- The rating of the guarantee issuer must be at least equivalent to BB- under Fitch classification, or other internationally recognized equivalent.

Tenderers shall include in their offer relevant information and documents demonstrating their financial capacity to manage the project, namely: the approved financial statements as of and for the years ended 31.12.2023, 31.12.2024. For companies required to audit their annual financial statements, the Auditor's Reports shall also be provided.

## **10.2 Advance Payment Guarantee**

If an advance payment is to be made to the Contractor, the Contractor shall provide an Advance Payment Bank Guarantee equal to 100% of the advance payment amount.

The Advance Payment Guarantee shall be:

- issued in euros by a recognized banking institution;
- unconditional and payable on first demand;
- valid until the advance payment has been fully recovered by the Employer through deductions from interim payments.

The guarantee shall automatically reduce in proportion to the amount of the advance payment recovered from each payment certificate. Once the advance payment has been fully offset, the guarantee shall be returned to the Contractor within 30 days.

In the event that the Advance Payment Guarantee is executed, the Employer shall be entitled to recover the outstanding balance of the advance payment and any associated losses.

- Template attached as Annex 14.1.

## **10.3 Warranty Bond**

In addition to the Performance Security, the Contractor shall provide a separate Warranty Bond, covering the Contractor's obligations for remedying defects during the warranty period.

The Warranty Bond shall meet the following requirements:

#### Value and Duration

- Equal to 5% of the Contract Price.
- Valid for the entire 24-month warranty period, starting from the date of issuance of the Final Acceptance Certificate (FAC).
- Must remain valid at least 30 days after the expiry of the warranty period.

#### Form of the Guarantee

- Issued in euros as an unconditional, irrevocable Warranty Bank Guarantee, payable on first demand.
- Issued by a banking institution meeting the same rating requirements applicable to the Performance Security.
- Template attached as Annex 14.3.

#### Execution and Reinstatement

If the Warranty Bond is executed partially or fully, the Contractor shall reinstate its full value within 10 working days.

Proceeds shall be payable to the Employer as compensation for any defects or failures not remedied in accordance with contractual obligations.

#### Relationship with the Performance Security

The Warranty Bond is complementary to the Performance Security.

The Performance Security covers overall contractual performance, including the measured operational performance of the PV Plant during the warranty period, while the Warranty Bond specifically covers defect remediation obligations.

Both guarantees shall remain valid concurrently for the full warranty period.

#### **10.4 EPC Contractor Insurance (covering the design, construction, commissioning, and O&M phases)**

The Contractor shall provide insurance/insurances (issued by insurance companies authorized to issue such insurance within the European Union) covering the design, procurement, construction, commissioning, and Operation & Maintenance phases for the entire warranty period of the system. The insurance shall include a per-event limit of not less than EUR 4 million and an aggregate annual limit of not less than EUR 8 million. Such insurances shall include, as a minimum, All Construction Risks insurance and professional civil liability insurance towards third parties.

For critical equipment and materials (with a value above EUR 100,000), the Contractor shall also provide Cargo Insurance in accordance with the agreed delivery terms (Incoterms).