Best Practice Checklist for EPC

☑/☒	Technical aspect & what to look for in the EPC contract
A	**Definitions, interpretation**
☐	1. Is there a set of definitions of important terms provided and are those clear and understood by all stakeholders?
B	**Contractual commitments**
☐	2. EPC contractor qualification
☐	3. Responsibility and accountability
☐	4. Date of ownership and risk transfer are defined and acceptable
☐	5. Construction start date and end date are defined and acceptable
☐	6. Plant Commercial Operation Date (COD) is defined and in line with FiT or PPA commencement dates
☐	7. The EPC works should be carried in compliance with (non-exhaustive list) • Grid code compliance: plant controls (e.g. ability for emergency shut-downs or curtailment according to grid regulations) • PPA compliance • Building permits (if applicable) • Environmental permits • Specific regulation for the site (e.g. vegetation management, disposal of green waste)
C	**Scope of works – engineering**
☐	8. Overall the scope of works for the EPC should be clearly defined. Which activities are included in the EPC services (is it a turnkey EPC)? Are they clearly defined?
☐	9. The EPC should include Technical Specifications consisting of • [Best practice] The operating environment is defined for: o Minimum and maximum ambient temperature o Maximum relative humidity o Maximum altitude o Local climate o Local conditions (e.g., snowy, sandy, near sea/chemical source/corrosive/agricultural activity/purpose of building usage/etc.) • Detail plant description on all major components including MV/HV equipment, monitoring, meteo stations, security and surveillance • Plant implantation schematic including not only the major components but also auxiliaries (electrical cabinet, substations etc.) and facilities (storage, office, guard house, fences, road access etc.) • Single wire diagram • Bill of materials of the major components • Recommended minimum spare part lists (draft version of this information during EPC negotiation should be updated to the final version when the plant is completed and handed over)

	• [Best practice] List of all applicable technical standards for major components (panels, inverters, electrical equipment) (non-exhaustive list) ○ CE Compliance ○ Panel: IEC61215, IEC61730, IEC61701, IEC62716, IEC62804, IEC62108 (CPV) ○ IR/EL: IEC60904-12 & 13 ○ Inverter: IEC62109 ○ Electrical equipment: IEC61000 ○ Tracker: IEC62817, IEC62727 ○ Design and installation: IEC TS 62548 ○ Commissioning: IEC62446 ○ Performance monitoring: IEC61724
☐	10. Who is responsible for grid connection and the infrastructure to connect the PV plant to the grid (transformer, export lines, substation) is clearly defined
☐	11. Site suitability (ground installation) • Geotechnical and soil study • Any flood risk • Other constraints (chemical in the air, corrosive air, etc.) Site suitability (rooftop installation) • Roof stability study • Structural requirements of roof and mounting structure (both static/snow load and dynamic/wind load • Lightning protection requirement • Fire protection (PV system should not be built across fire protection walls); design should be in compliance with the building fire protection codes • Requirement for weathering protection (lifetime of roofing film)
☐	12. If the site study has been done and the results have been shared with the owner and the EPC, the EPC contract should clearly acknowledge that the contractor has reviewed the results of the study and has designed the PV system taking into account the site conditions and constraints
☐	13. For rooftop system, the roof should be weatherproof throughout operations of PV plant without major overhaul of roof laminate layer
☐	14. Estimation of plant yield/production should follow best practice guidelines (see “Best Practice Checklist for Long-Term Yield Assessment”)
☐	15. The plant design and estimated yield/production should be validated by third party
D	**Scope of works – procurement**
☐	16. All major components should be visually inspected at delivery
	17. All modules should be tested for STC performance according to the IEC60904 standards at the factory and the test data should be submitted to the EPC contractor for verification [Best practice] All modules should be inspected with electroluminescence imaging camera at the factory and the test data should be submitted to the EPC contractor for verification
☐	18. PV modules should be sampled and tested after delivery and before acceptance • List of test (and criteria) should be included in the EPC contract • Tests are to be done by an accredited independent test laboratory

☐	19. [Best practice] Transportation and handling requirements on components should be specified
☐	20. [Best practice] EPC contractor is required to perform factory inspection on the module factory
☐	21. [Best practice] Negotiation of technical requirement in supply agreement (i.e. module) and warranty terms and conditions should involve inputs from technical advisors
E	**Scope of works – construction**
☐	22. The EPC should include comprehensive protocol and training to its field workers on how to un-package and handle components properly
☐	23. The installation of components should adhere the manufacturer's guidelines when applicable
☐	24. Regular construction monitoring by the owner (assisted by technical advisor) should be performed to check construction progress and quality (and for milestone payments)
☐	25. Reporting of construction progress should be included in the contract
☐	26. Health and safety, housekeeping and site security are defined as the responsibilities of the contractor during construction
F	**Scope of works – administrative and others**
☐	27. Responsible party for securing the site use is clearly defined: • For ground-mounted utility systems: land lease, land purchase, and land access • For commercial rooftop systems: roof lease, roof access
☐	28. Responsible party to obtain permits and authorizations to develop PV plant is clearly defined
	29. Any support required from the EPC contractors in permitting, grid connection etc. should be clearly defined
☐	30. Is the contractor responsible to carry out or only support warranty and insurance claims management during the EPC period?
G	**Manufacturer warranties**
☐	31. The terms and conditions of major components' manufacturer warranties are clearly defined • Effective start and end date • Definition of defects • Claim procedure • The compensations proposed are reasonable and logical • Exclusions • Provision to allow for the involvement of third party expert during technical dispute • Transferability
☐	32. The warranty timelines should be in line with the EPC warranty timelines
☐	33. Check if the jurisdiction of the warranty allows it to be legally enforceable
☐	34. [Best practice] Are there additional insurances (transportation damages, e.g.) from either the EPC contractor or component manufacturer?
H	**EPC warranty and Defect Liability Period (DLP)**
☐	35. Provide warranty of Good Execution of Works
☐	36. The EPC contract shall provide at minimum 2-year EPC warranty from the date of plant take-over
☐	37. The DLP duration coincides with the EPC and component manufacturer warranty duration

☐	38. During this DLP, the EPC contractor is responsible to repair faults or defect at its own cost, or an arrangement has been made with the O&M contractor to execute this. For the latter, clear scope of work ownerships must be aligned to prevent avoidance of responsibilities
☐	39. The party responsible to maintain the PV plant after take-over and before the end of DLP is clearly defined
I	**Key performance indicators (KPIs) and guarantees**
☐	40. The EPC contract should have key performance indicators for two aspects • Completion timeline: guaranteed completion date • System performance and quality: guaranteed performance ratio (PR) or guaranteed output
☐	41. The guaranteed PR or output should be calculated in a long-term yield estimation exercise using correct technical assumptions, i.e. all relevant losses and uncertainties
☐	42. Liquidated damages (LD) or penalties should be assigned in the contract in case the guaranteed KPIs are not met
☐	43. Completion delay LDs should be in line with the project revenue loss due to lateness in project entering operation. The LD is commonly a % of EPC price for each day of delay
☐	44. Performance LDs should be in line with the project revenue loss when the system is not meeting the guaranteed performance level. The LD is commonly a % of EPC price for each point of PR or output below the guaranteed value
☐	45. Maximum amount of LD (LD cap) to limit contractor's liability is usually included in the EPC contract. E.g., delay LD and performance LD could each be capped at 20% of the EPC contract price and the combined cap is 30% of the EPC contract price
J	**Commissioning and acceptance**
☐	46. The EPC contract should include plant provisional and final commissioning
☐	47. Short term performance test should be carried out after the PV system completes the construction phase
☐	48. Provisional test set-up should include appropriate: • Duration of the test • Irradiance threshold • Monitoring system, including measurement sampling rate and averaging method
☐	49. The calculation method for the key performance indicator for provisional acceptance should account for short-term effect on temperature and irradiance
☐	50. Final acceptance plant performance should be carried out after the plant has been in operation for a representative period of time (2 years after provisional acceptance)
☐	51. Final performance test set-up should include appropriate • Irradiance threshold • Monitoring system, including measurement sampling rate and averaging method
☐	52. The calculation method for the key performance indicator for final acceptance should account for: • Annual degradation • Plant availability
☐	53. Measurement of irradiance to assess plant performance • Irradiance measurements • Measurement in the POA according to the Secondary Standard or First Class quality classification (ISO9060:1990)

- Minimum requirement: one measurement device (pyranometer of high quality)
- [Best practice] At least 2 pyranometers
- If different array orientations, one pyranometer per orientation – careful assignment for proper calculation of PR and yield
- Sensors placed at the least shaded location
- Sensors installed according to manufacturer's guidelines
- Preventative maintenance and calibration according to manufacturer's guidelines
- Set irradiance to be recorded with averages of 15 min (minimum requirement) or 1 min and less (best practice)
- High quality satellite-based data to complement terrestrial measurements [best practice] – mainly for monthly and annual values and not daily since the RMSE is high (8-14%)
- Minimum requirements for satellite data: hourly granularity or 15 min. Set data to be retrieved once per day at least

☐ 54. Measurement of irradiance to assess plant performance

- Temperature sensor properly installed according to manufacturer's guidelines
- Use of stable thermally conductive glue to the middle of the backside of the module in the middle of the array, in the center of the cell away from junction box
- Accuracy should be <±1 C including signal conditioning
- For large systems, different representative positions for installing the sensor should be considered: module at the center of the array and at the edge of this module where temperature variations are expected

☐ 55. Inverter measurement to assess plant performance

- AC level: energy and power data should be collected
- Energy data should be cumulative values over the lifetime of the inverter
- Collect all inverter alarms – important to plan your maintenance activities (corrective and preventative)
- Monitor and manage control settings at the inverter level and the grid injection level
- DC input measurements <1s sampling and <1min averaging
- DC voltage to be measured and stored separately for allowing MPP-tracking and array performance problems
- [Best practice] measure all parameter from the inverters including internal temperature, isolation level etc.

☐ 56. Energy meter

- Collection of energy meter data by the monitoring system in daily basis and with 15 min granularity
- High accuracy energy meter is required – uncertainty of ±0.5% for plants >100 kWp
- The above point can be considered as best practice for plants smaller than 100 kWp

☐ 57. Plant visual inspection should be carried out during acceptance test

[Best practice] The visual inspection uses advanced tools such as IR camera

☐ 58. As part of the plant hand-over process, the EPC contractor must provide (non-exhaustive list)

- A complete set of as-build documentation (IEC62446, see "Best Practice Checklist for As-Build Documents – Type and Details" for complete set)
- Recommended minimum spare parts list

Best Practice Checklist for O&M

☑/☒	Technical aspect & what to look for in the O&M contract
A	**Definitions, interpretation**
☐	1. Is there a set of definitions of important terms provided and are those clear and understood by all stakeholders?
B	**Purpose and responsibilities**
☐	2. Is the fundamental purpose (goals) of the contract clearly defined?
☐	3. Are the roles and responsibilities (and boundary conditions) of the multiple stakeholders within the contract clear and understood?
C	**Scope of works – environmental, health and safety** Note: The Asset Owner has the ultimate legal and moral responsibility to ensure the health and safety of people in and around the solar plant and for the protection of the environment around it. The practical implementation is normally subcontracted to the O&M contractor.
☐	4. Environment • Regular inspection of transformers and bunds for leaks (according to the annual maintenance plan) • Recycling of broken panels and electric waste • Sensible water usage for module cleaning • Proper environmental management plan in place
☐	5. Health and safety (H&S) • Properly controlled access and supervision in the solar plant – necessary boundaries and site restrictions • Proper induction to ensure awareness of risks and hazards • Proper training and certification on the specifics of a PV plant and voltage level • Hazard identification/marking • Wiring sequence marking • H&S legislation available • Established personal protective equipment (PPE) (not exhaustive list): safety shoes, high visibility clothing, helmet, gloves (and/or insulated gloves), slash masks and glasses (depending on the site), fire retardant and/or arc flash rated PPE where necessary • Calibrated and certified equipment (full documentation available)
D	**Scope of works – operations**

☐	6. Documentation Management System (DSM)
	• As-built documentation / IEC62446 (see “Best Practice Checklist for As-Build Documents – Type and Details”)
	    ○ Site information
	    ○ Project drawings
	    ○ Project studies
	    ○ Studies according to national regulation requirements
	    ○ PV modules
	    ○ Inverters

- Medium voltage / inverter cabin
    - MV/LV transformer
    - HV switchgear
    - UPS and batteries
    - Mounting
- Management and control
    - Define type of storage (physical or/and electronical)
    - Ensure electronic copy of all documents
    - Ensure controlled access to documents
    - Ensure authorization for modifications – keep a logbook on name of person who modified the document, date of modification, reason for modification and further information e.g. link to the work orders and service activities
    - Ensure history of the documents (versioning)
- Record control (see “Best Practice Checklist for Record Control”)

☐ 7. [Best practice] Predictive maintenance

- Define scope of this cluster, the type of performance analysis, the level (portfolio level, plant level, inverter level, string level)
- Define the monitoring requirements needed to perform predictive maintenance, provide basic trending and comparison functionality

☐ 8. Power generation forecasting

- Ensure a service level agreement with the forecast provider
- Define the purpose and consequently the requirements for power forecasting (e.g. time horizon, time resolution, update frequency)

☐ 9. Reporting (see “Best Practice Checklist for Reporting Indicators”)

☐ 10. Regulatory compliance

- Grid code compliance: plant controls (e.g. ability for emergency shut-downs or curtailment according to grid regulations)
- PPA compliance
- Building permits (if applicable)
- Environmental permits
- Specific regulation for the site (e.g. vegetation management, disposal of green waste)

☐ 11. Management of change: define responsibilities and involvement when PV plant needs to be adjusted after the Commercial Operation Date: e.g. spare parts, site operation plan, annual maintenance plan etc.

☐ 12. Warranty management

- Warranty of Good Execution of Works
- Warranty of Equipment
- Performance Warranty: agree on reporting period
- Classification of anomalies and malfunctions: Pending Works, Insufficiencies, Defects, Failure or malfunction of equipment

☐ 13. Insurance claims management

E Scope of works – maintenance

☐	14. Inclusion of an adequate Preventive Maintenance Plan
☐	15. The minimum requirements for preventative tasks and their frequency follow the manufacturer's guidelines when applicable
☐	16. The minimum requirements for preventative tasks and their frequency should respect relevant national standards
☐	17. Corrective maintenance (CM) • Fault diagnosis (troubleshooting) • Repair and temporary repairs • Agreed response times and/or minimum repair times • Clear definition of "boarders" and "limitations" of CM tasks, especially with preventative maintenance and extraordinary maintenance. Definition of yearly cap of CM works (when applicable)
☐	18. Extraordinary maintenance • Define what is included in this cluster ○ Damages that are a consequence of a Force Majeure event ○ Damages as a consequence of a theft or a fire ○ Serial defects on equipment, occurring suddenly and after months or years from plant start-up ○ Modifications required by regulatory changes ○ Agreed interventions for reconditioning, renewal and technological updating • Define the rules on how to execute tasks and prepare quotations – ways of payment
☐	19. Additional services: define what is included in this cluster and how this service is paid (non-exhaustive list) • Module cleaning • Vegetation management • Road maintenance • Snow removal • Pest control • Waste disposal • Maintenance of buildings • Perimeter fencing and repairs • Maintenance of security equipment • String measurements – to the extent exceeding the agreed level of preventative maintenance • Thermal inspections – to the extent exceeding the agreed level of preventative maintenance • Meter weekly/monthly readings and data entry on fiscal registers or in authority web portals for FiT tariff assessment (where applicable)
F	**Scope of works – data and monitoring**
☐	20. Irradiance measurements • Measurement in the POA according to the Secondary Standard or First Class quality classification (ISO9060:1990) • Minimum requirement: one measurement device (pyranometer of high quality) • [Best practice] At least 2 pyranometers

- If different array orientations, one pyranometer per orientation – careful assignment for proper calculation of PR and yield
- Sensors placed at the least shaded location
- Sensors installed according to manufacturer's guidelines
- Preventative maintenance and calibration according to manufacturer's guidelines
- Set irradiance to be recorded with averages of 15 min (minimum requirement) or 1 min and less (best practice)
- High quality satellite-based data to complement terrestrial measurements [best practice] – mainly for monthly and annual values and not daily since the RMSE is high (8-14%)
- Minimum requirements for satellite data: hourly granularity or 15 min. Set data to be retrieved once per day at least

☐ 21. Module temperature measurements

- Temperature sensor properly installed according to manufacturer's guidelines
- Use of stable thermally conductive glue to the middle of the backside of the module in the middle of the array, in the center of the cell away from junction box
- Accuracy should be <±1 C including signal conditioning
- For large systems, different representative positions for installing the sensor should be considered: module at the center of the array and at the edge of this module where temperature variations are expected

☐ 22. Local meteorological data

- [Best practice] Ambient temperature and wind speed with sensors installed according to manufacturer's guidelines
- Ambient temp with shielded thermometer e.g. PT100
- Wind speed with anemometer at 10 m height above ground level
- For large plants >10 MW automated data from an independent nearby meteo source to smooth local phenomena and installation specific results

☐ 23. String measurements

- If not DC input current monitoring at inverter level, then current monitoring at string level is recommended – depending on module technology, combined strings (harnesses) can help reducing operating costs
- [Best practice] Increase up-time for timely detection of faults: 1 sec sampling and 1 min averaging at data logger, maximum two strings current measurement in parallel

☐ 24. Inverter measurement

- AC level: energy and power data should be collected
- Energy data should be cumulative values over the lifetime of the inverter
- Collect all inverter alarms – important to plan your maintenance activities (corrective and preventative)
- Monitor and manage control settings at the inverter level and the grid injection level
- DC input measurements <1s sampling and <1min averaging
- DC voltage to be measured and stored separately for allowing MPP-tracking and array performance problems
- [Best practice] measure all parameter from the inverters including internal temperature, isolation level etc.

☐ 25. Configuration

- In cases of change of O&M contractor (or recommissioning of the monitoring system), the configuration of the monitoring system and the data loggers should be checked
- [Best practice] if technically available, auto-configuration is recommended – e.g. automatic collection of inverter and sensor IDs and labels
- Back up of the configuration should be in place

☐ 26. Energy meter

- Collection of energy meter data by the monitoring system in daily basis and with 15 min granularity
- High accuracy energy meter is required – uncertainty of ±0.5% for plants >100 kWp
- The above point can be considered as best practice for plants smaller than 100 kWp

☐ 27. AC circuit / protection relay

- [Best practice] Monitor the AC switch position for (sub) plants. Read the alarms from the protection relay via communication bus if possible

☐ 28. Data loggers

- Sufficient memory to store at least one month of data
- Historical data should be backed up
- After communication failure, the data logger should resend all pending information
- The entire installation (monitoring system, signal converters, data loggers, measurement devices) should be protected by a UPS
- [Best practices] Memory to store at least six months of data and full data backup in the cloud. Separate remote server to monitor the status of the data loggers and inform the operations. The system should be an open protocol to allow transition between monitoring platforms. If possible, reboot itself once per day (during night time) to increase reliability

☐ 29. Alarms

- Minimum requirement: alarms sent by email (non-exhaustive list)
    - Loss of communication
    - Plant stop
    - Inverter stop
    - Plant with low performance
    - Inverter with low performance (e.g. due to overheating)
- [Best practice] (non-exhaustive list)
    - String without current
    - Plant under UPS operation
    - Intrusion detection
    - Fire alarm detection
    - Discretion alarm (or alarm aggregation)

☐ 30. Dashboard / web portal

- Minimum requirements for features of the monitoring system (non-exhaustive list)
    - Web portal accessible 24h/365d
    - Graphs of irradiation, energy production, performance and yield
    - Downloadable tables with all the registered figures
    - Alarms register
- [Best practices] (non-exhaustive list)

	○ User configurable dashboard ○ User configurable alarms ○ User configurable reports ○ Ticket management
☐	31. Data format • Data format of recorded files according to IEC61724 – clearly documented • Data loggers should collect alarms according to manufacturer's format
☐	32. Communication from the site to the monitoring servers • Best network connectivity with sufficient bandwidth according to the available monitoring system • DSL connection preferred if available at the PV site – industrial routers recommended • [Best practice] GPRS-connection as back up • For sites >1 MW it is advised to have a LAN connection and as an alternative an industrial router that allows for GPRS or satellite communication back-up in case the LAN connection fails. A router with an auto-reset capability in case of loss of internet connection is recommended • Data security should be ensured: as minimum requirements loggers should not be accessible directly from the internet or at least be protected via a firewall. Secure and restrictive connection to the data server is also important • Communication cables must be shielded and protected by direct sunlight • Physical distance between DC or AC power cables and communication cables should be ensured • Cables with different polarities must be clearly distinguishable (label or color) for avoiding polarity connection errors
G	**Scope of works – spare parts management**
☐	33. Definition of ownership and responsibility of insurance
☐	34. Define separate list of consumables if applicable (e.g. tools and fuses)
☐	35. Stocking level: consider initial EPC list and the following parameters • Frequency of failure • Impact of failure • Cost of spare part • Degradation over time • Possibility of consignment stock with the manufacturer
☐	36. Location of storage/warehouse • Proximity to the plant • Security • Environmental conditions
☐	37. List of minimum spare parts (non-exhaustive list) • Fuses for all equipment (e.g. inverter, combiner boxes etc.) and fuse kits • Modules • Inverter spares (e.g. power stacks, circuit breakers, contactor, switches, controller board) • UPS

	• Voltage terminations • Power plant control spares • Transformer and switchgear spares • Weather station sensors • Motors and gearboxes for trackers • Harnesses and cables • Screws and other supply tools • Security equipment (e.g. cameras)
H	**Scope of works – plant security**
☐	38. Define protective measures for the plant • Security protocol in place • Video monitoring • Alerting system • Fencing or barriers • Warning signs and notices • Security pad codes and passwords • Back up communication in case of vandalism
I	**Key performance indicators (KPIs)**
☐	39. Plant KPIs • Availability • Energy-based availability • Performance Ratio • Energy Performance Index
☐	40. O&M contractor KPIs • Reaction time • Reporting • O&M contractor experience • Maintenance effectiveness and maintenance support efficiency
☐	41. Security and surveillance of PV plant • On-site or remote • Around the clock coverage (24h/365d) • On-site patrol, security camera • On-site intervention time upon alarm etc.
J	**Contractual commitments**
☐	42. Qualification of parties involved: Owner's Engineer, O&M contractor, monitoring, security firm
☐	43. Responsibility and accountability
☐	44. Bonus schemes and liquidated damages

Best Practice Checklist for Long-Term Yield Assessment

☑/☒	Technical aspect & what to look for in the LTYA
A	**Solar resource assessment**
☐	1. Only reliable solar irradiation data sources should be used and the name(s) and version(s) must be clearly stated. Data source(s) used must be able to provide uncertainty estimations and ideally have been extensively validated
☐	2. The period covered by the solar irradiation data source(s) used must be reported. Only data sources with more than 10-year recent data should be used for LTYA calculations
	3. The effect of long-term trends in the solar resource should be analyzed. In the presence of such trends, the long-term solar resource estimation should be adjusted to account for this effect
☐	4. The use of site adaptation techniques is recommended to reduce the uncertainty. A measurement campaign of at least 8 months and ideally one full year is recommended
B	**PV yield modeling**
☐	5. The PV modeling software and the specific version used must be clearly stated in the report
☐	6. If in-house software is used, the name(s) and version(s) must also be stated
☐	7. All assumptions (e.g. soiling losses, availability, etc.) and sub-models used (e.g. transposition model) must be clearly stated
C	**Degradation rate and behavior**
☐	8. The degradation rate(s) used for the calculations must be clearly stated in the report. It is recommended to differentiate between first year effects and yearly behavior over project lifetime
☐	9. Degradation behavior assumption (e.g. linear, stepwise, etc.) over time should be clearly stated and ideally backed up with manufacturer warranties
☐	10. If specific manufacturer warranties are available (e.g. module warranty document or sales agreement), these can be used to fine tune the lifetime degradation calculation
D	**Uncertainty calculation**
☐	11. All steps in the long-term yield calculation are subject to uncertainties. All uncertainties should be clearly stated and references must be provided in the report
☐	12. Special attention must be paid to the solar resource related uncertainties as these are among the most important elements in the contribution to the overall uncertainty
☐	13. If special methods are used to reduce some uncertainties e.g. site adaptation techniques, these should be clearly documented and ideally backed up with scientific validation
☐	14. Special care must be taken when classifying each uncertainty as either systematic or variable (stochastic) since these are treated differently in overall lifetime uncertainty calculations
☐	15. When possible, exceedance probabilities (e.g. P90) for each uncertainty must be calculated using empirical methods based on available data instead of assuming normal distribution for all elements

Best Practice Checklist for As-Build Documents – Type and Details

Information type and depth of detail / as-built documents		
No.	**Minimum Requirements**	**Description**
1	Site information	• Location / map / GPS Coordinates • Plant access / keys • Access roads • O&M building • Spare parts storage / warehouse • Site security information • Rooftop condition and load requirements / restrictions (rooftop system only) • Stakeholder list and contact information (for example, owner of the site, administration contacts, firefighters, sub-contractors / service providers, ...)
2	Project drawings	• Plant layout and general arrangement • Cable routing drawings • Cable list • Cable schedule/ cable interconnection document • Single line diagram • Configuration of strings (string numbers, in order to identify where the strings are in relation to each connection box and inverter) • Earthing / grounding system layout drawing • Lightning protection system layout drawing (optional) • Lighting system layout drawing (optional) • Topographic drawing • Grid access point schematic
3	Project studies	• Shading study / simulation • Energy yield study / simulation • Inverter sizing study
4	Studies according to national regulation requirements	• Voltage drop calculations • Protection coordination study • Short circuit study • Grounding study • Cable sizing calculations • Lightning protection study
5	PV modules	• Datasheets • Flash list with PV modules positioning on the field (reference to string numbers and positioning in the string) • Warranties and certificates
6	Inverters	• O&M manual • Commissioning report • Warranties and certificates • Factory Acceptance Test • Inverter settings • Dimensional drawings
7	Medium Voltage / Inverter Cabin	• Medium Voltage / inverter cabin layout and general arrangement drawing • Medium Voltage / inverter cabin foundation drawing

		• Erection procedure • Internal normal / emergency lighting layout drawing • Fire detection and firefighting system layout drawing (if required) • HVAC system layout drawing • HVAC system installation and O&M manual • HVAC study (according to national regulations) • Earthing system layout drawing • Cable list
8	MV/LV transformer	• O&M manual • Commissioning report • Factory Acceptance Test report • Type Test reports • Routine Test reports • Warranties and certificates • Dimensional drawing with parts list
9	Cables	• Datasheets • Type and Routine test reports
10	LV & MV switchgear	• Single line diagram • Switchgear wiring diagrams • Equipment datasheets and manuals • Factory Acceptance Test report • Type Test reports • Routine Test reports • Dimensional drawings • Warranties and certificates • Protection relays settings (only for MV switchgear) • Switching procedure (according to national regulations) (only for MV switchgear)
11	HV switchgear	• Single line diagram • Steel structures assembly drawings • HV switchyard general arrangement drawing • HV equipment datasheets and manuals (CTs, VTs, circuit breakers, disconnectors, surge arresters, post insulators) • Protection and metering single line diagram • HV equipment type and routine test reports • Interlock study • Switching procedure (according to national regulations) • Warranties and certificates
12	UPS and batteries	• Installation and O&M manual • Commissioning report • Warranties and certificates • Datasheets • Dimensional drawings
13	Mounting structure	• Mechanical assembly drawings • Warranties and certificates • Structural design calculation (rooftop systems only)
14	Trackers	• Mechanical assembly drawings • Electrical schematic diagrams • Block diagram

		• Equipment certificates, manuals and datasheets (motors, encoders) • PLC list of inputs and outputs (I/O) by type (digital, analog or bus) • Commissioning reports • Warranties and certificates
15	Security, anti-intrusion and alarm system	• Security system layout / general arrangement drawing • Security system block diagram • Alarm system schematic diagram • Equipment manuals and datasheets • Access to security credentials (e.g. passwords, instructions, keys etc.) • Warranties and certificates • Service level agreement with security company (if applicable)
16	Monitoring / SCADA system	• Installation and O&M manual • List of inputs by type (digital, analog or bus); I/O list includes e.g. sensor readings that are collected by data loggers • Electrical schematic diagram • Block diagram (including network addresses) • Equipment datasheets
17	Plant controls	• Power plant control system description • Control room (if applicable) • Plant controls instructions • Breaker control functionality (remote / on-site) and instructions • List of inputs and outputs
18	Communication system	• Installation and O&M manual • System internal communication • External communication to monitoring system or operations center • IP network plan • Bus network plans

Best Practice Checklist for Record Control

Record control			
No.	**Activity Type**	**Information Type**	**Input Record**
1	Alarms / operation incidents	Alarms description	Date and time, affected power, equipment code / name, error messages / codes, severity classification, curtailment period, external visits / inspections from third parties
2	Contract management	Contract general description	Project name / code, client name, peak power (kWp)
3	Contract management	Asset description	Structure type, installation type
4	Contract management	Contract period	Contract start and end date
5	Contract management	Contractual clauses	Contract value, availability (%), PR (%), materials / spare parts, corrective work labor
6	Corrective maintenance	Activity description	Detailed failure typification, failure, fault status, problem resolution description, problem cause (*)
7	Corrective maintenance	Corrective maintenance event	Associated alarms (with date), event status (*)
8	Corrective maintenance	Corrective maintenance event log	Date and time of corrective maintenance creation (or work order), date and time status change (pending, open, recovered, close), end date and time of the intervention, start date and time of the intervention, technicians and responsible names and function (*)
9	Corrective maintenance	Intervention equipment / element name	Affected power and affected production, equipment code / name
10	Inventory management	Warehouse management	Inventory stock count and movement, equipment code / name
11	Monitoring and supervision	Equipment status	Date, status log (protection devices, inverters, monitoring systems, surveillance systems)
12	Monitoring and supervision	Meteo data	Irradiation, module temperature, other meteo variables (ambient temperature, air humidity, wind velocity and direction, …) (**)
13	Monitoring and supervision	Production / consumption data	AC active and reactive power at PV plant injection point and other subsystems or equipment, consumption from auxiliary systems, other variables (DC/AC voltages and currents, frequency), power from DC field (**)
14	Monitoring and supervision	Performance data	PV plant energy production; PR; expected vs real
15	Preventative maintenance	Intervention equipment / element name	Affected power and affected production, equipment code / name, intervention start and end date
16	Preventative maintenance	Maintenance description	Measurements, preventative maintenance tasks performed, problems not solved during activity and its classification and typification, technicians and responsible names and function
17	PV plant documentation	Commissioning	Commissioning documentation and tests results (***)

18	PV plant documentation	Operation and maintenance	Equipment manuals, PV plant O&M manual (***)
19	PV plant documentation	System documentation	As built documentation (datasheets, wiring diagrams, system data) (***)
20	Warranty management	Claims registration	Affected equipment, claim description, occurrence date, communications between O&M, client and manufacturer/supplier
21	Security management	Alarm intervention	Alarms log, type of alarm, time of occurrence, counter measures

(*) EN 13306 - Maintenance. Maintenance terminology

(**) IEC 61724 - Photovoltaic system performance monitoring - Guidelines for measurement, data exchange and analysis

(***) IEC 62446 - Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance - Part 1: Grid connected systems - Documentation, commissioning tests and inspection

Best Practice Checklist for Reporting Indicators

Reporting Indicators				
No.	**Proposed Indicator**	**Predicted**	**Measured**	**Estimated**
1	Insolation	●	●	
2	Active energy produced	●	●	✓
3	Active energy consumed		✓	
4	Reactive energy produced		✓	
5	Reactive energy consumed		✓	
6	Peak power achieved		✓	
7	Performance Ratio	●	●	✓
8	Energy Performance Index			✓
9	Balance of system efficiency			✓
10	Plant external energy losses			✓
11	Plant internal energy losses			✓
12	Energy-based availability			✓
13	Time-based availability			✓
14	Inverter specific energy losses			✓
15	Inverter specific efficiency			✓
16	Module soiling losses		✓	
17	Module degradation			✓

Note: ● Minimum Requirement, ✓ Best Practice