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:
	  ○ Minimum and maximum ambient temperature
	  ○ Maximum relative humidity
	  ○ Maximum altitude
	  ○ Local climate
	  ○ 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