



TECHNICAL SPECIFICATION FOR DESIGN, MANUFACTURING, SUPPLY, INSTALLATION AND COMMISSIONING OF TRACKER SYSTEM FOR VARIOUS SOLAR PV PROJECTS ACROSS INDIA

PS-439-1426

Rev No: 01

CODES	Description
UL 2703	Standard for Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat-Plate Photovoltaic Modules and Panels or equivalent
UL 3703	Standard for Solar Trackers or equivalent
IEC TS 62727	Photovoltaic systems - Specification for solar trackers
IEC 62817:2014+AMD1:2017 CSV	Photovoltaic systems – Design qualification of solar trackers
IS 875: Part 1 & 2	Code of practice for the design loads for buildings and structures-
IS 875: Part 3	Code of practice for the design loads for buildings and structures-Wind Loads
IS 800: 2007	Code of practice for use of structural steel in general building construction
IS 4759	Hot-dip zinc coatings on structural steel and other allied products
IS 1868	Anodic Coatings on Aluminium and its Alloys

Equivalent National and International standard/code would also be acceptable Module Mounting structures (MMS) with trackers.

6.3. DESIGN

- a) Single axis East-West real time tracking
- b) Configuration - Both, single and multi-rows options are accepted.
- c) Tracker Range of Movement (ROM): +/- 45 degrees or better
- d) DC Self-powered drive system with battery backup of 3 days autonomy.
- e) Individual row-level bi-directional control
- f) Redundant communication (wireless) for individual Trackers
- g) Stow configuration: optimal Angle, as per aero elastic instability analysis.
- h) Design wind speed as per site condition, basic wind speed as per wind map of India from IS 875 Part 3: 2015.



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- i) Suitable material for corrosion category compliance as per Corrosion map of India, EN ISO 14713, EN ISO 1461, EN ISO 12944-5 or ASTM 123.
- j) Operational temp: -10 to 50 degree Celsius.
- k) Comprehensive Integration to Plant SCADA with Tracker system to be done. Any communication cable, if required shall be provided and laid by Vendor only. BHEL SCADA to show all parameters of tracking system.
- l) Cleaning - Compliant with robotic module cleaning
- m) The minimum design clearance (at the highest tilt angle) between the lower edge of the modules and the developed ground level shall be 400mm for Single Axis Tracker based system.
- n) Foundation system shall be designed and adopted as per approved geotechnical investigation report and relevant IS standard. Considering the substrata condition, advanced and mechanized steel pile foundations may also be opted for MMS of a solar PV system. A pile cap should be cast by concrete of min. M25 grade having projecting length 150 mm above the ground level and minimum 250mm below the ground level to minimize the corrosion in the steel section. Length and other parameter of pile can be decided by performing the pile load tests and applying a suitable factor of safety as per code/ approved methodology.

6.4. REQUIREMENTS

- a) Tracking system shall be followed by either means of sun's positioning algorithm or optimization algorithm with a minimum tracking accuracy of $\pm 2^\circ$ between the pointing vector of the sun and the pointing vector of the modules.
- b) The tracking system shall have back tracking algorithm to avoid inter-row shading and optimizing irradiance collection for both row avoidance shading and diffuse light optimization.
- c) All local tracking controls shall be mounted on the tracking structure. A suitable arrangement/bellows shall be provisioned to protect actuator assembly from extreme outdoor harsh condition, dust and UV rays.
- d) In case of failure of supply, the arrays should return to the stow position. Bidder shall supply a tracking mechanism with an inbuilt feature for meeting the requirement.



- e) All modules associated with a specific tracking system should be connected to a common inverter.
- f) Suitable redundancy in sensing and auxiliary power supply shall be provided for fail-safe stowing of trackers. Redundancy in control is also desirable for the safe operation of trackers. Detail of the scheme for various redundancy shall be finalized at the time of detailed engineering.
- g) Safety measures such as stop devices shall be applied to ensure personal safety.
- h) Tracker shall be equipped with safety features like, auto high wind stow to the designed angular position and shall have uninterrupted communication with monitoring console/station. It should be capable of sending alarms to the monitoring station in case of failure or abnormal operations of the tracking systems.
- i) For each row an earthing cable shall be installed to interconnect all metallic parts of foundation, tracker structure and PV modules of each table.
- j) Tracker design shall also include a provision for fastening DC cables to the structure each 500mm without causing tearing or fluttering of cables.
- k) Tracker shall be able to track as per proposed stow strategy supported by Wind Tunnel test.
- l) Tracker Torque Tubes should be galvanized in accordance with, ISO 1461, ISO 14713, ISO 9223, or relevant standard as per Corrosive Category of proposed Solar PV Site.
- m) Minimum 400mm clearance to be maintained at module edge with maximum angle.

6.5. MODULE MOUNTING ARRANGEMENT

a) Module mounting structures shall be designed to withstand the extreme weather conditions in the area. The site design wind speed factors k_1 , k_2 , k_3 and k_4 and pressure coefficient shall conform to IS 875 (Part-3): 2015 or as per a Wind Tunnel Study from a reputed national/international facility, for the design of MMS. However, design wind pressure to be considered for design, shall not be taken less than the minimum wind pressure “ p_d ” as mentioned in the Technical Specification.

If the Bidder is going for wind tunnel test for the design and analysis of complete MMS and solar tracking system following shall be ensured.

- i. It must be done from an institute of repute (IITs / SERC or equivalent) in India/ international facility.



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ii. Bidders must ensure that offered tracker has proven design with wind tunnel test simulating actual site conditions. The analysis and design shall be completed within two months from the actual date of issue of LOA.

iii. Test results and design must comply with relevant Indian/ International codes.

iv. The design shall be shown in STAAD pro or similar commercially available software for further checking of BHEL/End Customer as and when required.

b) The structural material and design shall be as per Design Criteria for Module Mounting Structures (MMS). The structural Material Yield Strength and Minimum Design Thickness can be as per “Proprietary Design” of Tracker supplier, and It shall conform to Indian / international code design provisions. The Proposed Solar PV tracker system same should be certified for successful performance of MMS and tracker system by designer for its design life of 25 Years after COD. The Solar PV tracker system shall also fulfil the requirements of PQC given in tender document.

c) The design and the calculations for the MMS and the foundation system shall be submitted for prior approval of BHEL/End Customer before the commencement of construction and shall be based on the soil Geotechnical Investigation report.

e) The Structure shall be designed and analyzed in accordance with finite element method, the fundamental principles of Engineering using commercially available software (such as STAAD pro or similar), with dead load and wind load considered as per IS: 875 (Part 1& 3, respectively) or as per Wind Tunnel study done from a reputed national/international facility. Analysis shall be done as per appropriate load combinations preferably as per IS codes.

f) The Structure must be provided with limit switches to control the rotation of the frame.

g) Vendor to submit .shd file of Tracker system or key parameters of tracking system required for Energy simulation in PV Syst Software.

g) All nuts & bolts or clamps shall be of Stainless steel, Aluminium or Metal Alloy type for a module to structure connection, and other structural bolts shall be of grade HDG 5.6 or 8.8 or exclusively designed for solar tracker systems by manufacturers. Which should suffice the design life for 25 years and more for Corrosive Category proposed for Solar Park and confirm to Indian / international code provision.



6.6. PROTECTION AGAINST CORROSION & UV

Appropriate measures shall be considered, as required, to protect the structure, foundation, and all components against corrosion during the expected lifetime of the Plant. Structural steel shall be hot dip galvanized as per ISO 1461 (or BS 729), EN 10346, ISO 14713, IS 4759, ISO 9223 and as per Corrosive Category of proposed Solar PV Site.

Non-metallic materials placed outdoors shall be UV and sand resistant and withstand high ambient temperature operation regimes as per the climatic conditions over the whole Plant design lifetime, and where materials are specified in any part of this RFP, those characteristics are to be considered as a minimum requirement. Metallic materials are not explicitly required to be UV resistant but in case protective coating is required, this shall be UV and sand resistant.

All materials used for concrete, reinforced concrete structures, steel structures, aluminum structures or structural elements or any other building material shall be of high quality, free from defects likely to undermine the strength and duration of service of the Plant.

6.7. BEARING

- a) The bearing should be type tested for operation cycles which solar plant will go through in its life of 25 years.
- b) Preferably there should not be any lubrication in the bearing, but if there is any, then it should be maintenance free. No cleaning should be needed.
- c) The bearing should also be resistant to dust, water and any other external parameters.

6.8. MOTOR AND ACTUATOR

- a) The motor should be IP 65 or better and it should be powered by reliable supply to drive the link through gear or hydraulic/electric actuator.
- b) The temperature rises in the motor during operation specified in IS12802: 1989 should not be more than approximately 10°C.
- c) The location and moisture or fumes shall not seriously interfere with the operation of the motor.
- d) The severity of vibration for the motors shall be within the limits specified in IS 12075: 1987.

6.9. CONTROLLERS



- a) Trackers should have an industrial grade system for its automatic control and operations. For all outdoor controllers, it should be housed in IP-65 enclosure.
- b) Battery back-up should be provided for Controller and motor for at least 15 minutes with power pack cum UPS. Alternatively, the bidder can provide backup power from the UPS of inverter room or CMCS room.
- c) The controller must be enabled with a feature of stowing during highspeed winds.
- d) The Real Time Clock (RTC) of the trackers shall have a facility to be time synchronized with SCADA on Network Time Protocol (NTP).
- e) A suitable communication link between the master controller of tracker and tracker SCADA system shall be arranged. The software for communication and analysis shall be provided by the tracker supplier. Tracker SCADA shall be interfaced with solar SCADA on an open protocol such as MODBUS.
- f) Battery back-up should be provided for Controller and motor as per design specified in Cl 6.2. Alternatively, the bidder can provide backup power from the UPS of inverter room or CMCS room.

6.10. STUDIES/REPORTS

The following studies, and reports shall be submitted by the Bidder for the offered solution. The studies and reports shall provide a positive outcome of the respective tests, designs, and concepts for the utilization of the proposed single axis tracking system in the Project:

a) Stow strategy control system: The Tracker supplier is solely responsible for the definition and implementation of a proper stow strategy, which clearly demonstrates and guarantees the safe operation of the tracker during all wind events with speed up to and including the maximum one defined as per local structural code. The following points, including but not limited to, should be made available as part of the safety stow strategy:

- Tracker inclination and orientation at safety stow position
- Maximum wind speed in [m/s] as [3-sec gust / 10min average] defined at 10m height which the tracker can withstand in working position
- Stow alarm function and wind speed at which it is triggered
- Safety strategy during installation / commissioning



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- In case that batteries are used, which is the minimum charge level required in order to reach safety stow position
 - Security of communication protocols required for the active stow
 - Time requirement to move the tracker from working position into stow position considering also safety factors
 - System redundancies that help to minimize risk of failure. Emergency system in case of tracking or measurement defects
 - Dynamic analysis and tests along with static coefficients based on the actual tracker configuration, stiffnesses and geometry
 - Aeroelastic instability analysis for the proposed tracker structure to show that the stow angle will not result in aeroelastic instability
 - Definition of tolerances, maximum terrain inclinations North-South, East- West
- b) Wind tunnel tests from a recognized wind expert institute (CPP Wind Engineering, RWDI or an alternative experienced institute subject to approval by the Off taker).
- c) Independent Engineers Bankability review report from reputable agencies like Black and Veatch, DNV, IITs or other premier institutions/agencies.
- d) Structure design review document from any IIT civil/Structural certifying department, if required.

7.0 QUALITY ASSURANCE PLAN (QAP) & INSPECTION:

- 1.1. Detailed Material Quality Plan (MQP) for Tracker and its accessories shall be submitted within 7 days from the manufacturing clearance for BHEL/End Customer's approval.
- 1.2. The Tracker and all its accessories shall be inspected by an authorized representative of BHEL/End Customer/TPI at Manufacturer's/Supplier's premises before dispatch as per approved QAP (Quality Assurance Plan) of manufacturing. The items shall only be dispatched after issue of Material Dispatch Clearance Certificate (MDCC).



- 1.3. Bidder to raise inspection call 7 days in advance. The inspection call should contain BBU ref., QAP ref., internal test reports, RMTC etc. for review.
- 1.4. For Installation & Commissioning works, a detailed Field Quality Plan (FQP) shall be submitted within 7 days from the manufacturing clearance for BHEL/End Customer approval. The FQP shall detail out for all the works, equipment, services, quality practices and procedures etc in line with the requirement of the technical specifications to be followed by the BHEL Sub Contractor at site. Tracker Vendor has to supervise and ensure follow of FQP during Installation works.

8.0 WARRANTY FOR TRACKER SYSTEM:

- 10-year warranty starting with the successful commissioning of complete tracker system for the structural integrity of Tracker System including but not limited to the design, material, MMS, power unit, motor, gear, damper, controller etc.
- 25-year lifetime design (at least) considering local ambient conditions and in respect of all standards for the PV modules support structures and foundations
- 25 years for corrosion protection.

9.0 COMPREHENSIVE ANNUAL MAINTENANCE CONTRACT (AMC)

Bidder has to furnish comprehensive AMC on yearly basis from the date of completion of O & M of the Tracker system for period specified in Project Information. Comprehensive AMC shall include all preventive maintenance and breakdown maintenance including replacement of any component to ensure that equipment is working satisfactorily as per design/system requirement. Bidder has to depute sufficient no. of persons at site during AMC period as per project size requirement. During AMC period, the OEM is required to respond within one working day through telecom or any electronic means. This AMC to include the following:

- I. Attending to and resolving any breakdown/fault of the tracker system.
- II. Periodic maintenance schedule for checking the Tracker condition and any other maintenance needed to maintain healthiness of Tracker system. The bidder shall be



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responsible for supply of all spare parts, repairs / replacement of any defective equipment at his own cost as required from time to time during the AMC period.

- III. Bidder shall maintain a minimum stock of each component of Tracker system and its accessories as spare at site during complete AMC Period for maintenance of the system as per requirement. Bidder to replenish the spares if consumed and maintain minimum stock at any time during AMC period.
- IV. Schedule and methodology of checking of tracker system components periodically for its wear and tear.
- V. Schedule of preventive maintenance and checks
- VI. Mandatory quarterly to assess the Tracker system for any failure or any sign which may lead to subsequent failure. Vendor to send the assessment report to BHEL/End customer through email.

In case of severe breakdown of the system, OEM has to send their expert representative within 72 hours. For the minor faults not hampering the generation, the OEM has to get the fault rectified within 7 working days. Failure from the OEM to adhere the activity and the time schedule may lead to BG encashment.

10.0 DELIVERY SCHEDULE:

Will be intimated at the time of inviting project specific tender.

11.0 QUOTATION AND PRICE VARIATION DUE TO CHANGE IN PV MODULE CAPACITY

The bidder shall design the Tracker system as per the PV Module wattage for Min. 540 Wp. The quoted cost shall be based on minimum wattage of Modules and DC capacity specified in project information and BOQ. However, there is a contract price adjustment on account of variation of PV module wattage. Price variation shall be adjusted as per the formula below:

Award Price based on 540Wp = P

Reference Wp/SqM Considered for 540 Wp Module = 209.41

Contract Price Variation for each unit increment in Wp / SqM.

$\Delta P\% = (-) 0.27\% \times (Wp / SqM_{new} - 209.41)$



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Where,

SqM is Area of Module in m²

Wp/SqM_{new} is the Wp/SqM of Offered Module by BHEL.

Final Price after Correction = $(1 + \Delta P\%) \times P$

All values for calculation purpose would be rounded off to 2nd Decimal Place only.

Example:

Award Price including all Taxes and Duties (P) = INR 100 Crores (Say)

BHEL Offered Weighted Average Nominal Wattage = 590Wp with Module Dimensions as 2350x1150 (Say).

Wp / SqM for Offered Module i.e. Wp/SqM_{new} = 218.32

Difference of Wp / SqM = 218.32 - 209.41 i.e. (+)8.91

Correction on awarded price ($\Delta P\%$) = (-) 0.27% x (+) 8.91 i.e. (-)2.41%

Final Contract Price Post Correction = $(1 - 2.41\%) \times 100 \text{ Cr.} = 97.59 \text{ Crores}$

The reduction factor of price will be applied on all BOQ line items.



SOLAR BUSINESS DIVISION

TPQR
REV.00

TENDER NO. MANPVT0003

TECHNICAL PRE-QUALIFICATION REQUIREMENTS (PQR)

Item: DESIGN, MANUFACTURING, SUPPLY, INSTALLATION AND COMMISSIONING OF TRACKER SYSTEM

Sl. No.	PRE-QUALIFICATION REQUIREMENTS	Bidders claim in respect of fulfilling the PQR Criteria	
		Name and Description of qualifying requirements	Supporting document
A	Technical Criteria		
A1	<p>The Bidder to be an OEM of tracker systems and should have designed, manufactured, supplied, erected/supervised erection, and commissioned/supervised commissioning Solar Tracker System of the proposed design/type of cumulative capacity of 50 MWp or above, out of which at least one such supply order for a single plant should be of 10 MWp or above capacity.</p> <p>The bidder may use the credentials of its Parent/Group/Holding company for meeting the requirement. The reference plant in which 10 MWp or above capacity Solar Tracker System was supplied, must have been in successful operation for at least one (1) year as on Offer submission date for Techno-Commercial MOU.</p>	As an evidence vendor shall submit PO/WO copy, Completion certificates from Customer to be submitted for validation of the above experience clearly indicating date of commissioning and MW commissioned.	<p>Supporting document (Attached / Not-attached) <input type="checkbox"/> / <input type="checkbox"/> (please tick at appropriate place)</p>
A2	Technology criteria	The proposed Tracker design/type shall be of proven technology with Independent Engineers Bankability review report from reputable agencies like Black and Veatch, DNV, IITs or other premier institutions/agencies.	<p>Supporting document (Attached / Not-attached) <input type="checkbox"/> / <input type="checkbox"/> (please tick at appropriate place)</p>
A3	BHEL reserves the right to visit the plant cited in the experience certificate. Bidder has to arrange necessary permissions from Plant owner during visit.		<p>Accepted/Rejected <input type="checkbox"/> / <input type="checkbox"/> (please tick at appropriate place)</p>

NOTE: Supporting documents for qualification against PQR needs to be enclosed.

Seal and signature of the Bidder

TECHNO COMMERCIAL MEMORANDUM OF UNDERSTANDING (EXCEPT PRICE)
FOR DESIGN, MANUFACTURING, SUPPLY, INSTALLATION AND COMMISSIONING
OF TRACKER SYSTEM

BETWEEN

M/S. BHEL, SOLAR BUSINESS DIVISION, BANGALORE - 560012

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- 1.1 This Techno commercial MOU is signed for the DESIGN, MANUFACTURING, SUPPLY, INSTALLATION AND COMMISSIONING OF TRACKER SYSTEM as per the agreed specifications & commercial terms & conditions.
- 1.2 The various aspects covered in this MOU are as follows & it is agreed to follow the same without any deviation.
 - 1.2.1 Commercial Requirements as per GCC R0 & SCC R0.
 - 1.2.2 Technical Specifications DOC NO: PS-439-1426 Rev: 01
 - 1.2.3 PRE-QUALIFICATION REQUIREMENTS- DOC NO: TPQR Rev: 00
- 1.3 The party II agrees to take no deviation while submitting the offer, other than deviations agreed by BHEL with or without %age of cost of withdrawal as agreed in TC-MOU.
- 1.4 Same cost of withdrawal will be loaded in quote at the time of evaluation of price in enquiry, however bidder can withdraw such deviation in offer at the time of enquiry.

VENDOR'S SIGNATURE WITH SEAL

BHEL SBD

- 1.5 If any deviation is taken in the technical, commercial & quality points in the offer submitted by party II, the offer will be rejected straight away. Any request for revaluation will not be entertained.
- 1.6 If BHEL has any other requirement/deviation from the MOU for a particular enquiry, it shall be clearly given in the enquiry itself. Confirmation for that requirement/deviation alone is to be given by the bidder. All other terms & conditions shall be as per the MOU. Such deviations/requirements, if any, shall pertain to that enquiry alone and MOU shall be followed for all other enquiries unless otherwise specified.
- 1.7 This MOU shall be valid from _____.
- 1.8 The MOU shall stand valid for TWO (02) years from the date of finalization of the MOU. The MOU validity may be extended eve after the initial period of TWO years if required by BHEL, with the consent of party II. However, in case any change is required; the MOU may be amended before the expiry of the validity with mutual consent.