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**TECHNICAL SPECIFICATION  
FOR  
DESIGN, MANUFACTURING,  
SUPPLY, SUPERVISION  
OF  
ERECTION  
AND COMMISSIONING  
OF  
TRACKER SYSTEM  
FOR  
GROUND MOUNTED SOLAR PV  
PROJECTS**

Revision details: 02	Prepared by: VKC	Checked & Approved by: PM	Date: 30.04.2025
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## **1.0 INTRODUCTION**

The PV modules shall be mounted on metallic structures called Module Mounting Structures (MMS) having adequate strength and appropriate design, which can withstand the load of the modules and design wind pressure. Modules shall be mounted on non-corrosive support structures with Automatic motor powered Realtime East-West tracking. This document describes the technical specification for design, manufacturing, supply, installation and commissioning of Tracker system.

## **2.0 BRIEF SCOPE OF DESIGN, SUPPLY AND WORKS**

### **2.1. DESIGN**

- I. Design, Engineering and approval from End customer of complete Tracker system along with all accessories.
- II. Design, Engineering and approval from End customer of MMS material for Tracker system including foundation design.
- III. Design validation of Foundation design by conducting trial pile test at site.

### **2.2. SUPPLY OF TRACKER SYSTEM**

- I. Tracker System along with all accessories, Connections, tools & Consumables and mandatory spares specified.
- II. Module mounting structure components and all associated accessories and mandatory spares, as applicable.
- III. Any auxiliary requirement of trackers system for regular functioning or maintenance to be supplied.

### **2.3. WORKS & SERVICES:**

- I. Demonstration of erection methodology and supervision of erection during complete erection of Tracking system. Erection works shall be done by BHEL Sub-contractor.
- II. Commissioning, trial run and acceptance test of Tracking system.
- III. Comprehensive AMC of complete Tracker system including all accessories on yearly basis for specified period.



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Based on above scope of design, supply and works, a BOM will be prepared for providing quotations during project specific tendering. Detailed specification and scope elaborated in relevant section of the specification and its enclosures which are the integral part of the specification.

**2.4.BHEL SCOPE OF WORK (NOT INCLUDED IN SCOPE OF TRACKER VENDOR):**

- I. Foundation works & Mechanical Installation of Trackers shall be done by BHEL's Subcontractor under supervision of tracker supplier.
- II. Dry Robotic Cleaning system shall be installed by BHEL's another Subcontractor. Tracker system should be compliant with dry robotic cleaning system. The robots shall run cleaning cycle while tracker is in stow position, so all necessary coordination/communication will be provided by tracker manufacturer to Dry Robotic Cleaning Sub contractor, wherever required.
- III. Supply of PV Module by BHEL/End Customer as specified in project specific document.

**3.0PROJECT INFORMATION:**

As per project specific document.

**4.0 SITE SPECIFIC DATA:**

As per project specific document.

**5.0MANDATORY TECHNICAL REQUIREMENTS/DOCUMENTS TO BE SUBMITTED BY THE BIDDER ALONG WITH TECHNICAL BID:**

- I. Bidder should be an OEM of Tracker System. A self-declaration along with details of manufacturing facilities to be submitted.
- II. Details and drawings of the Trackers being offered to BHEL.
- III. Indicative MQP and FQP of the Tracker System.

**6.0TECHNICAL SPECIFICATIONS FOR TRACKER SYSTEM**

**6.1.GENERAL**

The Tracker System shall be of proven design capable of tracking Sun's path actively, intended to maximize the energy output from PV Module. Design shall be based in accordance with the site climatic conditions and seismic loads, soil characteristics, thermal loads caused by expected fluctuations of materials and ambient temperatures and the minimum required design wind speed.



## **6.2. CODES AND STANDARDS**

The Tracker system must conform to the latest edition of any of the following IEC/ equivalent standards for Tracker system design qualification and type approval.

<b>CODES</b>	<b>Description</b>
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 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 for Design of Module Mounting structures (MMS) with trackers.**

## **6.3. DESIGN**

### **6.3.1. Tracking System**

- Only Single axis East-West real time tracking
- Configuration - Both, single and multi-rows options are accepted.
- Tracker Range of Movement (ROM): +/- 45 degrees or better
- DC Self-powered drive system with battery backup of 3 days autonomy.
- Individual row-level bi-directional control
- Redundant communication (wireless) for individual Trackers
- Stow configuration: optimal Angle, as per aero elastic instability analysis.
- Design wind speed as per site specific documents.



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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 as per project specific document for Single Axis Tracker based system.

### **6.3.2. MMS Design**

#### **I) Design Loads:**

A. Dead Load: The load obtained by summing up the weight of modules and self-weight of Structure including Purlins, rafter/beams, tracking system, Bracings, struts, columns, necessary fittings, etc. to be added as a Dead load.

B. Wind Load: The wind load (positive and negative) normal to surface on the modules and wind load on the structural members.

C. The concept of wind tunnel studies may be considered in the design philosophy for fixed seasonal module mounting structure as well as Tracker System.

If the Bidder is going for wind tunnel study for the design and analysis of complete MMS following has to be ensured.

- i. It must be done from an institute of repute having suitable wind tunnel facility (IITs / SERC Chennai or equivalent level institute in India).
- ii. If the study is done by any reputed international facility, the study results must be vetted by the wind domain expert at any of the IITs / SERC like institutes in India.

#### **II) Design Parameters:**

- A. MMS design & analysis to be done on computer software (preferably STAAD) and the Bidder shall submit a write-up on the computer program used and its input (soft format) and output data for review and approval.
- B. An increase in allowable stresses of structural materials should not be considered during design and analysis.



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- C. Wind pressure for following loads shall be considered as follows:
- (1) Dead Load of steel with all members, fittings & panels.
  - (2) Load due to fair wind direction on design tilt angles of solar mounting structural members.
  - (3) Load due to adverse wind direction on design tilt angles of solar mounting structural members.
  - (4) Load on the side face of mounting structural members.
- D. Wind pressure coefficient, load and load combination shall be as per Indian standards (latest revision) such as IS: 875, IS: 800, IS 801.
- E. Design analysis and the forces on MMS (Compressive force, uplift force, shear and moment) shall be used for the design of foundation system.
- F. Vertical Deflection and Horizontal Sway Limits:
- Limiting Deflection: The limiting permissible vertical deflection for structural steel members shall be as per following:
- a) Maximum vertical deflection in purlin =  $\text{Span} / 180$ ,
  - b) Maximum vertical deflection in rafter (cantilever span) =  $\text{Span} / 180$  and
  - c) Maximum lateral deflection in column/vertical post =  $\text{Height} / 240$
  - d) All deflection limits can also be as per the serviceability limit defined by the module manufacturer & tracker manufacturer OR the proposed deflection limits duly approved by the module manufacturer during detailed Engineering.

#### **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. For Diffuse light optimization GHI sensors are also acceptable.
- 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.



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- e) 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.
- f) Safety measures such as stop devices shall be applied to ensure personal safety.
- g) 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.
- h) For each row an earthing cable shall be installed to interconnect all metallic parts of foundation, tracker structure and PV modules of each table. In case of Self Grounded Tracker declared by OEM, no need of earthing cables to be provided.
- i) Tracker design shall also include a provision for fastening DC cables to the structure each 500mm without causing tearing or fluttering of cables.
- j) Tracker shall able to track as per proposed stow strategy supported by Wind Tunnel test.
- k) 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.
- l) Minimum 400 mm clearance to be maintain at module edge with maximum angle or as specified in project specific document.

## **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.
- 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 one months from the actual date of issue of LOA.





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- 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 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.
- h) 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.





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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 steel structures or structural elements 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



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inverter room or CMCS room. Bidder to inform Aux. power consumption requirement to BHEL during detailed engineering.

c) The controller must be enabled with a feature of stowing during highspeed winds. Trackers should move to the wind stow positions automatically when high wind speed values are trigger from the NCUs.

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/MODBUS TCP.

## **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
- 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



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- 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 system 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



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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:

- 25-year lifetime design (at least) considering local ambient conditions and in respect of all standards for the PV modules support structures and foundations
- 5-year warranty starting with the Project Commercial Operation Date (COD) for the complete mounting structure including but not limited to the design, material, and installation of the tracker, substructure, power unit, piles, and foundations.
- 25 years for corrosion protection., damper, controller etc.

## 9.0 TRIAL PILE TESTING AT SITE:

Foundation design validation by trial pile test at site shall also conducted by Tracker Supplier at site. The scope covers conducting Initial and Routine Pile Load Tests (vertical compression, lateral, and pull-out) as per IS:2911 (Part 4)-1985. Tracker supplier has to inform pile data viz no. of piles, dia., depth, location etc. to BHEL in advance for preparation of Trial pile by BHEL's Subcontractor. Casting of pile shall be done by BHEL's Subcontractor under supervision of Tracker Supplier representative. Vertical compression tests will be carried out using the maintained-load method with hydraulic jacks reacting against a kentledge platform, applying loads up to 2.5 times the working load for initial tests and 1.5 times for routine tests. Lateral and pull-out tests will involve applying horizontal and uplift forces respectively with required factor of safety as per IS 2911. Trial Pile test procedure to be submitted by Tracker supplier for approval of BHEL/End Customer. Load displacement curves and detailed test reports shall be submitted for all tests for approval of BHEL/End Customer. Piling can be commenced only after approved pile test report by End Customer. Approval of Trail pile test is responsibility of Tracker supplier only.

## 10.0 TRAINING OF EMPLOYERS PERSONNEL

The bidder shall provide training (free of cost) to the personnel of BHEL & End Customer for 15 man-days at his works and at site for design, erection, testing, commissioning and



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O&M. Expenses towards travel, lodging, and boarding and other expenses for the personnel shall be borne by BHEL/End Customer/BHEL's O & M Subcontractor.

**11.0 SUPERVISION OF INSTALLATION & COMMISSIONING:**

- 10.1. To eliminate delays and avoid disputes and litigation, Foundation works & Mechanical Installation of Trackers shall be done by BHEL's Subcontractor under close supervision of tracker supplier.
- 10.2. Tracker Supplier to depute sufficient nos. of expert, experienced, qualified and competent person for supervision works at site based on project size requirement.
- 10.3. Demonstration & Training on Erection of MMS & Tracker to be provided by Tracker supplier to BHEL's Sub contractor for Minimum 1 Exterior and 1 Interior Table. The demonstration of erection methodology should be complete in all respect i.e. it includes the functions of tracker like tracking, back tracking, stow configuration etc. as per specification.
- 10.4. The demonstration of Erection shall be part of detailed BBU which will be finalised after detailed engineering.
- 10.5. A joint protocol between Tracker Supplier and BHEL's Erection Sub contractor shall be treated as completion of demonstration and used for payment of demonstration work.
- 10.6. Further Erection works Supervision shall be done in such a way by Tracker Supplier so that no reinstallation/modification occurs in Trackers later.

**12.0 CONNECTIONS:**

Supply of all connections for Tracker system including PV Modules shall be in the scope of Tracker Supplier.

Sr. No.	Connection	Grade
1	Solar PV module to MMS connection	SS304, A2-70
2	Other Structures	As per Site specific requirement



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- A. SS304 Fasteners (nuts, bolts, washers and U-bolts) shall be of corrosion resistant austenitic steel. SS 304 Fasteners shall have a good anti-seize finish with proper wax coating for better durability and firm resistance to all types of failures.
- B. All fasteners shall be provided according to the connection design requirement. All bolts shall be tightened with designed torque mechanically immediately after the erection of MMS to avoid any possible damage due to any incidental storm during the erection stage.
- C. One set of fasteners shall consist of one hexagonal head nut, one hexagon shape bolt, and two plain washers & 1 spring washers. The bolts and nuts with inbuilt washers may also be provided.

### **13.0 COMPREHENSIVE ANNUAL MAINTENANCE CONTRACT (AMC)**

Bidder has to furnish comprehensive AMC on yearly basis from the date of Project Commercial Operation Date (COD) for period specified in Project specific document. 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 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.





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- 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.
- VII. Replacement of equipment/spare parts/ updating of softwares being phased out is also included in bidder's scope.

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.

**14.0 DELIVERY SCHEDULE:**

As per project Specific Document.

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