TrinaTracker

1

1

The correct position of the components of the tracker to be able to track the sun correctly

Deformations and deflections caused in the poles during their installation

Cost of Balance of System will include the cost of the hardware (and software, if applicable), labour, permitting Interconnection and Inspection (PII) fees, and any other fees that may apply. For large commercial solar systems, the cost of BOS may include the cost of land and building, etc. The cost of BOS can be about two thirds of the total cost.

Cermak Peterka Petersen, Inc.

Det Norske Veritas

Engineering, Procurement and Construction

Finite Element Method

A process that protects against corrosion

Reinforcements on the inside of the plastic parts

Levelized Cost of Energy (LCOE), or Levelized Cost of Electricity, is a measure of the average net present cost of electricity generation for a generating plant over its lifetime

An exceptional metallic coating that provides a breakthrough in corrosion protection

Mean Time Before Failures

Operation and Maintenance

Post rammed into the ground

A method for obtaining plastic parts by injecting plastic into a mould

Photovoltaic

The loads on the bearing from the centre of the bearing in the direction of the radius

Research and Development

Return on Investment (ROI) is a performance measure used to evaluate the efficiency or profitability of an investment or compare the efficiency of several different investments

Rowan Williams Davies & Irwin Inc.

The profile that rotates along with the allowing tracking of the sun

(BNEF) estimated that between now and 2050, 77% of investments in new power generation will be in renewables.

Specifically, utility-scale photovoltaic energy has become an attractive investment area since installation and interconnection times are short, and it involves low risk, since energy production can be easily predicted.

The reliability of solar power plants depends on how accurately the solar trackers can follow the course of the sun. The more precisely these solar systems operate, the more efficient and the more profitable the plants will, therefore, be.

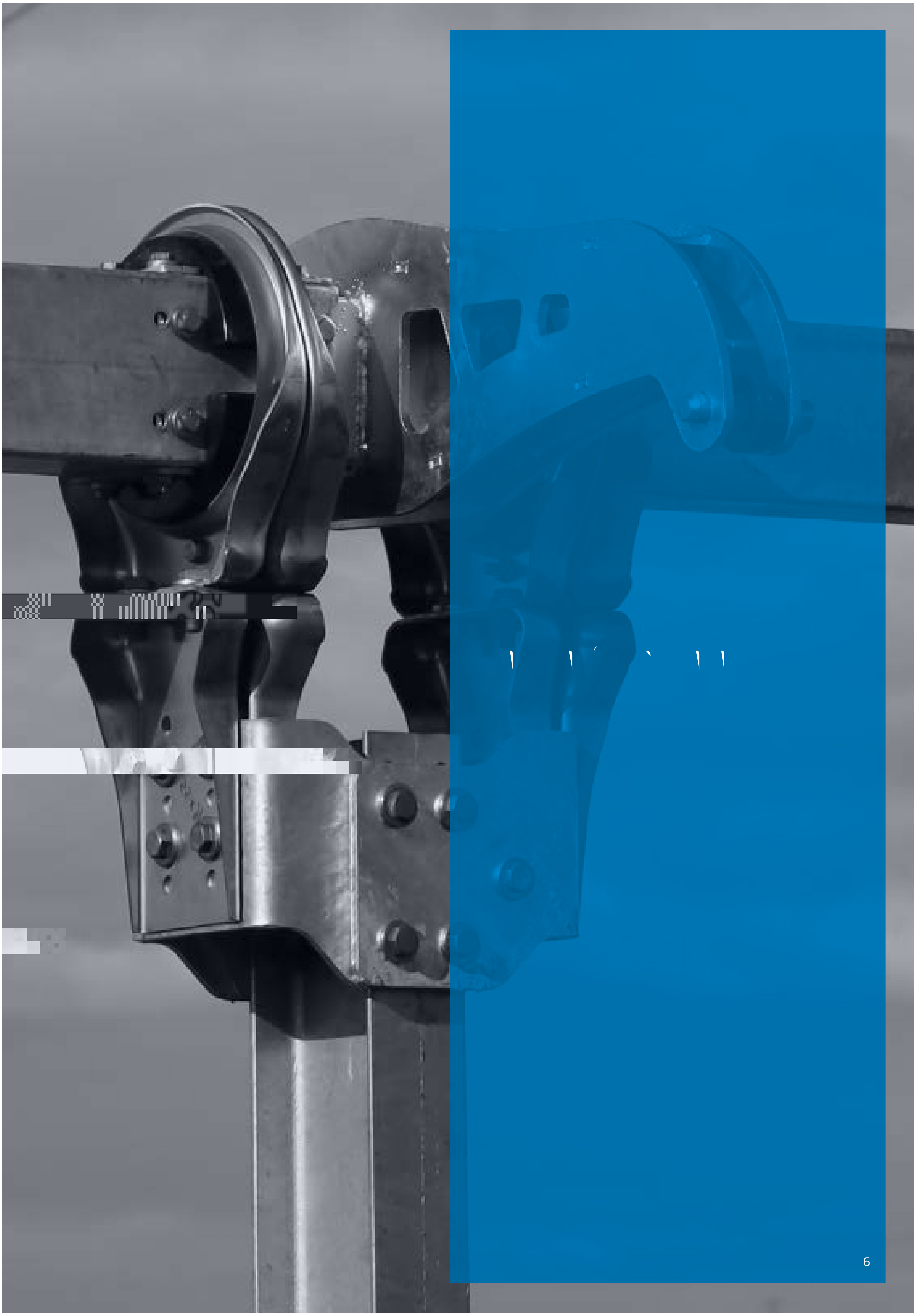
The quality of solar trackers is the key to making PV projects reliable assets. Moreover, the of projects is mostly evaluated by the quality of system components.

Therefore, bearings make an important contribution here since they are critical for the reliability and cost effectiveness of the solar power plant. These components must have high rigidity and high load-carrying capacities even when operating under extreme conditions.

's (R&D) is continuously developing improvements in the quality and design of all components in the trackers, thus increasing their reliability, and decreasing failure rates.

The company strives to be at the forefront of innovation and technology and its patented , which is unique in the photovoltaic market, is a result of its endeavour to maintain its positioning as a in the solar industry.

offers long-lasting reliable products that achieve optimized production, and increase the life expectancy of the installation while reducing and to provide maximum to their customers.



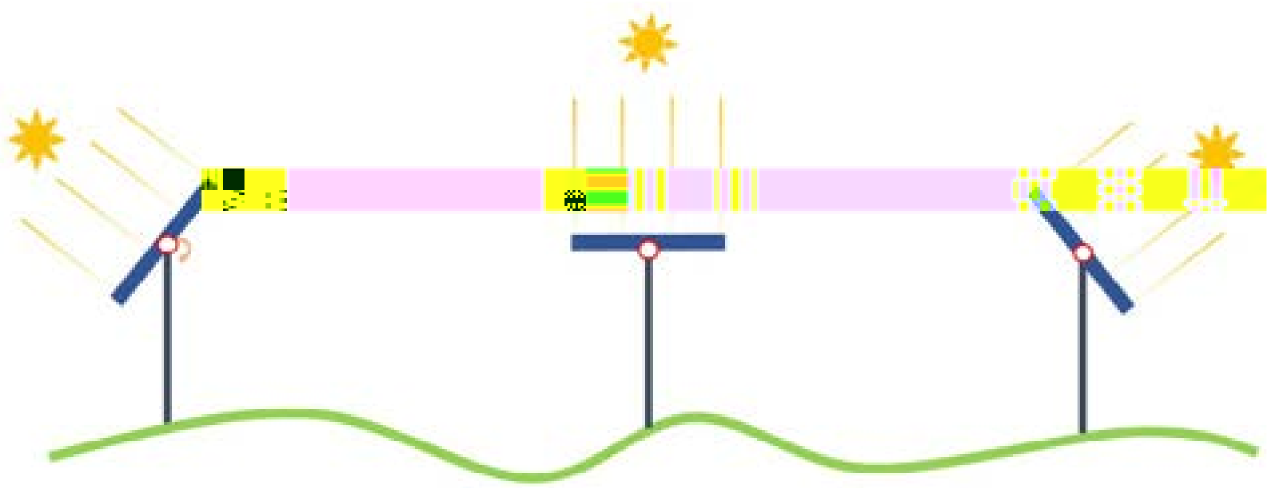
TrinaTracker

Regarding solar trackers, the design optimization of any component can contribute to achieving a more accurate rotation movement to follow the sun and capture most of the existing radiation in a particular site.

When it comes to innovation and technology, , is always.

The company works non-stop to better its design and offer trackers that include the most innovative components. Many of the components are , like the patented " ."

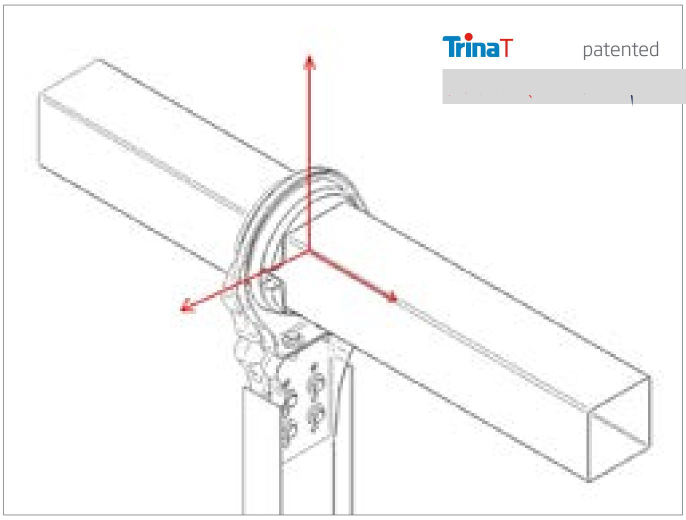
In general terms, a bearing is an element that allows the rotation of a torque tube on a fixed part or structure.



1 Tracker rotation

The use of bearings in the photovoltaic sector arises from the need to make a semi-fixed structure that allows for tracking the sun's position to take advantage of solar energy throughout the sun's cycle.

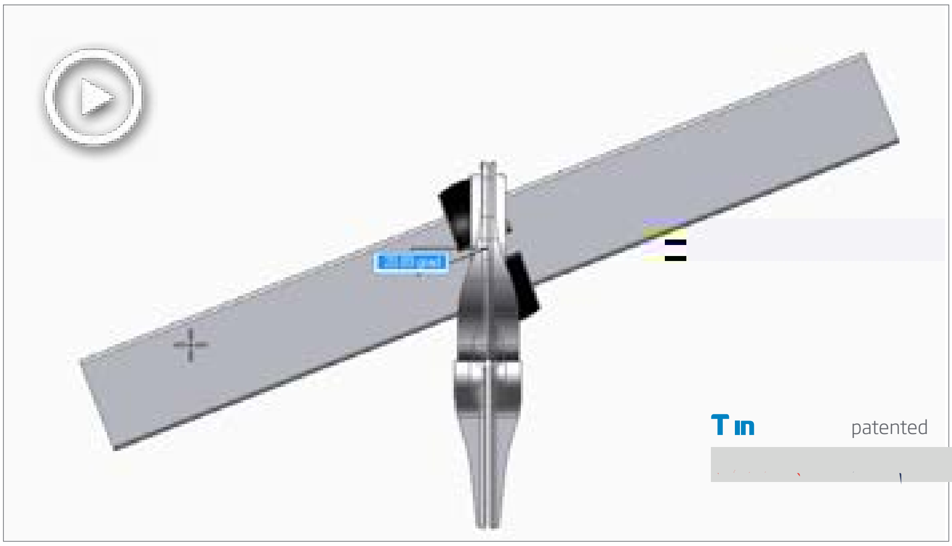
The bearing assembly is one of the main parts of a tracker. Apart from being the component that allows the torque tube to rotate (and therefore the tracking of the sun), it is the element that , and therefore it will have to withstand high vertical, horizontal, and axial loads.



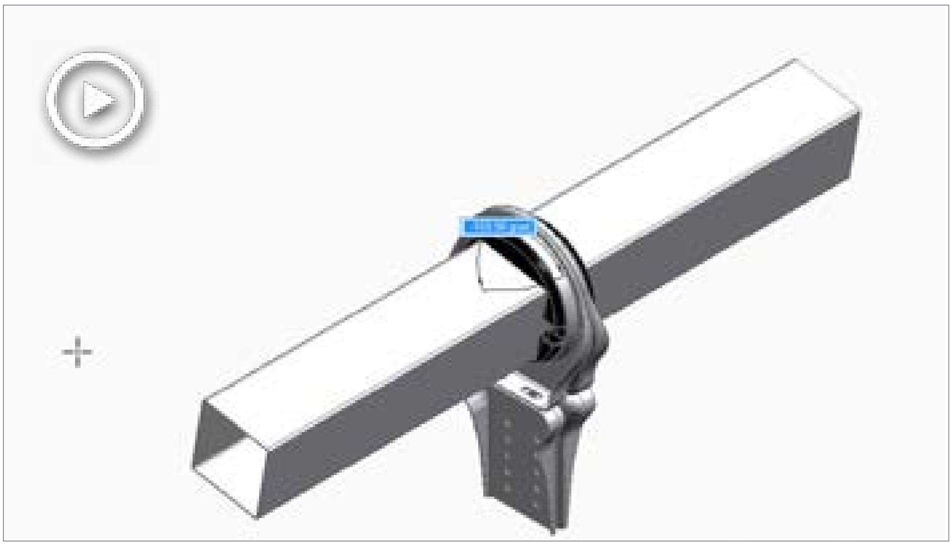
Vertical, horizontal, and axial loads

Tolerance on post twist

Without bearings, a single-axis tracker would only be a fixed structure. A good bearing design will allow for optimal tracking, minimizing energy losses due to friction. It will also allow and the generated from the driving in of the posts.



1 rotation



rotation

The first bearing design was cylindrical. In the first assembly of a test tracker, the problems of assembly and alignment became apparent.

Initially, all bearings were, and still are cylindrical; however, R&D Department has gone a step further, and after analysing and testing the installation and operation of the trackers with bearings installed, the team discovered that there was still room for improvement.

When the R&D Department installed the cylindrical bearings in testing tracker samples, they identified specific issues related to the , derived from the mechanical operation.

The use of cylindrical bearings meant adding an extra difficulty in the alignment of the trackers since they can overcome neither the bends of the poles nor the irregularities of the ground.

Alignment is a crucial process for during the assembly process since the proper functioning of the tracker depends on a precise alignment.

installed in Habei, China, 400 MW

After the performance and testing of different bearings, [illegible] designed and implemented a spherical geometry for these elements. The component, through its [illegible], rather than two-dimensional axial movement, provided such significant added value, easing and lowing risk to the tracker installation that the company decided to patent the product.

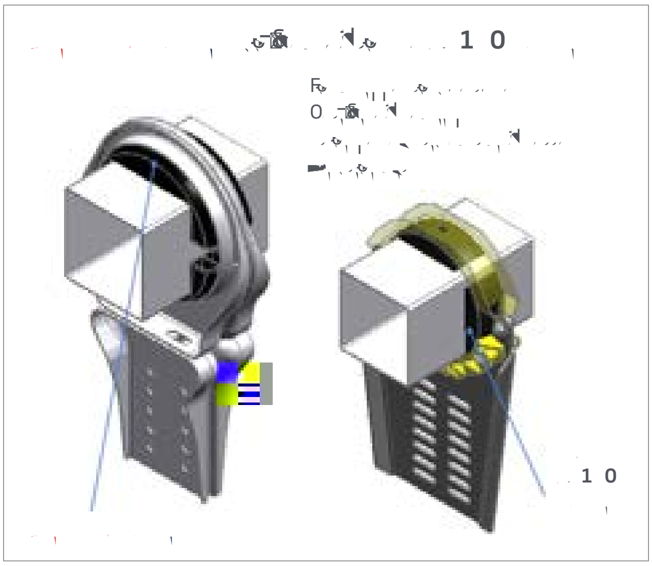
[illegible] installed in Habei, China, 400 MW

M[illegible]	N[illegible]	N[illegible]	[illegible]	A[illegible]	D[illegible]	N[illegible] P[illegible]	C[illegible]	G[illegible]	D[illegible]
European Patent	EP2735817A3 EP2735817A2	Swivel mount for solar tracker shafts	Granted	22/11/2013	30/11/2020	9th annuity	F16C11/06; F24J2/52; F24J2/54; F16C23/04	DE IT ES	
European Patent	EP2735817B1 EP2735817B8	Soporte giratorio de ejes de seguidores solares Swivel mount for solar tracker shafts	Granted	22/11/2013	30/11/2020	8th			

[illegible] 1 [illegible] patents

This [illegible] design helps the alignment of the tracker, as it aligns itself. As a result, it [illegible] for EPC companies (including reduction in civil works and cut and fill costs and risks) and improves the trackers' unimpeded operation in service.

[illegible] assembled in [illegible] 2P



Evolution of [illegible]

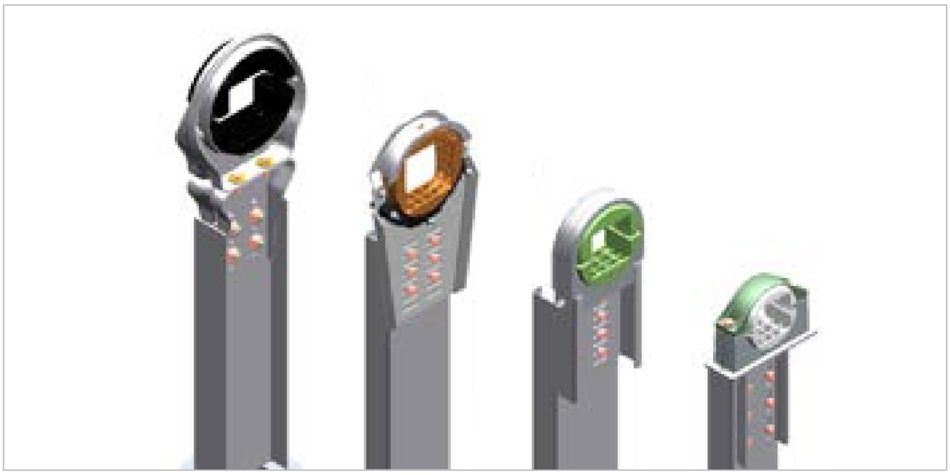
The new bearing design makes the joints more efficient; therefore, [illegible]

The joint of the lower bearing support to the W post is designed with [illegible] instead of slotted holes. This restricts movement associated with long term settlement and accordingly improves durability.

The component is made of UV stable and hard-wearing polyamide with fiberglass, which allows for the rotation axis to slide while [illegible] when trackers move.

Since the adoption of this type of geometry, the [illegible] became a critical element of the company's trackers. The bearing design has been in continuous [illegible], adapting to the different characteristics of [illegible] 1 and [illegible] and innovating in materials, both in plastics and metallic housings.

The evolution of the bearing is going hand in hand with the development of the trackers, keeping up with the latest updates and optimization of the tracker industry in terms of

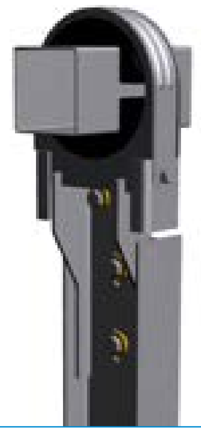


Different designs

	1	
	PA66+GF30	S420GD
	S420GD (excellent thermal performance & UV resistant)	
	POM (Excellent at self-lubrication, Hydrolysis resistance, stability of size in different temperatures, UV resistant)	
	Designed to be installed in different type of piles	
	Flexible assembly (Split design)	Rigid assembly (robust design)
	Adapted for 100, 120 mm torque tube	Adapted for 170 mm torque tube
	Tilted stow position and high horizontal loads	Extremely high mechanical strength

Differences between and 1 ´s

TrinaTracker patented



1

10

has patented the , and therefore, it is unique to the and 1 series. The rest of the trackers available in the market employ cylindrical bearings.

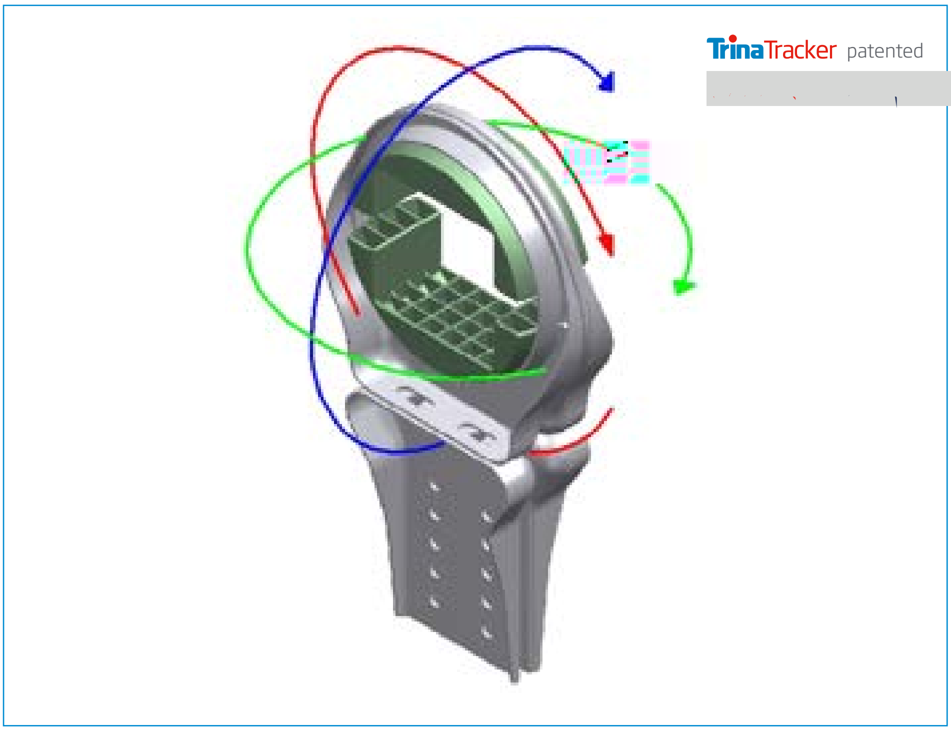
11 1 Example of a commercial cylindrical bearing

The bearing structure is very simple at a first sight. It is comprised of two parts: the "housing," or fixed part, and the "Sphere" or moving part.

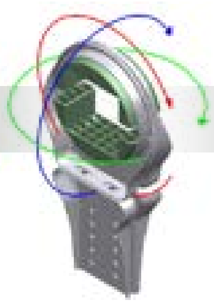
1 Housing (fixed part)

1 Sphere (moving part)

patented can move around the three axes of rotation. This type of bearing has worked efficiently for during the operation phase of trackers. The split feature of the bearing enables expedient installation of the torque tubes into the bearing assembly before the other bearing half and cap are assembled.



1	Three-axis rotation

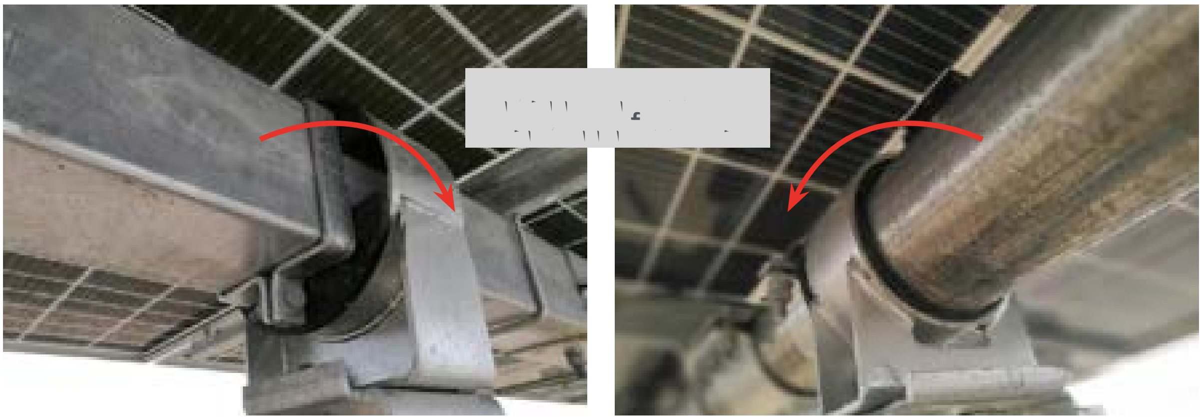


TrinaTracker patented

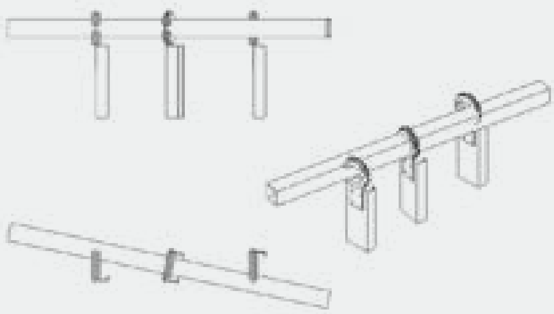
1 A [illegible]

The torsion in the "Z " axis (longitudinal axis of the post) keeps the sphere inside the [illegible] housing (cavity) and therefore maintains its ability to [illegible]

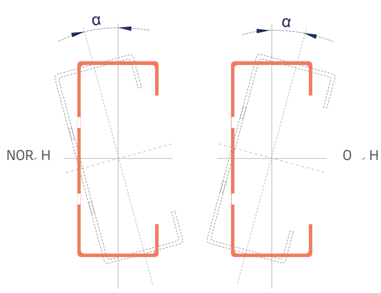
Installing cylindrical bearings would likely result in twisted posts. This effect is avoided by assembling [illegible]



1 Cylindrical bearing structure



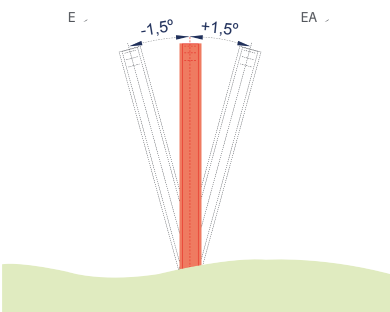
1 Misalignment with cylindrical bearings on twisted post



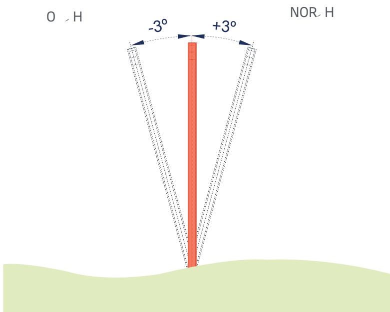
1 Twist tolerance

A [illegible]

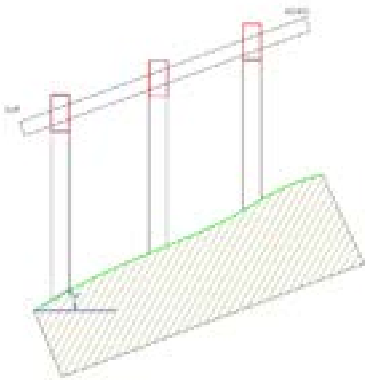
In [illegible], the bearing geometry can rotate by itself requiring without making extra adjustments or adding elements to the bearing.



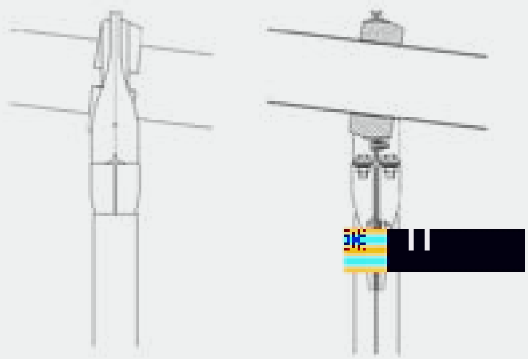
1 Slope tolerance west-east



0 Slope tolerance west-east

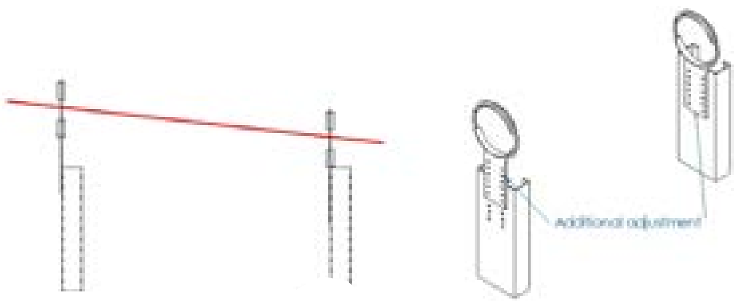


1 [illegible] installed in N-S slope



[illegible] performance when installed in N-S slope

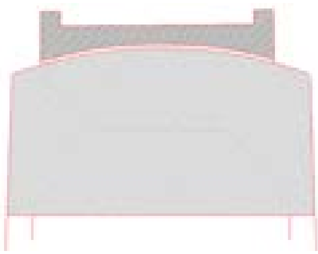
Since the cylindrical bearings are typically larger, heavier, more difficult to mount, and require more substantive housings, they become disadvantageous when achieving perfect alignment.



Cylindrical bearing performance when installed in N-S slop

P ( )

The spherical geometry of the housing interface with the other spherical elements (the balls) prevents the latter from coming out of the bearing from disassembling itself during the operation.



Front view of cut in half

R

This happens due to the same reason mentioned in the previous point.

Being eases the assembly process of the tracker.

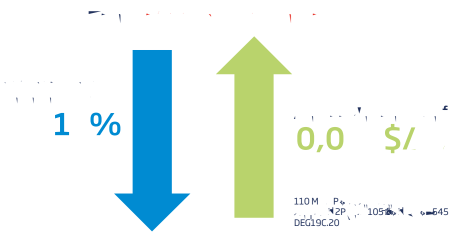
installed in 2P

50%

The allows a reduction of at least 0% of each post, resulting in a considerable reduction of the overall installation time.

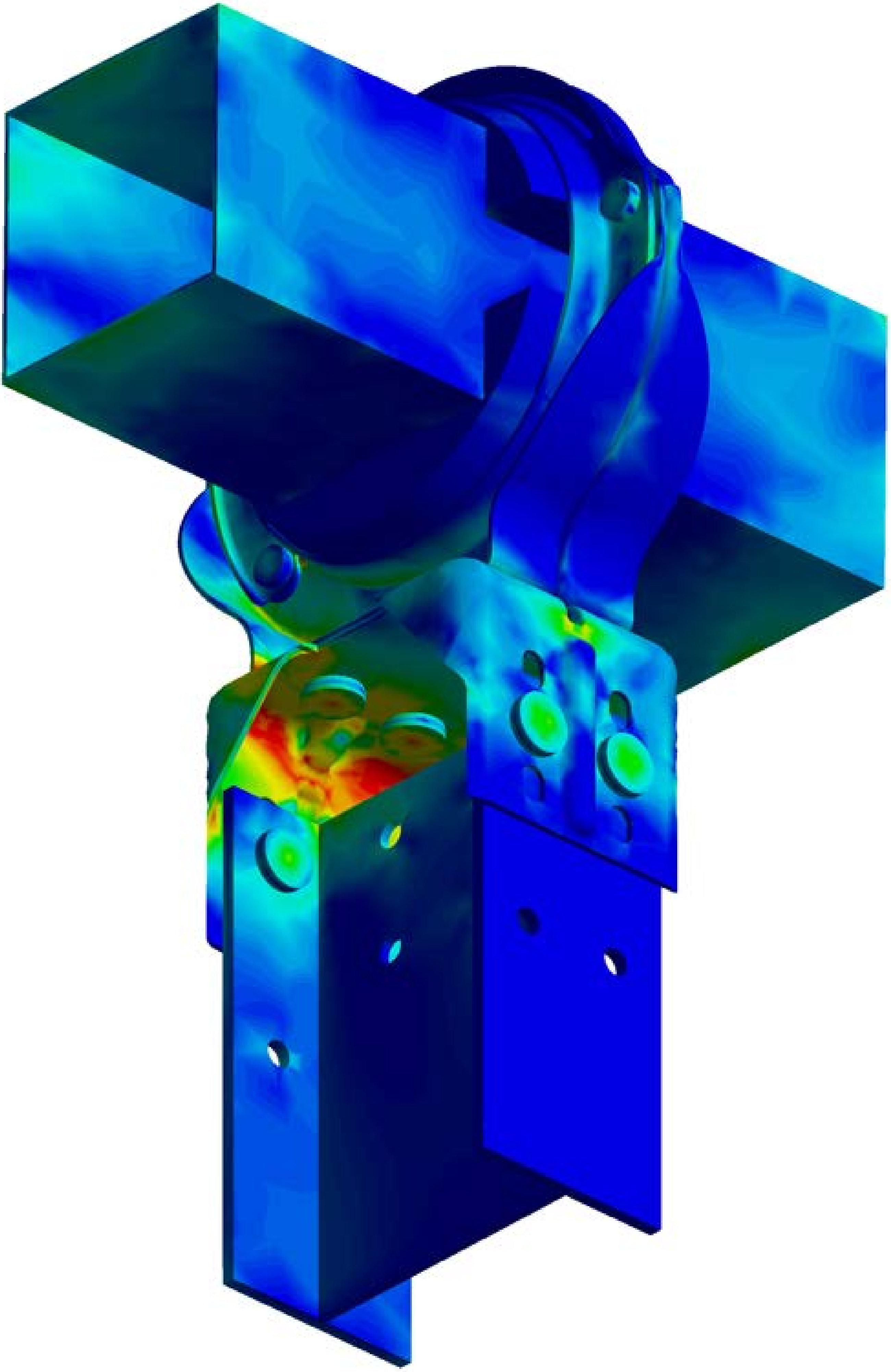
N°	13	13
( )	0.43	0.86
( )	0	5.59
( )	31.75	37.34
	15%	
M	412.75	485.42
M ( )	72.67	
	9.08	

Reduction of assembly time



Time and cost savings

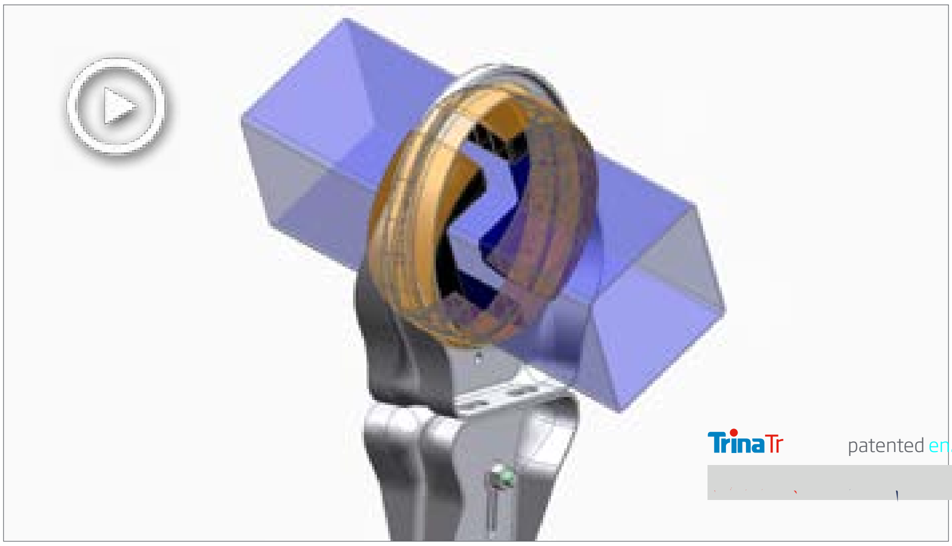
Besides time reduction, also contribute to a lower LCOE. For example, when assembling instead of cylindrical bearings in a standard tracker, the BOS cost is reduced by 0.029 $ per Wp and assembly times decrease by 15 %.



Each type of bearing is configured to withstand the maximum loads for which the tracker is designed.

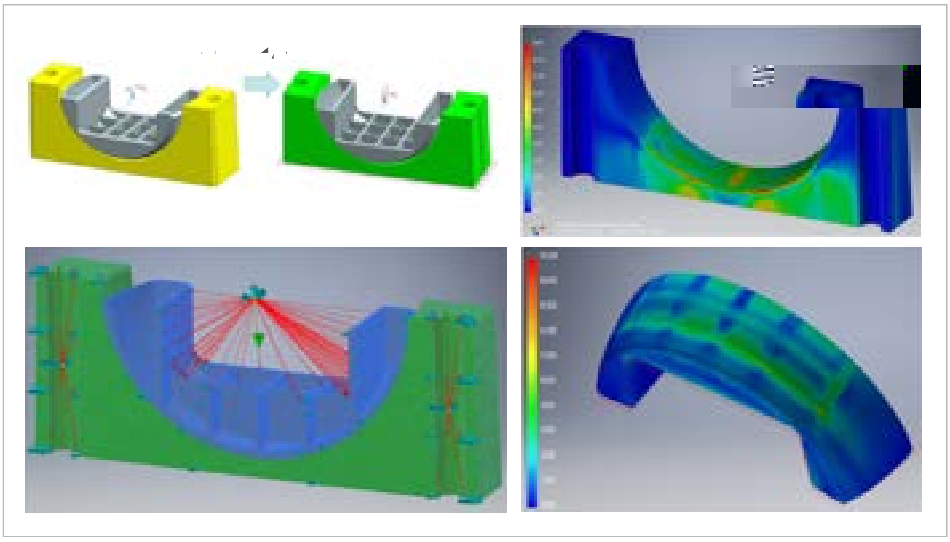
The loads for bearings are evaluated and defined for subsequent projects by the R&D team.

The geometry of the bearings allows high resistance to radial loads (vertical and horizontal) and axial loads due to the ball's spherical shape.

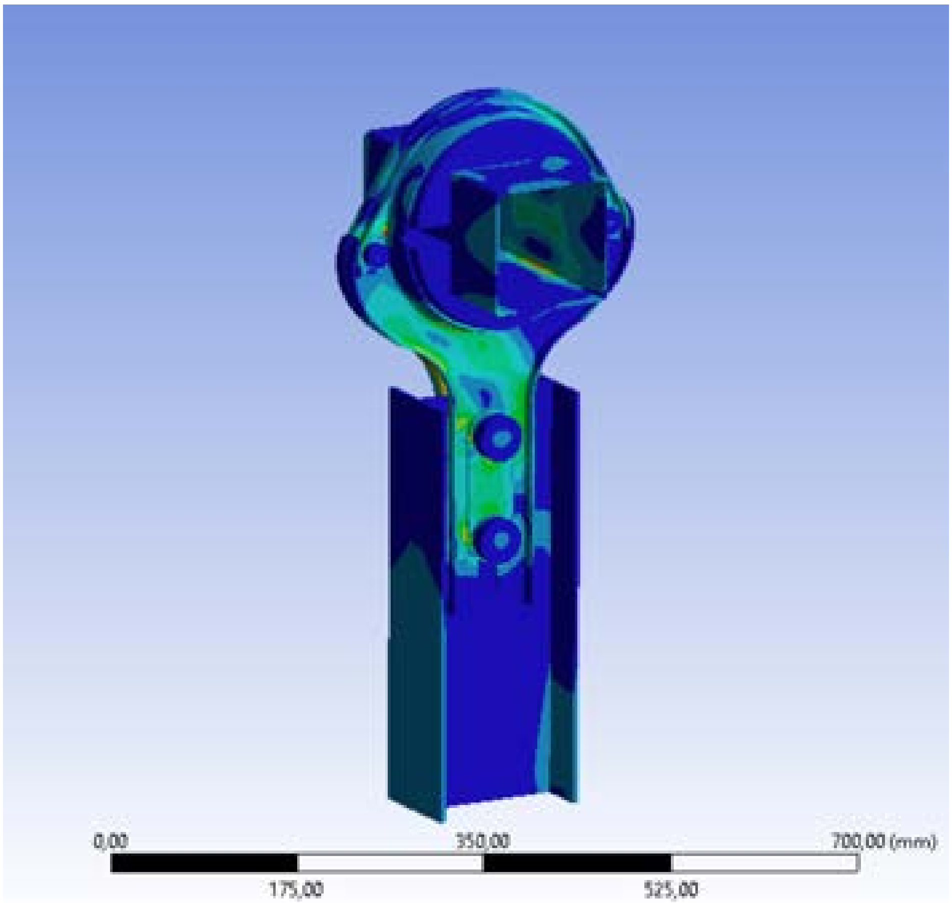


Operation of

are carried out on each model using the resulting loads to evaluate their structural adequacy under ultimate loads and optimize and check the geometry according to the plastic properties in the injection of the material.



Optimizing calculation of plastic part of bearing component



FEM calculation sample

Load tests are performed at in-house facilities or to evaluate the maximum mechanical load to which the bearings can be subjected to.

0 testing

1 testing

testing

testing

The tests are carried out following the EN1990: 2002. This regulation establishes a system of repetition of assessments to come at the resistance values of the union employing a statistical calculation.

report hardly any failure rate during the whole operation phase of the plant. Therefore, the installation of this component contributes to a reduction of operation and maintenance costs and tasks, providing to 's clients.

The failure rates shown below are reported for **1** and *.

		(N°)	100 M (N°)	R	R ( )	F R (%)	O&M (/)
5 years	Bearing	16.0	25.520	15	0.25	0.0250%	1.60

failure rate in A 1P

		(N°)	100 M (N°)	R	R ( )	F R (%)	O&M (/)
5 years	Bearing	8.2	13.317	120	2.00	0.0250%	6.66

failure rate in 2P

** Data gathered from data base*

Zuera 11 MW: Spherical bearings' excellent and long-lasting performance

is an 11MW PV plant installed in Zaragoza, Spain. Since its interconnection in 2008, no failure ratio has been reported, therefore the installation has become an example of ' excellent and long-lasting performance.

It was in **Zuera** where the first were assembled in trackers, and nearly have passed with no instances of suboptimal actuation.

installed in Zuera 11 MW, Zaragoza

Zuera 11 MW, Zaragoza

Tongchuan, 30 MW: Spherical bearings’ efficiency in uneven terrain

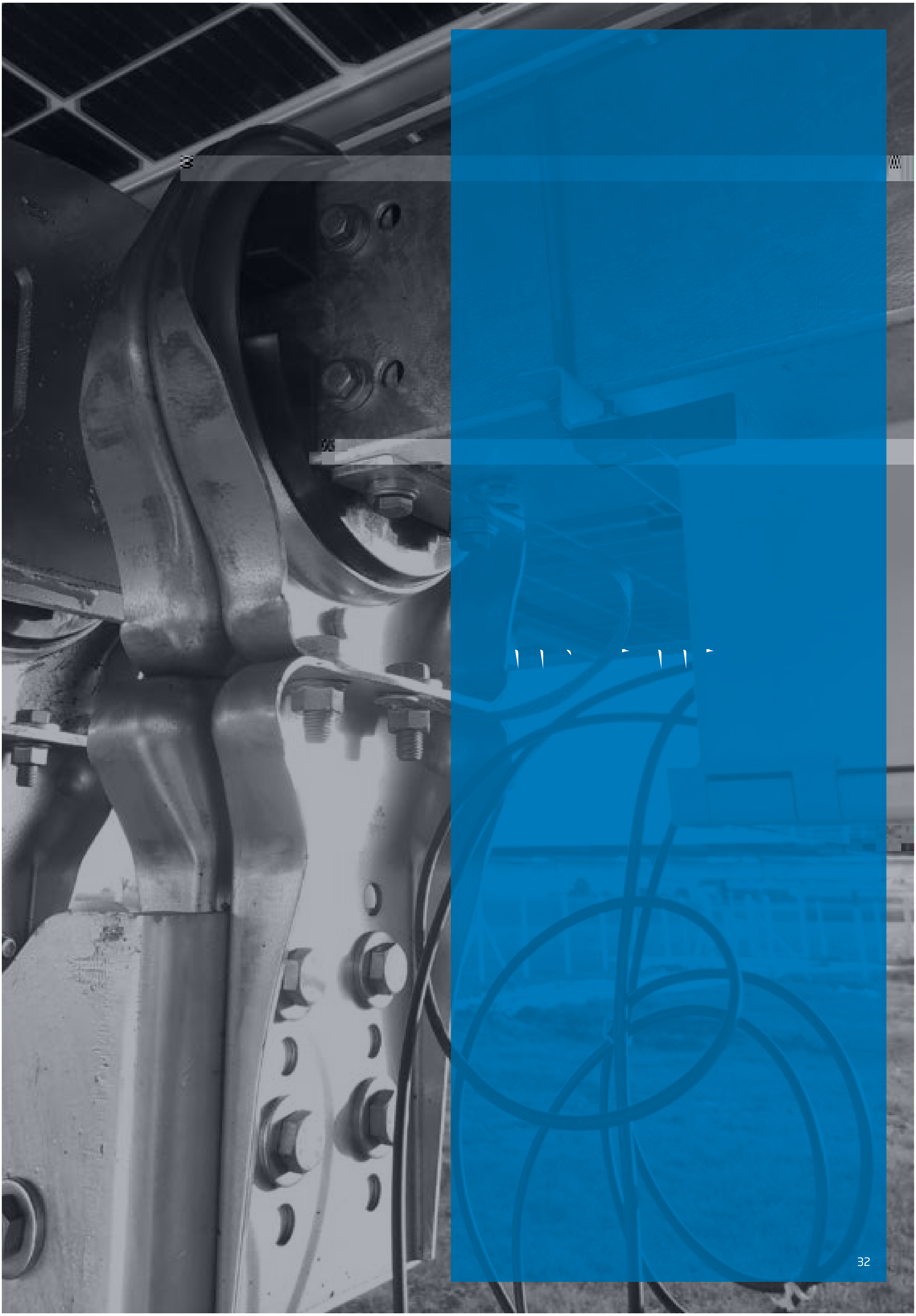
[illegible] is a 250 MW plant installed in China. The project is divided into two parts: 30 MW with TrinaPro and 220MW with fixed tilt racking system.

Surrounding mountains decreased site accessibility to both construction crews and materials. The [illegible] added one more challenge to the plant design and installation.

[illegible] employed adjustable bearing supporting structure along with flexible [illegible] and reduced number of piles per tracker to alleviate construction complexity in this project, expediting the installation process.

[illegible] project, which trackers have all spherical bearings assembled, achieve 3.5% better LCOE, brings 7.75% more generation output and 0.6% better IRR than fixed tilt structure. The results reinforce our confidence in our products and services for our customers worldwide.

Tongchuan 250 MW, China



has always focused on , aiming its resources to continuously reduce product failure and achieve the highest and most assure long term energy outcome for our clients.

This is achieved by 's fanatical continually improvement of every element in the design of the company's trackers, both at component level and as holistic system upgrading every single one of its components, increasing the solar systems' reliability and decreasing failure rates precipitously.

This document aims to demonstrate the advantages of employing in place of cylindrical bearings by evaluating all possible load conditions in service. The benefits have been shown from different analyses and comparisons.

Some of the main advantages summarized in this document are:

TrinaTracker patented

As explained here, the bearing is one of the essential parts of the tracker, and patented is recognized worldwide as industry leading.

Hundreds of customers and our own experience confirm these benefits.

& assembling example

10

10

, a business unit of . (SHA:688599), is a global solar tracker technology leader focused on providing "state-of-the-art" design solutions tailor-made to any terrain characteristics and weather conditions.

The company has more than 6GW of solar trackers deployed in 40 countries in which they accurately adapt the solar systems to each site's features. 1 and stand out in the market for their reliability, optimized design and minimal operation and maintenance requirements.

The trackers' compatibility with ultra-high power modules has been reported by . Furthermore, 1 and have been subjected to static, dynamic and aeroelastic loads through the most extensive tunnel test implemented in the solar industry and performed by leading wind engineering consultants, and .

is entirely focused on quality and innovation to provide its clients with high-technology solutions that achieve the highest energy yield and lowest costs and .

Founded in 1997, is the world-leading PV and smart energy total solution provider. The company engages in PV products R&D, manufacture and sales; PV projects development, EPC, O&M; smart micro-grid and multi-energy complementary systems development and sales; and energy cloud-platform operation.

In 2018, launched the Energy IoT brand, established the Trina Energy IoT Industrial Development Alliance and leading enterprises and research institutes in China and around the world and founded the New Energy IoT Industrial Innovation Center. With these actions, is committed to working with its partners to build the energy IoT ecosystem and develop an innovation platform to explore New Energy IoT, as it strives to be a leader in global intelligent energy. In June 2020, was listed on the STAR Market of the Shanghai Stock Exchange.

For more information, please visit

11

11

Vanguard™ 2P

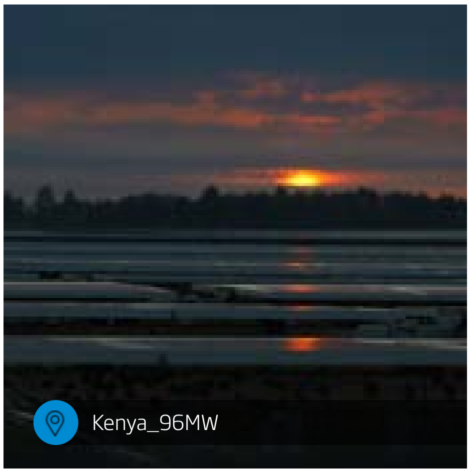
- 2P ... 210 ...
- M ...
- 120 ... 4 ...
- I ... E ...
- F ... 7 ... 120 ... M
- G ... 30% ...
- ... 8%.

Agile™ 1P

- I ... E ...
- 120 ... 4 ...
- D ... E ...
- O ...
- H ... 20% N/ , 10% E/ .
- ...
- ... 8%.

1

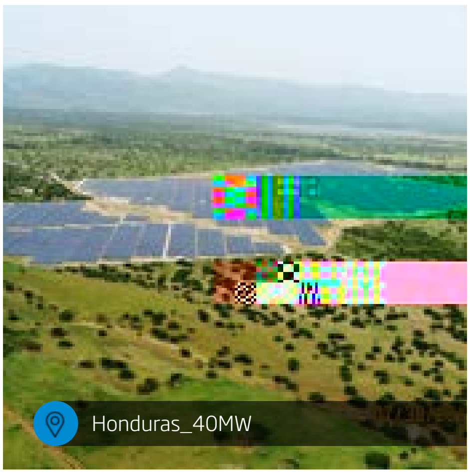
China_600MW



Kenya_96MW

Chile_33MW

Argentina_32MW



Honduras_40MW

Spain_22MW


TrinaTracker
Trinasolar