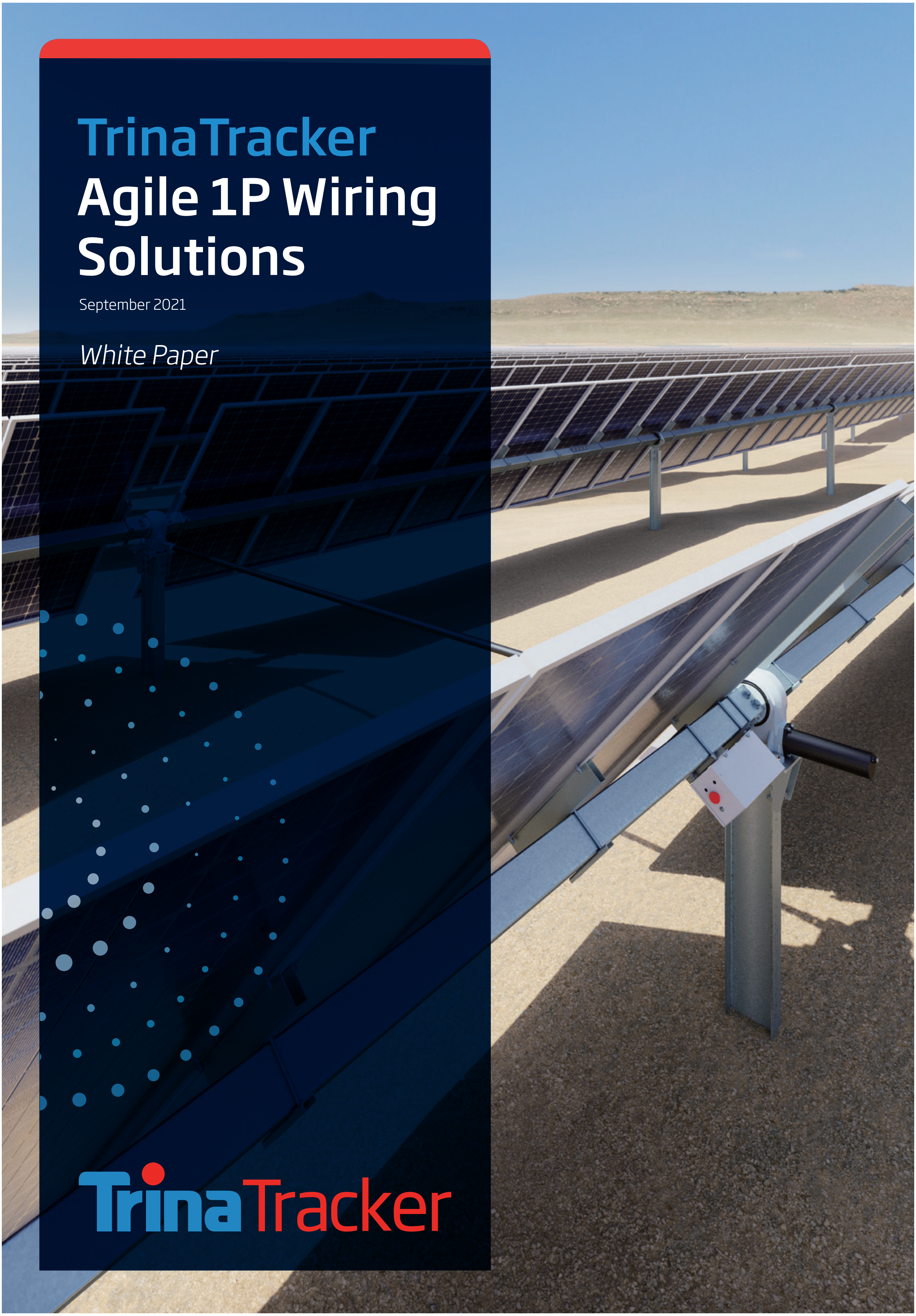
# TrinaTracker
# Agile 1P Wiring Solutions

September 2021

*White Paper*



TrinaTracker

# Content



TrinaTracker

# 1

# Executive Summary

# 1 Executive Summary

| | |
|---|---|
| **BOS** | Balance of System |
| **CPP** | Cermak Peterka Petersen Inc. (wind engineering consultants) |
| **DC** | Direct current |
| **FEM** | Finite Element Method |
| **IEC** | International Electrotechnical Commission |
| **Kg/m** | kilogram per metre |
| **LCOE** | Levelized Cost of Energy |
| **MW** | Mega Watt |
| **NCU** | Network Computer Unit |
| **N/m** | Newton per metre |
| **N-S** | North-South |
| **PV** | Photovoltaic |
| **PVC** | Polyvinyl chloride |
| **RWDI** | Rowan Williams Davies & Irwin Inc. (wind consulting engineering firm) |
| **SBA** | Smart Backtracking Algorithm |
| **SCADA** | Supervisory control and data acquisition |
| **STA** | Smart Tracking Algorithm |
| **UL** | Underwriters Laboratories |
| **US** | United States |

**TrinaTracker recommends wiring between adjacent trackers since this option simplifies the installation process.**

According to the **International Renewable Energy Agency (IRENA)** the world added more than 260 gigawatts (GW) of renewable energy capacity in 2020, exceeding 2019 by close to 50 per cent.

To be specific, solar photovoltaic is estimated to generate a quarter (25%) of total electricity needs globally by 2050, becoming one of the top energy sources.

The rapid increase of photovoltaic energy is mainly due to innovations along the entire value chain that lead to higher energy production and low **BOS** costs. The choice of pv systems is promoted by their contribution to **lowering LCOE**, which depends on their power generation capacity, installation expenditure and operating costs.

An important aspect of the path to solar innovation is the evolution of modules resulting in the availability of 600W+ ultra-high power modules which lead to considerably higher yield generation and a reduction in **BOS** costs.

Therefore, the most critical challenge for tracker manufacturers is to adapt the tracker designs so they become compatible with 600W + ultra-high power, mitigating the associated wind risks involved in their accommodation, guaranteeing optimum energy production and low installation and operation and management costs.

As the leading solar energy solution provider, **Trina Solar** has been always well prepared for changes in technology. Our product roadmap is continuously optimising the tracker designs to achieve reliable, compatible, smarter solutions.

Therefore, it is not surprising that the **TrinaTracker Agile 1P** series, compatible with large size modules, allows higher yield generation even when installed in sites with the most adverse terrain characteristics and under extreme weather conditions. Moreover, the trackers also contribute to LCOE since they are easy to install and require minimum operation and maintenance.

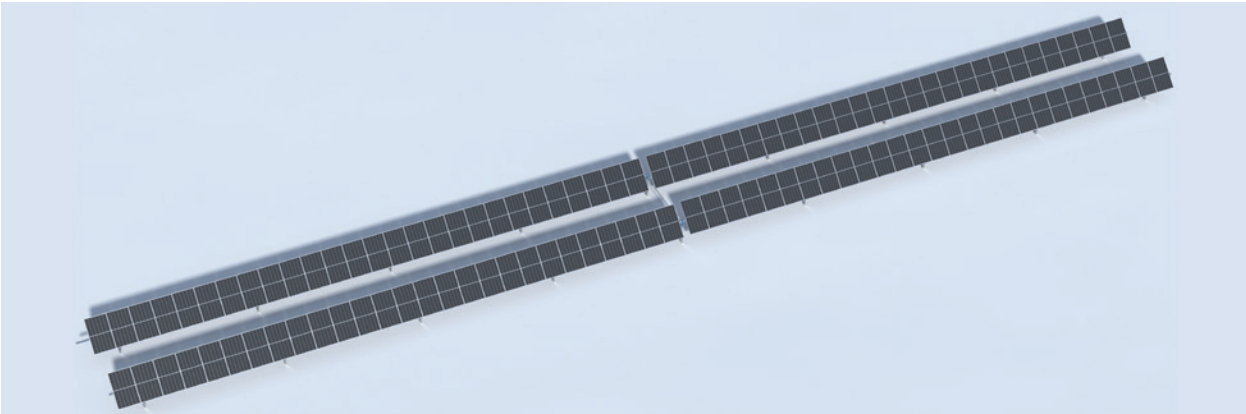


**Image 1:** TrinaTracker Agile 1P Dual Row


# 2

# Agile 1P Primary Wiring Solutions

# 2.1 Introduction

The photovoltaic industry has experienced a tremendous evolution over the past two years, leading to higher energy production and lower installation costs.

The module industry experienced some substantial changes from the beginning of the millennium until 2014. However, the arrival of **bifacial** modules in 2018 represented a significant technological milestone, which was followed in 2019 by the production of large-format modules to accommodate broad wafers (M10:182x182mm and M12: 210x210mm).

The widespread availability of large-format modules and the increase of energy generation brought about a significant **reduction in system cost**. Furthermore, the need arose of accommodating technology changes in the PV systems, since ultra-high power modules add significant weight and require mechanical and electrical **adaptations** in trackers, to guarantee optimum yield and efficiency.

**TrinaSolar**, a leading module manufacturer and system solution provider with consolidated experience in module R&D, engineering and tracker design, prioritises aeroelastic stability and module compatibility in the process to create a tracker design that guarantees energy production and system reliability when accommodating large-format modules.

**Large-format modules add significant weight and require mechanical and electrical adaptations in trackers**

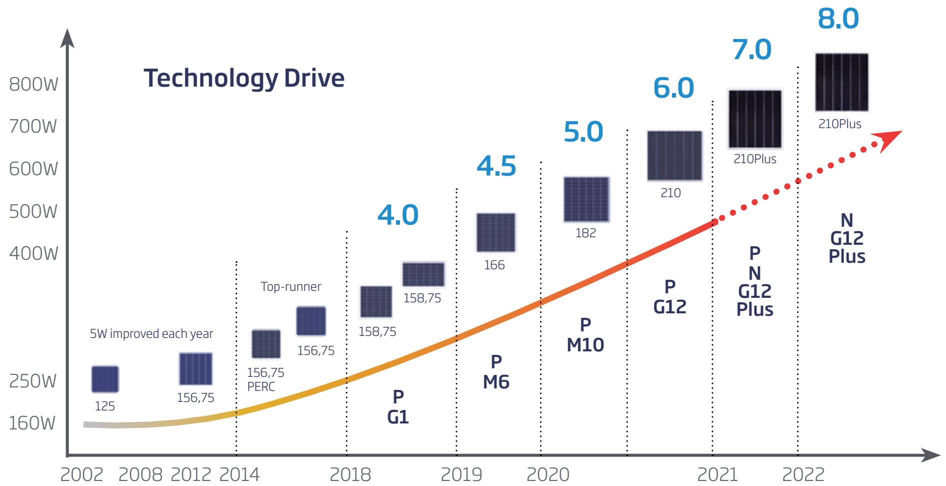



**Image 2 - Chart:** PV cell technology roadmap from 2002 to 2022

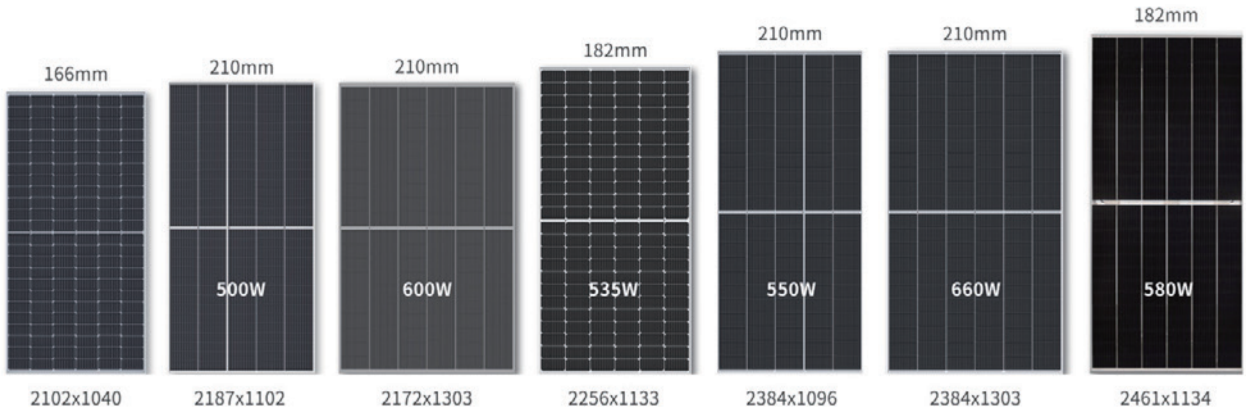



**Image 3:** PV module size change

## Change Of Module Parametres 2018 - 2021

| Timeline | | 2018 | 2019H1 | 2019H2 | 2020H1 | 2020H2 | | 2021H1 | 2021H2 |
|---|---|---|---|---|---|---|---|---|---|
| Power (Watt) | | 370 | 400 | 450 | 500 | 550 | | 600 | 660 |
| Wafer Type | | 157mm | 158mm | 182mm | 210mm | 182mm | 210mm | 210mm | 210mm |
| Frame Thickness (mm) | | 35 | 30 | 35 | 35 | 35 | 35 | 35 | 35 |
| Electrical | VOC (V) | 48.3 | 49.9 | 49.3 | 51.5 | 49.5 | 38.1 | 41.7 | 45.9 |
| | ISC (A) | 9.83 | 10.39 | 11.6 | 12.13 | 13.85 | 18.39 | 18.42 | 18.45 |
| | Toc* (%/°C) | -0.29 | -0.25 | -0.27 | -0.25 | -0.28 | -0.25 | -0.25 | -0.25 |
| Mechanical | Size (mm) | 1960x992x35 | 2024x1002x30 | 2094x1038x35 | 2187x1102x35 | 2256x1133x35 | 2384x1096x35 | 2172x1303x35 | 2384x1303x35 |
| | Size increase % | base | 4.3 | 11.8 | 23.9 | 31.5 | 34.4 | 45.6 | 59.8 |
| | Weight (Kg) | 21.5 | 26 | 23.3 | 30.1 | 32.3 | 32.6 | 35.3 | 38.7 |

**Image 4 - Table:** Module technology roadmap

The mounting of ultra-high power modules requires new geometrical and electrical features to incorporate bigger wafers and a configuration of lower open-circuit voltage, higher short circuit current, and a new string design.

**TrinaTracker** has focused its research and engineering resources on accomplishing an optimum adaptation of the tracker design parameters to solve any issue originating from the large dimensions of the panels, like the impact of higher wind pressure on the modules.

**TrinaTracker**, in collaboration with leading wind engineering experts, **RWDI** and **CPP**, has accurately adapted the trackers' design to mitigate risks and guarantee optimum energy production and system reliability.

In this document **TrinaTracker** details the cable management for **Agile 1P** tracker with ultra-high power modules modules.

The main proposals are option 2.2: wiring one half-string accommodated in one tracker to the other half fitted in the adjacent tracker. or option, 2.3: connecting strings between rows in the same tracker.

# 2.2 Connecting Strings from Adjoining Trackers

**The most convenient solution assembly is wiring one half-string in one tracker to the adjacent tracker.**

The most convenient solution from the assembly aspect is **wiring one half-string accommodated in one tracker to the other half fitted in the adjacent tracker**.

The wire that connects the two half-strings is placed on the end at opposite sides of each row, as the picture below illustrates.

This solution places all the cables connected to the inverter on one side of the tracker. Therefore, the wire goes through the available space between the two adjacent trackers.

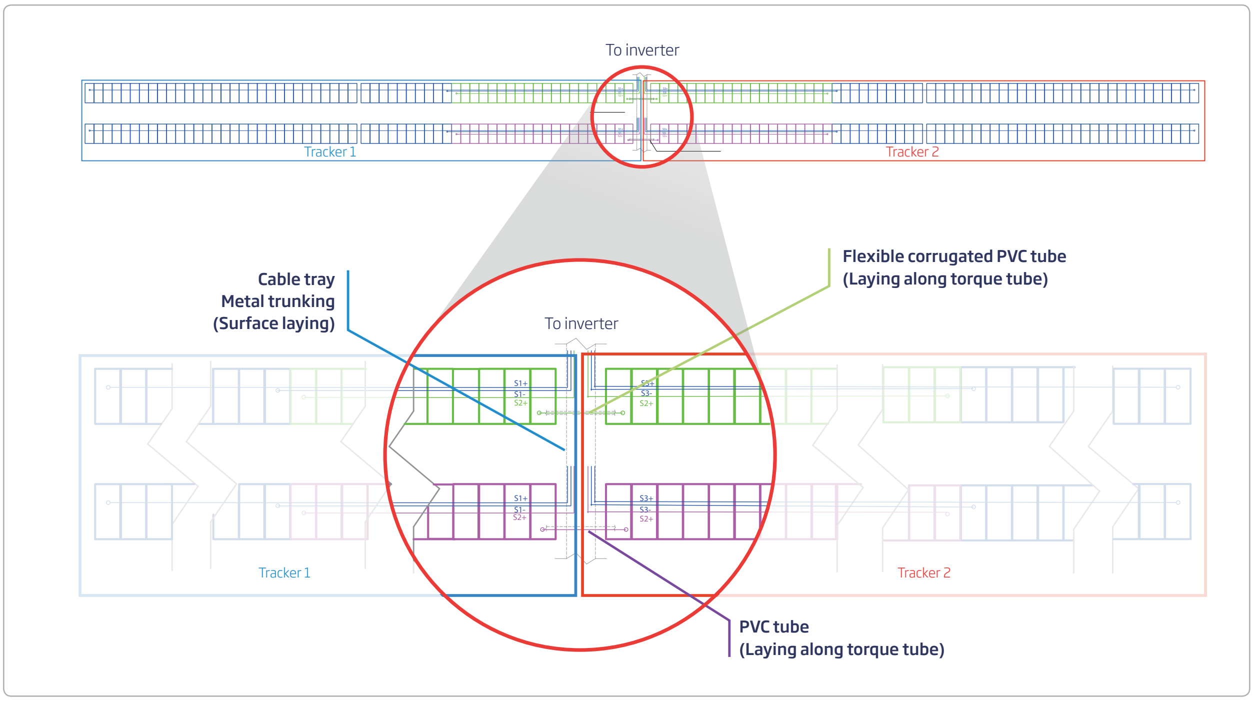



**Image 5:** Wiring strings in rows from adjoining trackers

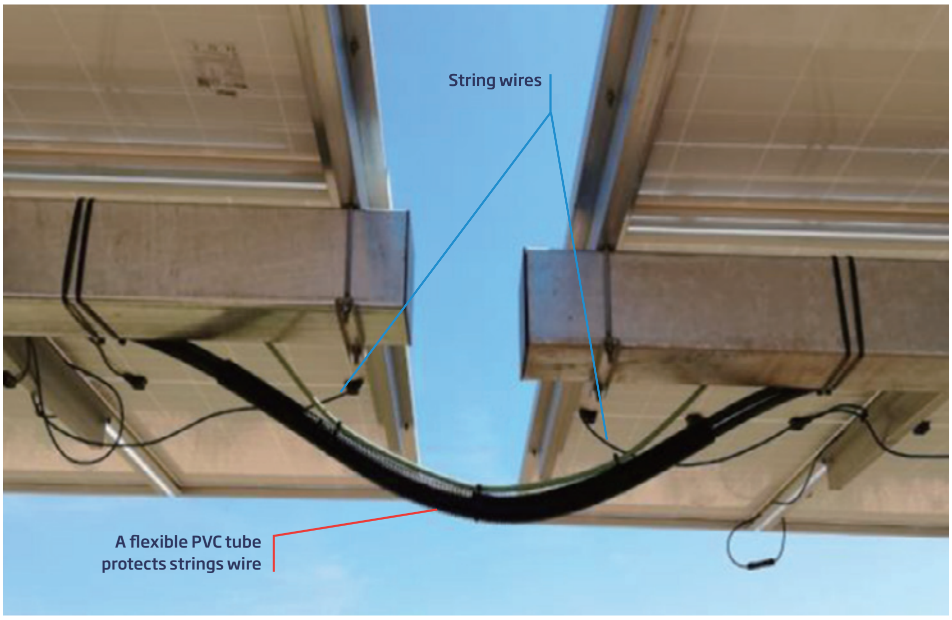


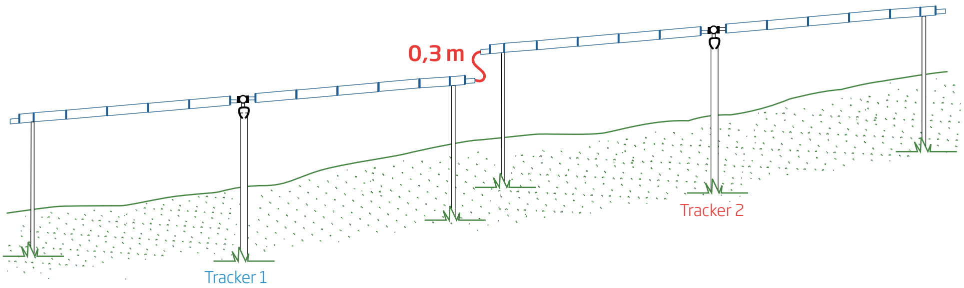

**Image 6:** Wiring between adjoining trackers

The **distance** between adjacent trackers and the **height** difference of their torque tubes are critical for this wiring option. The difference in height between torque tubes cannot be more than 0.3m.

TrinaTracker recommends the following actions to ensure the proper functioning of this solution:

- ✔ Guiding the wiring along the torque tube, since this is the area where the wiring will not be damaged by rotation
- ✔ Protecting the segment of the wire exposed to solar degradation with a tube.
- ✔ Use of a 6 $mm^2$ wire to minimize voltage drop*

** Cable section should be verified per project*




**Picture 7:** Maximum difference in height

# 2.3 Connecting Strings Between Rows in a Tracker

TrinaTracker recommends connecting strings between rows in a Tracker if connecting strings from adjoining trackers (2.1) is not feasible for a given plant when **1.5 string** does not fit in the same row.  This happens when the number of trackers is even.

Connecting strings between rows in the same tracker involves **bridging a cable** to connect two half-strings assembled in parallel rows of the same tracker.

The wiring will be done at **the end side of the tracker** connecting the two half-strings assembled in parallel rows.

The local codes need to be checked per project to avoid inductive coupling between cables.

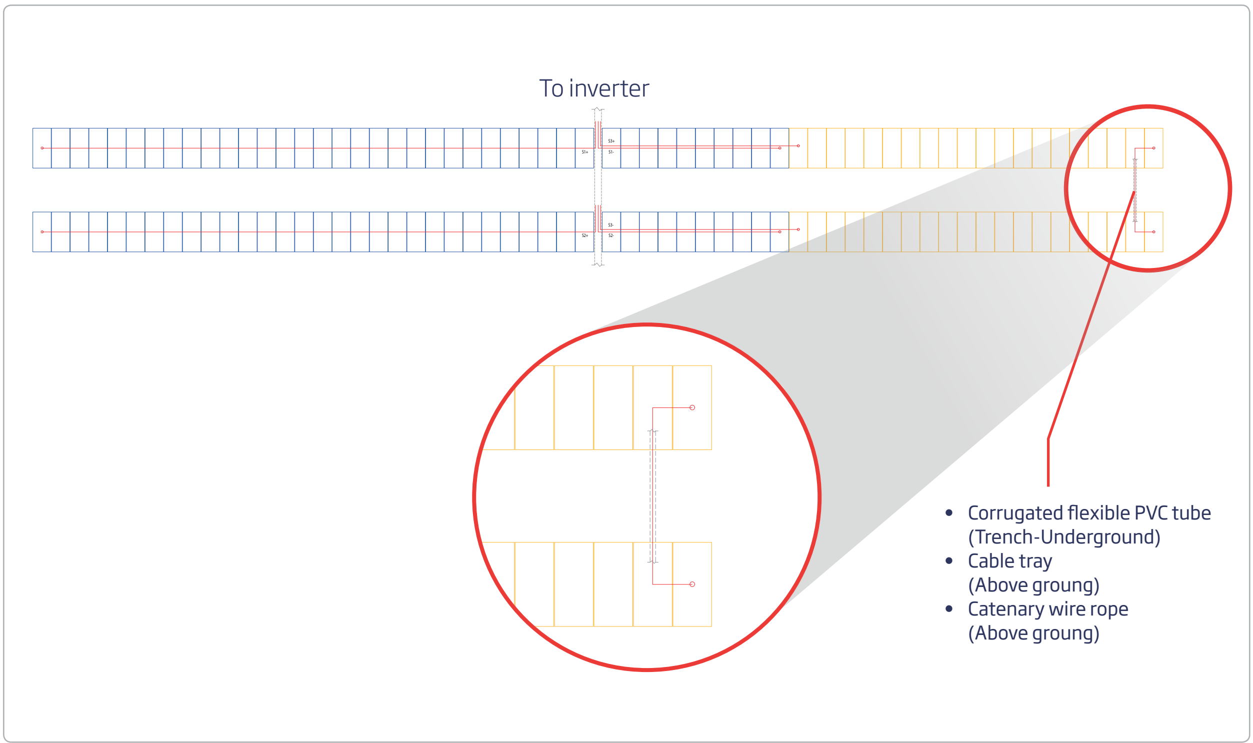



**Image 8:** Wiring strings between rows in a tracker

## 2.3.1 Trench

In the case of connecting strings between rows in a Tracker TrinaTracker recommends the trench to bridge the string cable between the rows of the same tracker.

The wires will be buried in a **trench** previously dug for this purpose.
This wiring distribution requires a **134 m DC** cable per tracker.

The additional tools required to implement this solution are a **tube to protect the wires buried underground, a mini bulldozer to dig the trench and a standard spanner**.

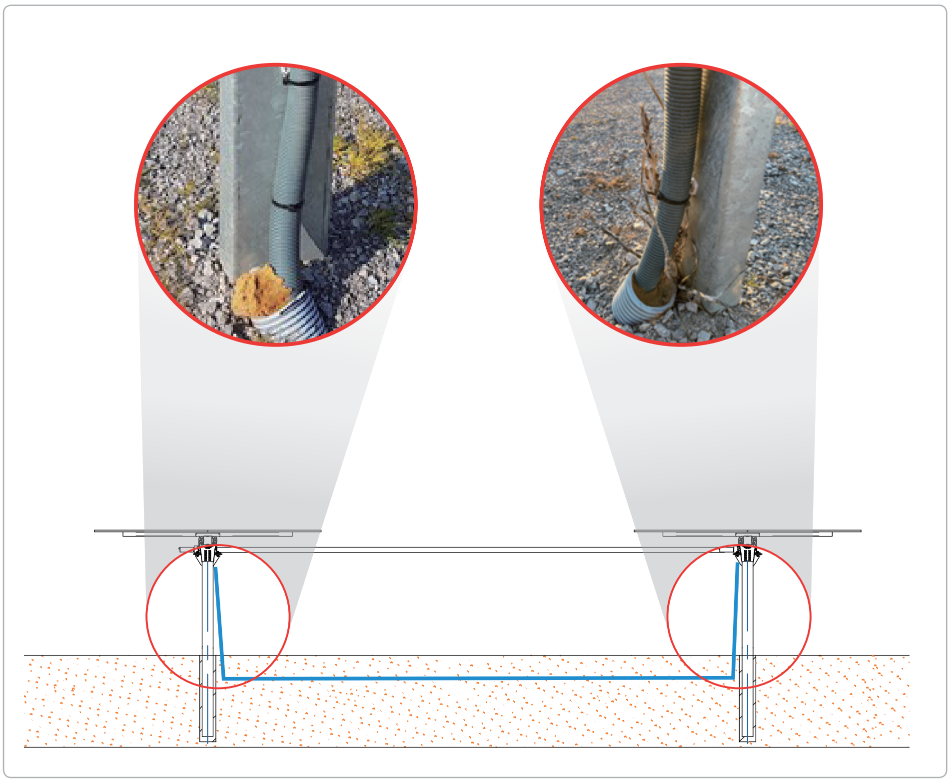


**Image 9:** Tube to protect the wires

This wiring management **optimises the yield gain** of the plant. Positioning the wire on the side of the tracker reduces energy losses, avoids shade at the rear of the modules, and prevents row misalignment.

This solution provides better access for cleaning between rows and increases safety for **O&M** (Operation and Management) operators.

Trenches must be dug as the piles are being driven since the **machinery** for digging them will already be in place, and as a result, installation **time and costs** will be reduced.

## 2.3.2 Cable Tray

**If the previously recommended solutions are not feasible, a cable tray can bridge the wires connecting two half-strings, between parallel rows of the same tracker.**

If the previously recommended solutions (2.1 & 2.2) are not feasible, a **cable tray can bridge the wires connecting two half-strings**, between parallel rows of the same tracker.

The cable tray will be fixed in the last piles of one side of the tracker.

This solution means a straightforward assembly process since it does not require any digging; besides, the **O&M** services regarding wiring maintenance will be more accessible.

Compared to the last option (2.1. Connecting Strings between Rows in Adjacent Trackers), the length of the **cable** will be shorter since it will not be buried.

It is essential to bear in mind that **pile fixing** must be checked by the **engineering department** in each project, since the additional mechanical loads applied to the pile could affect the performance of the tracker.

The implementation of this solution requires a tray, **an element to fix the tray to the pile and the bolts to join them**.

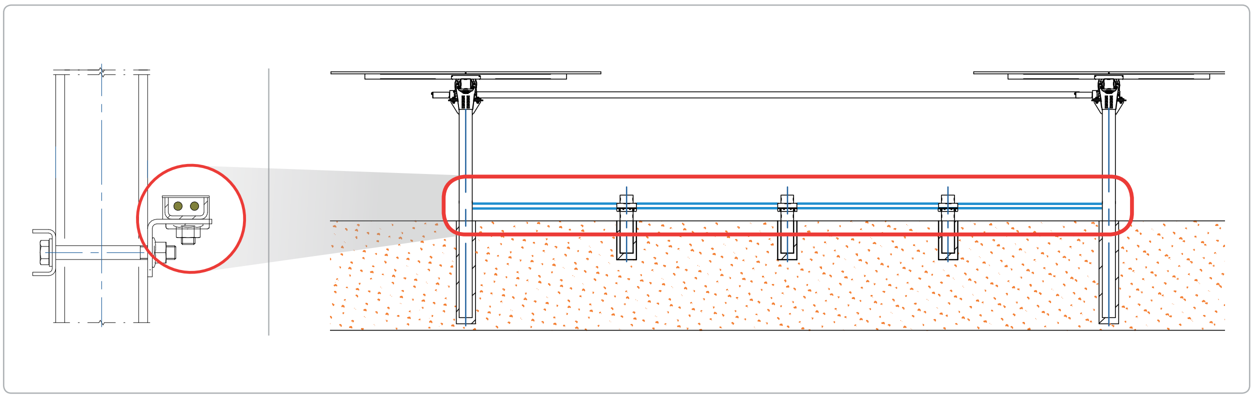


**Image 10:** Cable tray

## 2.3.3 Catenary Wire Rope

**One more optional solution is securing a catenary rope between the piles of two different rows on one side of the trackers.**

Lastly, one more optional solution could be **securing a catenary rope between the piles of two different rows on one side of the trackers**. This solution needs careful analysis by the designated engineer.

Compared to option 2.2 (Connecting Strings between Rows in a Tracker), this solution **reduces assembly time and costs**; additionally, the length of the cable will be shorter since it will not be buried.

However, the cantenary wire rope will create some **shadows** on the rear of the nearest module, and **O&M** services will become more difficult since the wiring is raised above the ground.

It is essential to bear in mind that pile **fixing** must be checked by the **engineering department** in each project, since the additional mechanical loads applied to the piles could affect the performance of the tracker.

The maximum weight of the cable will be **0.2 Kg/m** and the catenary **0.1 Kg/m**. Consequently, the maximum tension applied between the two piles will be **35N/m**.

Only one string wire will pass through the catenary. If additional cross wires are needed, the **engineering department** responsible for the plant must analyse the impact of the extra load added to the structure.

The additional components that this solution requires are a **catenary wire rope, fix ties and catenary bolts**.

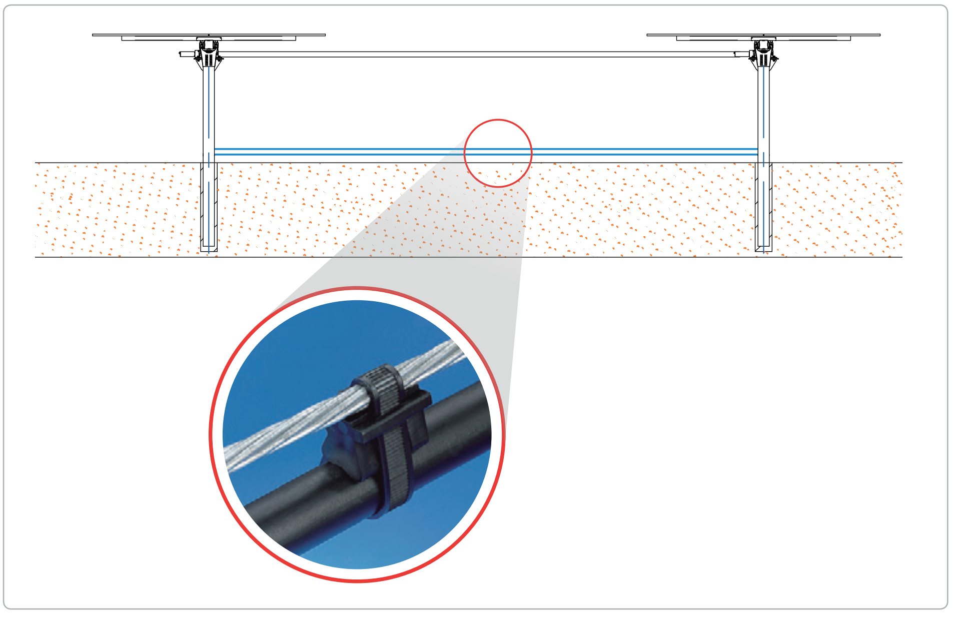
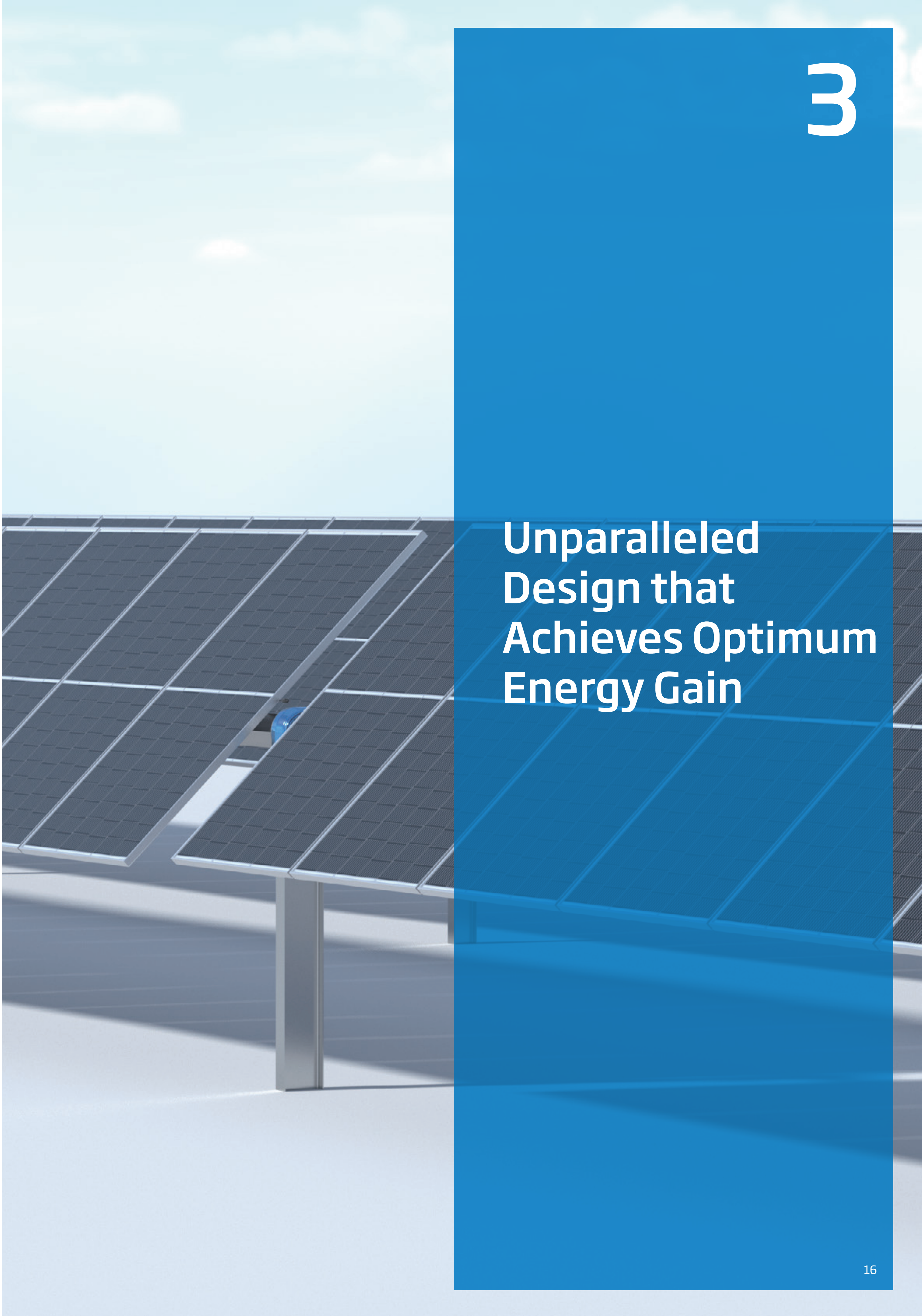


**Image 11:** Catenary wire rope



# 3

# Unparalleled Design that Achieves Optimum Energy Gain

# 3 Unparalleled Design that Achieves Optimum Energy Gain

**TrinaTracker** has optimised its tracker design to the limit **achieving optimum energy yield** and unparalleled efficiency, accommodating large-format modules even when the tracker is installed in **challenging terrains** and/or under **extreme weather conditions**.

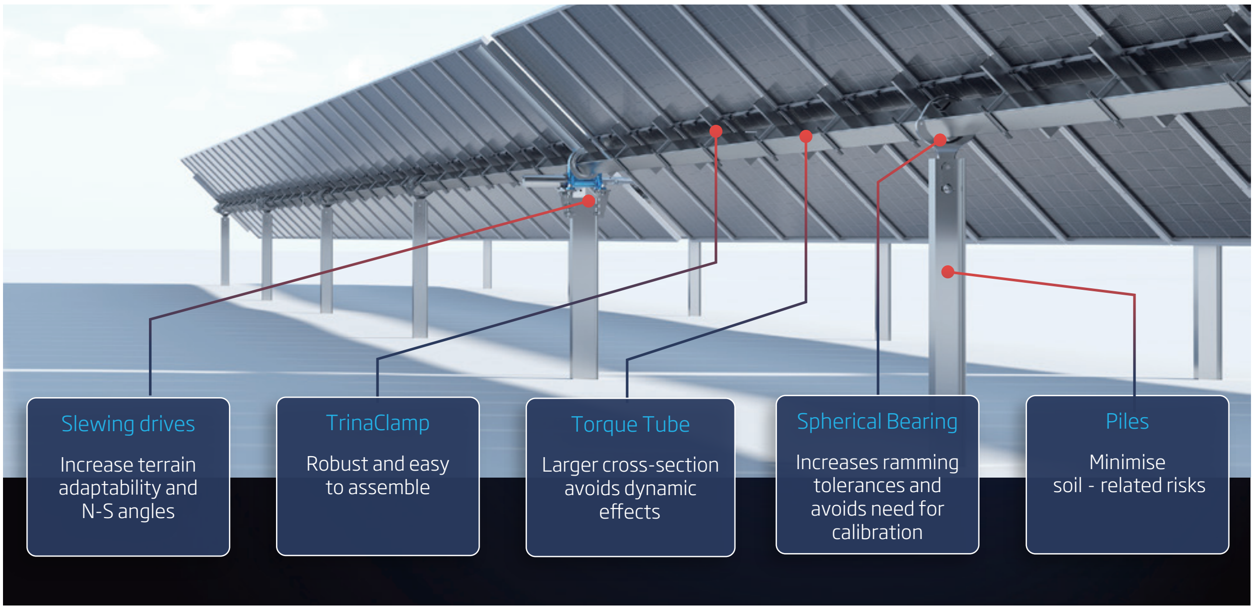



**Image 22:** **Agile 1P** Key mechanical components

**The design includes high-tech innovative elements that improve solar plant performance:**

- **Shorter dual 1P dual rows** (up to 72 metres) that require 33% fewer trackers per MW (12.6), 12% wire length reduction compared to the previous longer **Agile 1P** dual row (110 metres). On the other hand, the new **Agile 1P** design optimises **BOS** costs and land extension.
- **Two slewing drives**, allowing 12° terrain adaptability and 20% slope N-S, compared to trackers incorporating linear actuators.
- **Spherical Bearing** resistant to solar degradation that minimizes structure stress and deformation, increase of ramming tolerances and avoids the need for calibration during the installation process.
- **TrinaClamp** saves 50% installation time.
- **TrinaTracker** SuperTrack algorithm combined by:
    - **Smart Tracking Algorithm (STA)**, designed for bifacial modules and accounting for diffuse and reflected irradiance, boosting energy production up to 5% on cloudy days.
    - **Smart Backtracking Algorithm (SBA)**, accounting for complicated terrain variations, ensuring module shading avoidance and being 3% more effective during dawn and evening periods.
    - **TrinaScada** monitoring system allows easier O&M (Operation and Management services), including tracker monitoring, integrated alarm, system diagnosis and intelligent control.

The new **Agile 1P** has been designed according to the output resulting from performing of a wind **tunnel test** completed in collaboration with **CPP** (Cermak Peterka Petersen Inc.), a leading wind engineering consulting firm. **Agile 1P** enables photovoltaic plants to produce energy effectively when accommodating large-format modules, mitigating risks related to wind loads.

**As a result, the new tracker design incorporates:**

- **Stiffer torque tube**, that adds thickness and strength to the structure with a larger cross-section to avoid the dynamic effects of wind.
- **Optimised purling design** which, apart from adding extra rigidity to the modules, optimises steel usage.
- **Optimised post** design that prevents risks of ramming, bumps and twisting and reduces the required the number of units, minimising soil-related risks.
- **A high tilt angle at stow position** that attains aerodynamical stability.
- **Integrated alarm system** commanded by NCU sensors and /or operator criteria.
- **Tracker lay-out tailor-made** for each proyect.

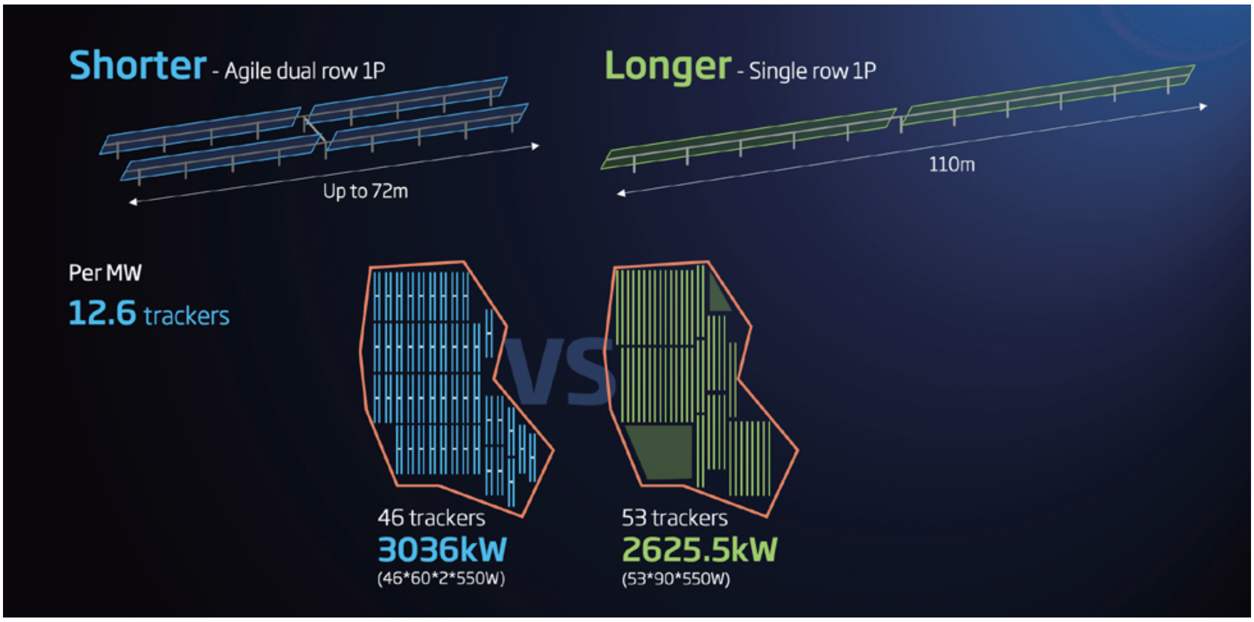



**Image 23:** Agile 1P dual row length vs Agile 1P single row length

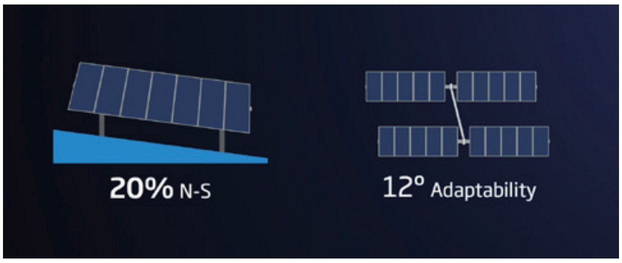



**Image 24:** Two slewing drives allow 12° terrain adaptability and 20% slope N-S

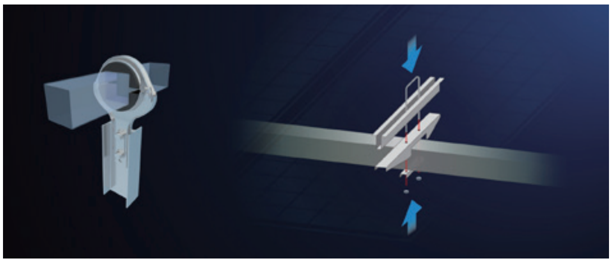


**Image 25:** Spherical Bearing | TrinaClamp

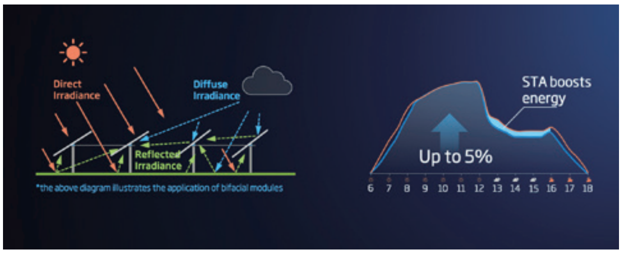



**Image 26:** Smart Tracking Algorithm (STA)

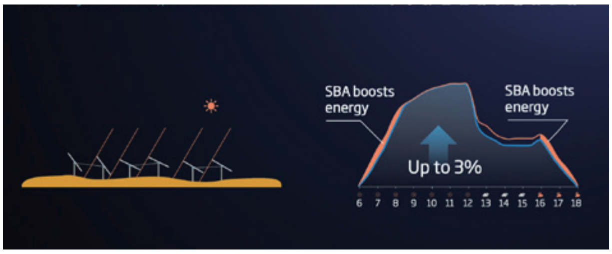



**Image 27:** Smart Backtracking Algorithm (SBA)

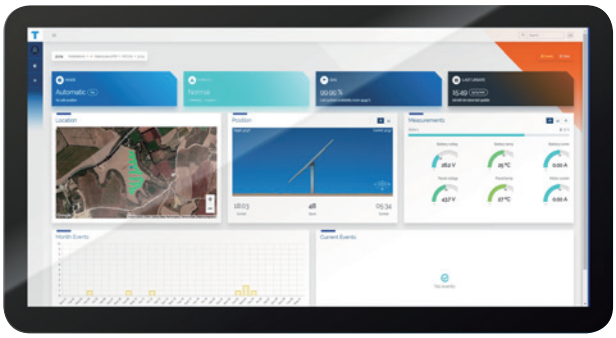
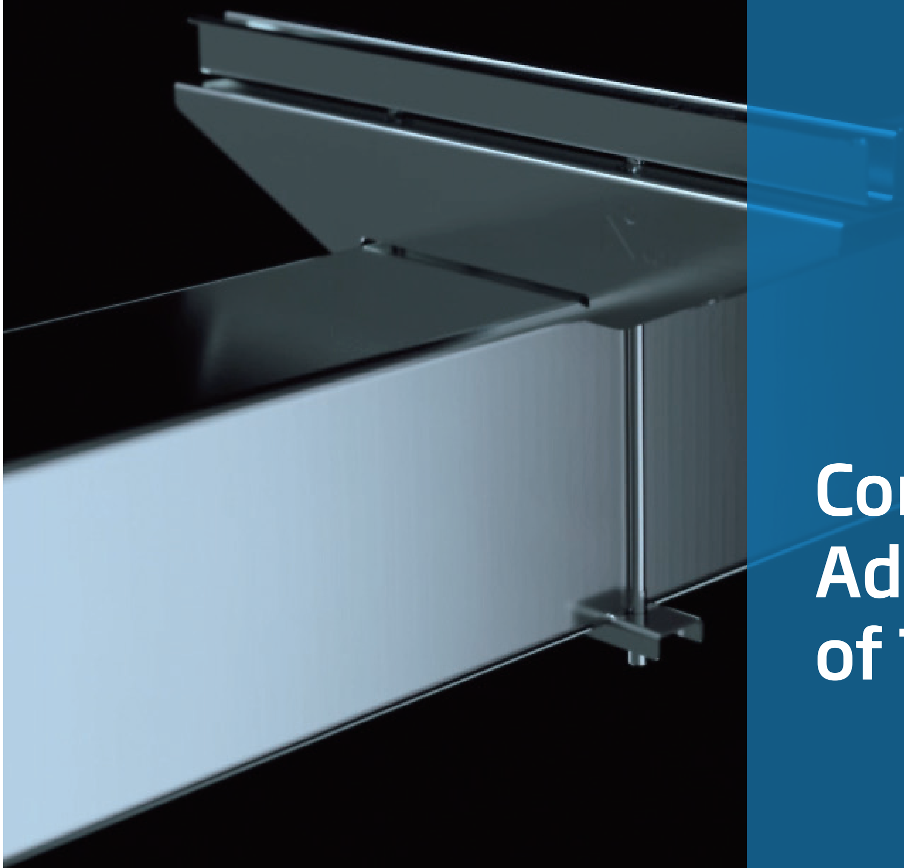


**Image 28:** Upgrade to SCADA system based on current TrinaTracker Cloud



# 4

# Competitive Advantage of TrinaTracker

4

# Competitive Advantage of TrinaTracker

**TrinaTracker**, a business unit of **Trina Solar Ltd.** (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 across 40 countries in which they accurately adapt the solar systems to each site's features. **TrinaTracker Agile 1P** and **Vanguard 2P** stand out in the market for their reliability, optimised design and minimum operation and maintenance requirements.

The trackers' compatibility with ultra-high power modules has been reported by DNV. Furthermore, **Agile 1P** and **Vanguard 2P** have been subjected to static, dynamic and aeroelastic loads through the most extensive tunnel test implemented in the solar industry and perform by leader wind engineering consultants **CPP** and **RWDI**.

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

## About Trina Solar

Founded in 1997, **Trina Solar** 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, **Trina Solar** 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, **Trina Solar** 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, Trina Solar listed on the STAR Market of the Shanghai Stock Exchange.

For more information, please visit **www.trinasolar.com**.

TrinaTracker

## Competitive Factors

**Own** R&D & Engineering Department

**Team** of more than **50** experienced and highly qualified engineers

**Consolidated expertise** in modelling, calculation and engineering design

**Extensive know-how** of solar industry technology and markets

**+6 GW** of plants where tracker design is tailor-made to meet the site characteristics and clients' requirements

Trackers installed in more than **40 countries**

**In-house resources** to carry out geotechnical design, structural design, FEM analysis, physical testing, software and hardware design, detailed project design, research and development of products.

**Work partnership** with leading wind engineering consultancy companies (**RWDI** and **CPP**)

State-of-the-Art **engineering** design

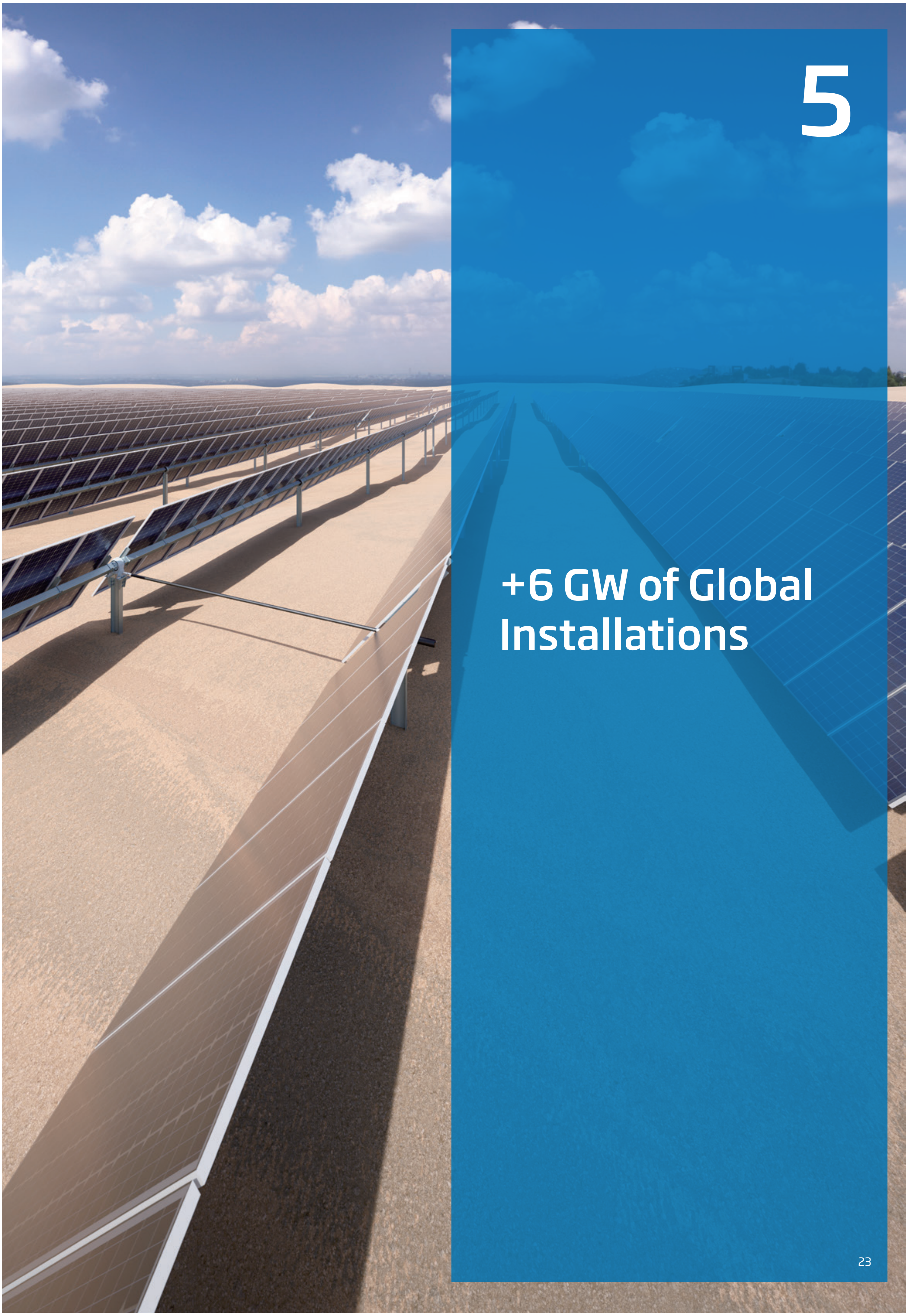
Designed technology that complies with the highest **European and US standards** (IEC62817 and UL3703 Certifications respectively)

RWDI

cpp WIND ENGINEERING & AIR QUALITY CONSULTANTS

DNV

sbpsonne



# 5

## +6 GW of Global Installations

# 5 +6 GW of Global Installations


China_600MW

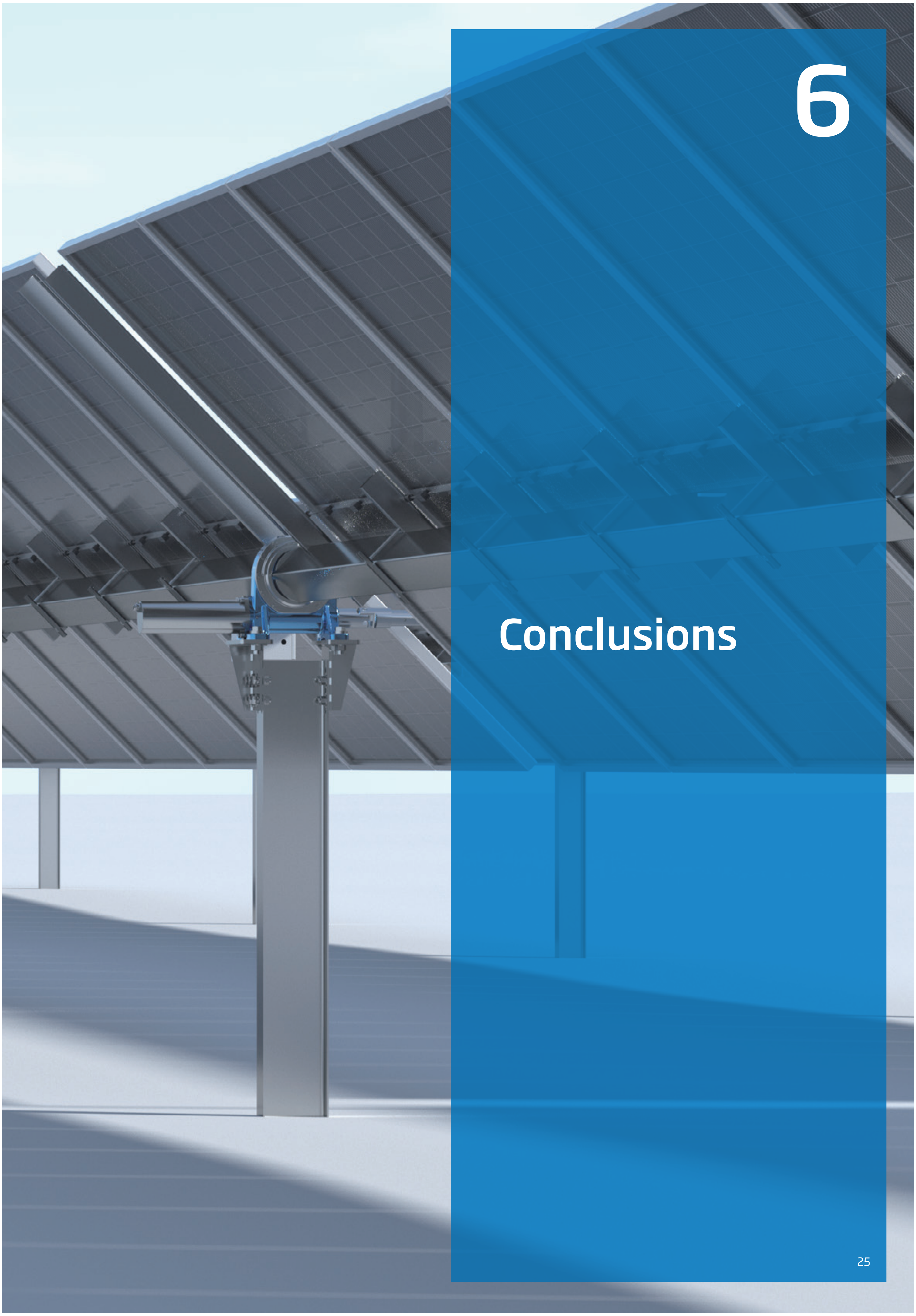

Kenya_96MW


Chile_33MW


Argentina_32MW


Honduras_40MW


Spain_22MW



# 6

# Conclusions

# 6 Conclusions

**TrinaTracker always recommends connecting half-strings from adjoining trackers.**

The main differences between the wiring options of connecting rows of adjoining trackers and connecting half-strings between parallel rows of the same tracker are that the former requires longer cables and does not contemplate digging trenches. The latter demands less cable but needs more trenches.

TrinaTracker always **recommends connecting half-strings from adjoining trackers** when the height difference between torque tubes does not reach 0.3m, and the distance between adjoining trackers is shorter than 1m.

TrinaTracker recommends **wiring between rows of the same tracker** using a trench to bridge the string cable to avoid any cable damage or reduction of energy production if these requirements cannot be met.

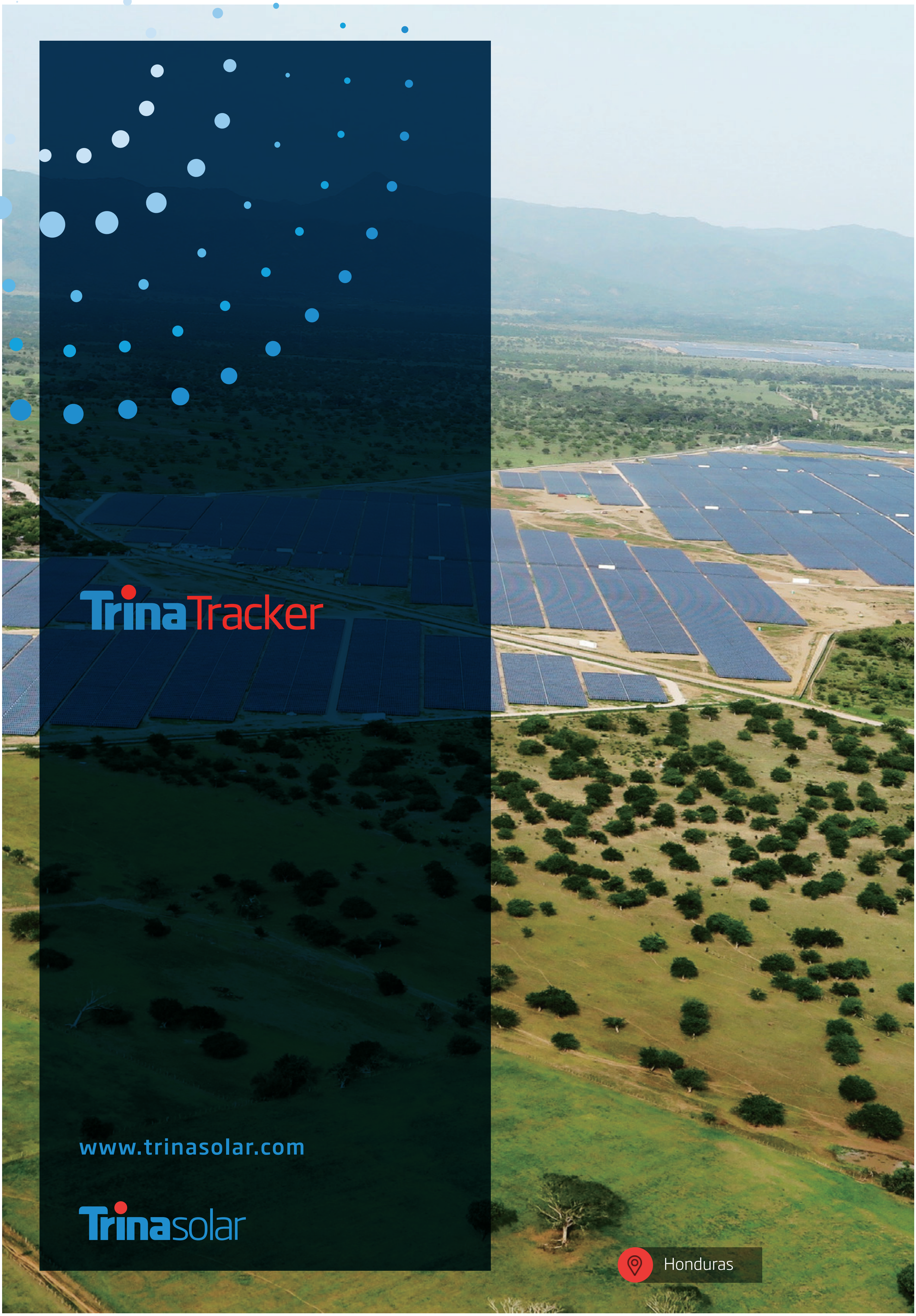
| | Length of wiring per tracker (m) | Tray / trenches number per tracker | End of tracker strings |
|---|---|---|---|
| Connecting strings from adjoining trackers | 134 | 2 | Centre |
| Connecting strings between rows in a tracker | 232 | 1 | One side |

In the event that none of these solutions is feasible for a particular project, the use of a cable tray or a catenary wire rope could be considered, after performing an accurate analysis of the site characteristics, to achieve optimum energy production and stay within the budget.

The mismatch loss for **Agile 1P** with bridging happens **only when the terrain is not flat**. The results given in Table 1 present the worst situations with few possibilities. In an actual project, the mismatch loss for **Agile 1P** with bridging is insignificant because the weighted ratio should be considered for the whole array.

For example, if **only one** suffers from shading in every five trackers, then mismatch loss for the whole array would be weighted with 1/5.

Moreover, by integrating with TrinaTracker proprietary smart tracking technology **SuperTrack**, which can effectively avoid or mitigate row-to-row shading, **Agile 1P** with bridging would be less affected by the complex terrain.

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