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REM Tec is an Italian French company, founded in 2015 as a spin-off based on two basic worldwide patents of Agrivoltaics filed in 2009 by REM. REM Tec has developed several globally recognized patents that enable the coexistence and optimization of agricultural production and renewable energy production: this is the Agrovoltaico® project. In a global context the world population has increased 4 times in 80 years, desertification has removed a third of arable land and energy needs are growing exponentially and it is necessary to find sustainable solutions, taking into consideration all factors: environment, energy, food and landscape. Producing solar energy requires large spaces, and farmland is the most coveted, but at the same time assumptions are made, it cannot be indiscriminately occupied by photovoltaic panels.

Agrovoltaico® technology developed by REM Tec fits into the international power sector by being the meeting point between the world's two main needs: food and energy, while respecting environment and landscape.

REM Tec's research works has shown that the impact of the system on crops is virtuous and sustainable.

Studies carried out in cooperation with several well-known R&D institutions like the Catholic University of Piacenza, the CNR, INRAe as well as other research institutes and universities, and the experience gained on several plants since 2011, have made it possible to arrive at a perfect comprehension of the shadow impact generated by the PV modules on the growth of different agricultural products.

On some species the Agrovoltaico® system has no impact on agricultural yield, others it significantly improves production.

REM Tec among other experiments on numerous horticultural and fruit products, has produced the world's first Agrovoltaico® wine and this year will be the third consecutive year of production. (Figure 1)

Figure 1: REM tec's vineyard and Agrovoltaico® wine

All our research activities are conducted under a scientific support of leading international R&D institutions from Italy and France.

REM Tec 's service provides a one-stop-shop solution tailored to assist project developers and asset managers in all relevant project phases, from the preliminary project phase to project development phase, construction and O&M services.

In 2021 REM Tec has introduced a fixed Agrovoltaico® technology, with PV modules mounted on suspended wire ropes at around 5 m height. The design is done to have a span up to 25 m between the poles allowing large agriculture machine to optimize agriculture and related operation costs for crop production. This design is also done for large field cultures and has a really low footprint. Then, the PV modules can be arranged in a chessboard placement (Figure 2) generating a more homogeneous shadow on the ground, very important for agricultural compatibility, or in a linear configuration with modules continuously along the row. The choice between the 2 configurations is done according to the crop irradiation needs

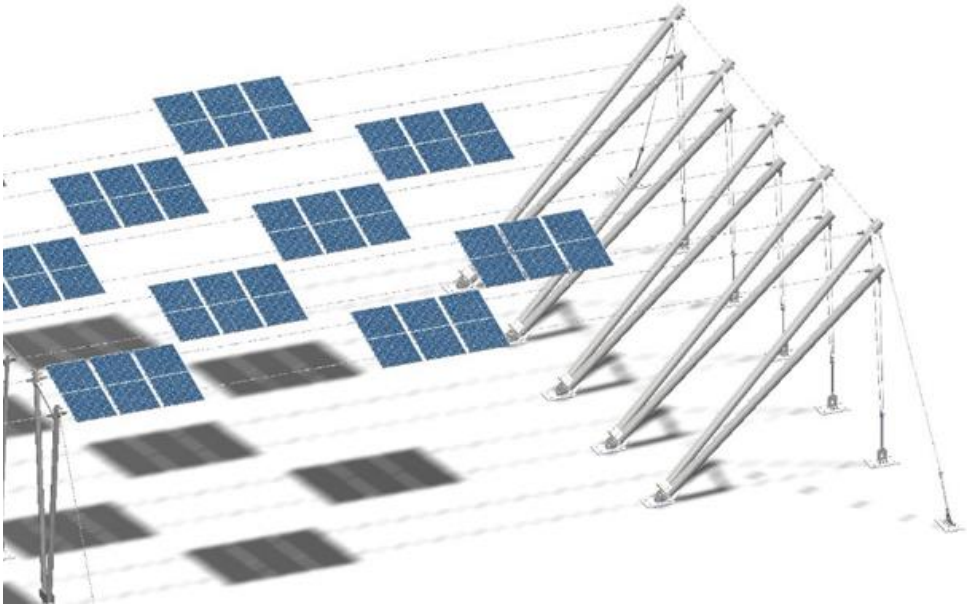


Figure 2: Agrovoltaico® fixed chessboard configuration

The first technology developed by REM Tec is the mono-axial or bi-axial tracker. The last release of Agrovoltaico® trackers 2.1 (Figure 1), consists in a 14 meter long horizontal tube “primary axis”, supported by two poles 4.5 - 6 meters high, crossed by 4 wing rows, each one supporting three photovoltaic modules, typically made by 78 cells; the use of bifacial modules, as demonstrated by experience during the years, can lead to a total increase up to 50% in energy production compared to ground mounted systems, as it allows a greater efficiency of solar radiation reflected from the ground. The trackers are arranged in rows which are typically distant from each other from 12 to 18 meters, accordingly to the geography of the land, the configuration of the existing, or future, crops and the optimized shading for these crops.
The tracking algorithm is designed to optimize crop growth combined with power production through an optimized shadow management. For a bi-axial tracking system, the combined rotation of the two axes allows the modules to be constantly perpendicular to direct radiation when the energy requirement for photosynthesis has been reached. Added to that, the backtracking algorithm *VoltaicoPlus* avoids the mutual shading between the panels in the initial and final phases of the day, through a correction of the calculated theoretical position returned by the tracking algorithm. Crop behaviour to optimize agriculture can be integrated in the *VoltaicoPlus* algorithm.

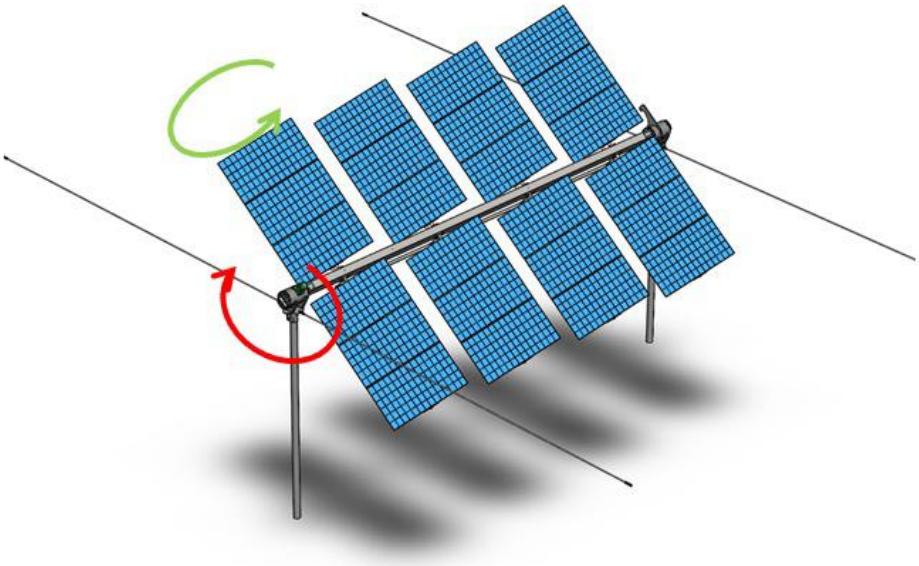
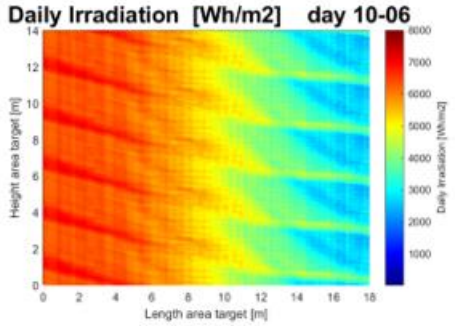


Figure 1: Agrovoltaico® Tracker 3D-T2.1

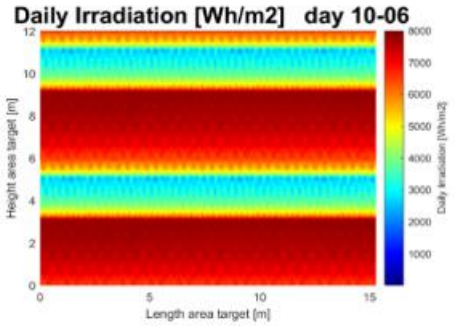
The choice between fixed vs. tracking systems depend on various factors, with irradiation reduction and management being one of the most important ones. The tracking system guarantees a homogeneous and dynamic solar radiation for the underlying crops and it allows to manage the percentage of shading on the ground, even making it zero, if necessary, in order to optimize agricultural production (Figure 4).

Figure 4: Management of the shadow below Agrovoltaico® tracker 3D

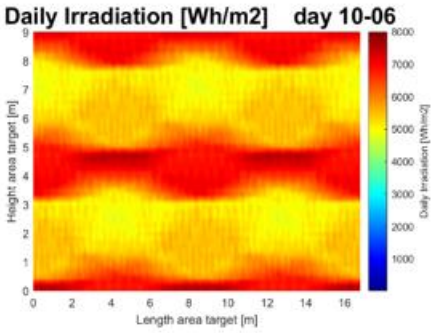
The linear configuration of the fixed AGV produces a very static shadow on the ground with a marked gradient of irradiation, while the chessboard configuration of the fixed AGV allows all part of the ground to receive high amount of irradiation.
The graphs in Figure 5 the cumulative irradiation on the ground on a late spring day under different configuration of Agrovoltaico® plants. The area considered is the target area, which is representative of the irradiation over the entire plant. The dimension of the target area varies with the distance between the rows.



(a) 3D-T2.1 TRACKER Agrovoltaico®
45°N oriented, 18m rows pitch



(b) Fixed Agrovoltaico® system, Stripes configuration, south oriented, 20°tilt, 6 m pitch



(c) Fixed Agrovoltaico® system, Chessboard configuration, south oriented, 20°tilt, 3 m pitch

Figure 5: comparison of the cumulative daily irradiation in the target area

Studies conducted in cooperation with several R&D centres show that the shadow generated by the modules has a positive impact in terms of water saving and yield; as example, for what concerns corn crops cultivated under a double axis system, a decrease of 26% in water consumption and an increase of 4,3% in agricultural yield can be reached,

compared to an open field situation. In fact, Agrovoltaico® technology is helpful for crop production under drought conditions, because it reduces the evapo-transpiration, therefore reducing the water consumption.
Agricultural research conducted by REM Tec on Virgilio site shows positive impact of the Agrovoltaico® system on soil humidity and air temperature, which are respectively increased and reduced under the plant in comparison with open field scenario.

Agrovoltaico® plants are in operation in Italy, France, China, Japan, Portugal as well as Israel very soon. Further projects are currently under development in other countries. We have a track record of operation since 2011 when the first worldwide three agrivoltaic plants have been connected to grid in North Italy, for a total of 6.7 MWp with 2384 3D trackers over 35 ha (Figure 6).

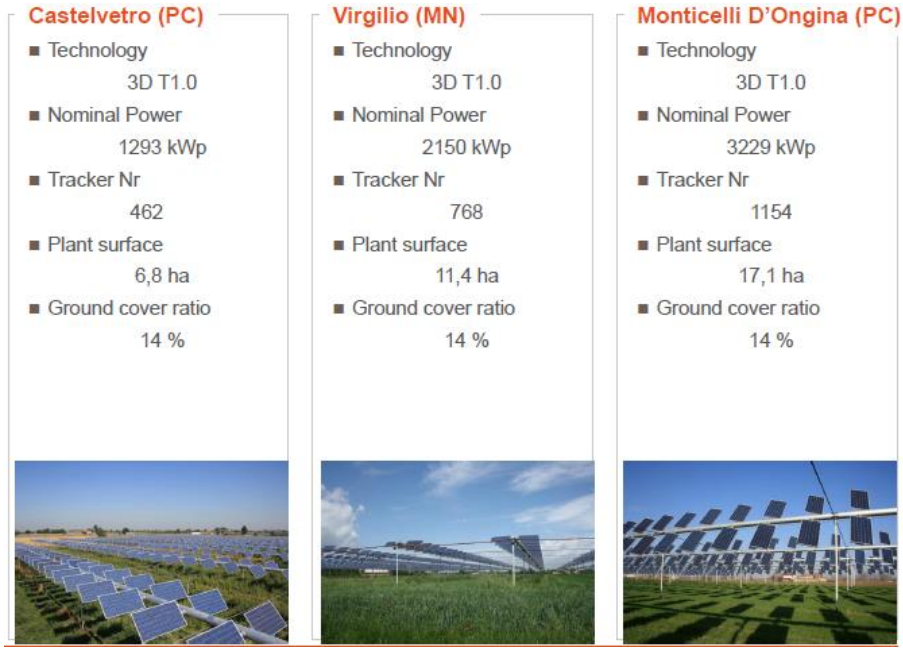


Figure 6: Agrovoltaico® plants built in 2011 in Italy

Said plants are built with the first release of Agrovoltaico® tracker 3D-T1.0, which consists in a 12-meter-long horizontal tube, which supports 5 wing rows, each one supporting a photovoltaic module, typically made by 72 cells. The rows of trackers are distant from each other at least 12 meters. They are connected through a tensile structure to support cabling and to minimize soil footprint. The height of the system is around 4-4.5 m from the ground allowing traditional agricultural machinery work underneath.
A part the feedback of the industrial plants, REM Tec is conducting since many years experimental research on the largescale Virgilio agroPV plant with wheat, corn, alfalfa, soy, rice, grapes, horticultural crops, such as salad, potatoes, tomatoes, pumpkin, melons, raspberries as well as kiwi, etc. Results remains preliminary and until results have been confirmed through multiple harvests, the data mining is ongoing.
With the same technology it has been built 544 kWp in China through our licensee Sharepower in 2016 (Figure 7).

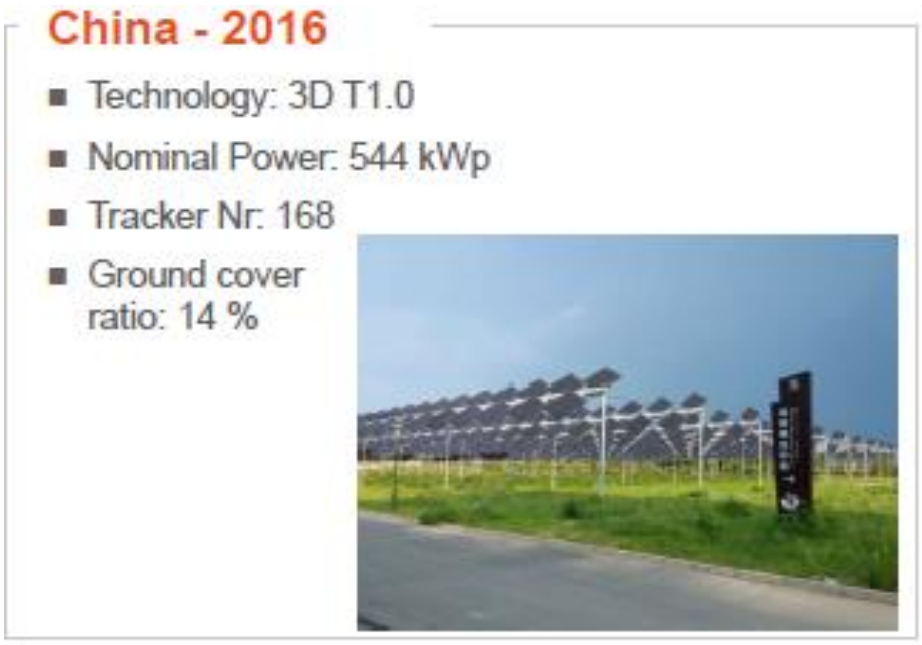


Figure 7: Agrovoltaico® plant in China (2016)

In 2019 a demo plant for EDF R&D has been installed by REM Tec in Les Renardières using the technology 3D-T2.0 (Figure 8). The main differences with T1.0 are:

- 32 PV modules (60 cells) on 4 secondary axes vs 10 PV modules on 5 secondary axes;
- Improved tracker control system for better efficiency;
- Use of actuators and triphase motors instead of stepper motor

Figure 8: Agrovoltaico® plan in France (2019)

In 2020-21 our Japanese licensee Notus Solar has installed with REM Tec's support 1 MW of Agrovoltaico® plants using both 3D-T2.0 and 3D-T2.1 trackers (Figure 9).

Figure 9: Agrovoltaico® plants in Japan

In 2023, REM Tec has installed a demo plant as partner of EDF and under support of the French ADEME in Beaucaire. This plant will use a newly developed fixed suspended technology (Figure 10).

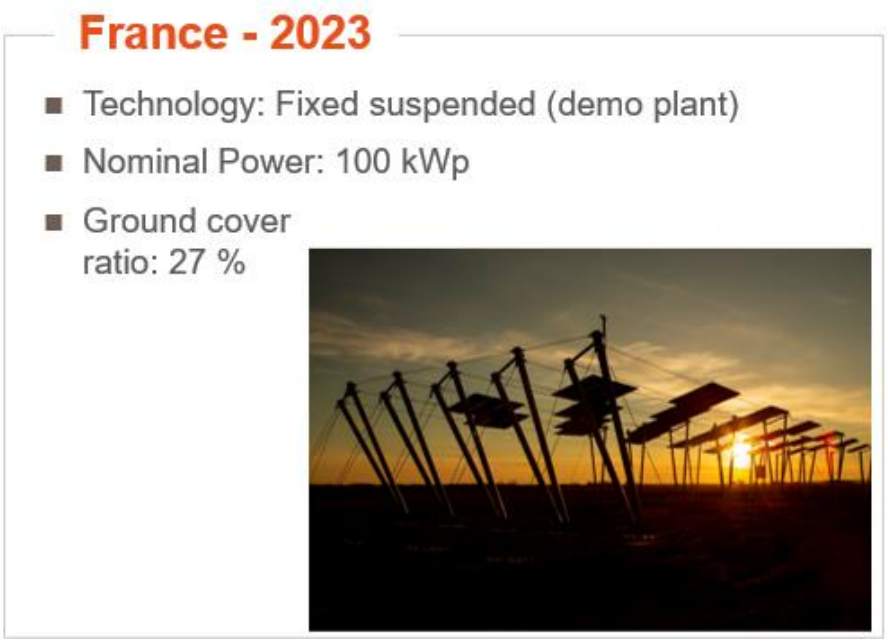


Figure 10: Agrovoltaico® plant in Beaucaire (France)

Further plants are currently under construction and will go in operation within 2023. Many others are in development.