TECNOSUNSOLAR

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DUAL-AXIS TECHNOLOGY

SINGLE-AXIS TECHNOLOGY

Smart Motion – High Return

Suntracker EcoChamp ST 3000 and EcoChamp ST 2000

TecnoSun Solar Systems AG

A company with a vision for outstanding solutions

TecnoSun Solar Systems AG stands for profitable and highly efficient use of solar energy. The goal of the company is to use the power of the sun in the best possible way for maximum yield at minimum cost – achieved through worldwide preeminent patents.

TecnoSunSolar is driven by a clear philosophy: high returns through simple and elegant solutions – with a healthy portion of enthusiasm for unconventional results. At the heart of this ethos are sound economics and increased returns.

As a finalist in the Northern Bavarian Business Plan Competition, one of Germany's most renowned competitions, TecnoSunSolar attracted a great amount of attention from the very beginning – both among experts in the solar industry and investors. The launch of the company with the globally unique dual-axis tracking system EcoChamp ST 3000 was followed by the expansion of the product range to include the single-axis tracking system EcoChamp ST 2000. The tracking systems have low investment costs and short amortization times in common. The high level of flexibility of both systems makes a large variety of applications possible, as shown on the following pages.

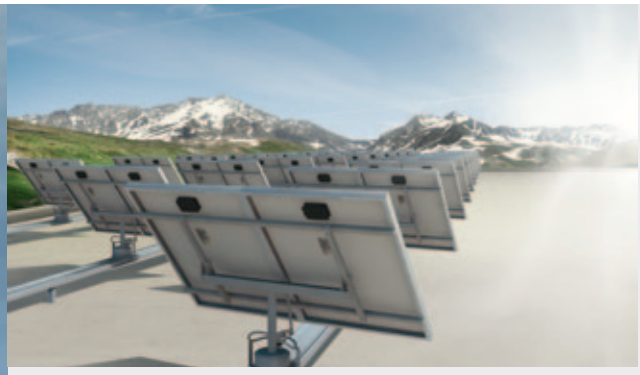
EcoChamp-tracking systems

High flexibility and a large variety of applications

UP TO 40% HIGHER OUTPUT

Open field
Open spaces such as redevelopment land offer great potential for the generation of solar power. The EcoChamp-tracker are ideally suited to this. Due to their low installation height, they integrate into the landscape in an aesthetic manner and can be easily installed to even bend around curves.

OPEN FIELDS AS SPECIAL USE AREAS
For areas along highways and railway lines, EcoChamp-systems offer an optimal opportunity for surface utilization.



Flat roof

Flat roofs, especially on large industrial buildings, are well suited for the generation of solar power. Fixed installations are predominantly used here. The drawback: the sun's position changes, the fixed installation does not. As a result, the systems do not achieve maximum yields. TecnoSunSolar supplies globally patented tracking systems that enable solar tracking even on flat roofs. This is achieved by the extremely low-profile and lightweight design.

Electromobility

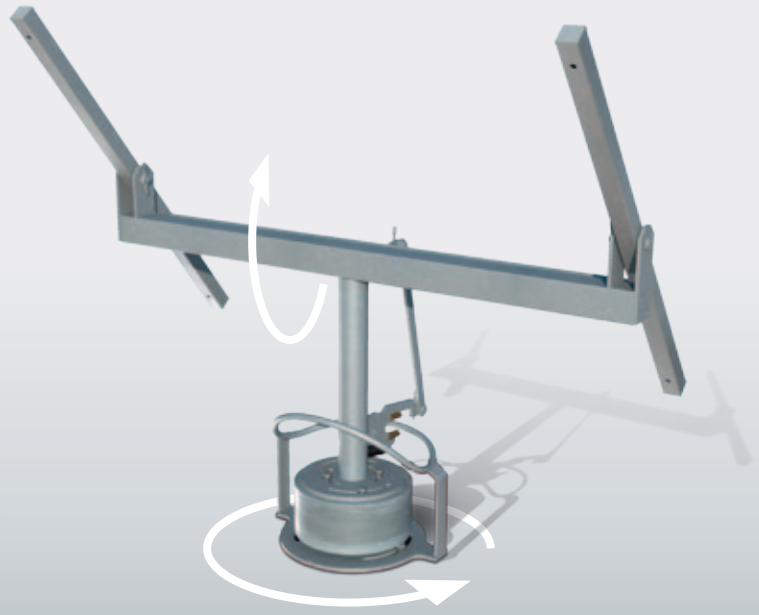
Parkload-system: Make multiple use of parking areas. Even sealed ground can contribute to energy harvesting. The EcoChamp-trackers enable both the charging of electric vehicles and income-generating grid feed-in. In addition to the generation of energy, the integration of a flexible canopy makes it possible to protect parking areas and vehicles from the effects of weather.

Noise-absorbing barrier

EcoWall-system: Kilometers of noise-absorbing barriers next to roads and railway lines are unused spaces which represent ideal potential locations for energy generation. With the flexible orientation of every single tracker, an optimum south orientation is possible at all times with the EcoChamp-series.

EcoChamp ST 3000

Unique dual-axis technology



1 MOTOR MOVES UP TO 30 TRACKERS

With the patented and globally unique technology of the EcoChamp ST 3000, a single drive unit can be used to control two axes. The technology of the dual-axis solar tracker enables maximum exploitation of available solar energy. The modules are always oriented towards the sun, and up to 30 trackers are moved with just one motor. This corresponds to a total module surface area of 78 m². This extremely energy-saving solution is globally unique.

The robust solution, intentionally designed with simplicity in mind, leads to low investment costs. With maximized

LEIGHTWEIGHT +++ LOW-PROFILE +++ ROBUST +++ ENERGY-EFFICIENT +++ WORLDWIDE UNIQUE DRIVE CONCEPT ++

EcoChamp ST 2000

Powerful single-axis technology

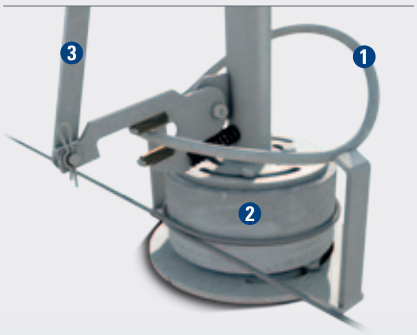
1 MOTOR MOVES UP TO 120 TRACKERS

The single-axis tracker EcoChamp ST 2000 repositions the modules horizontally to follow the sun. This results in a substantial increase in efficiency compared to systems with a fixed installation. In addition, up to 120 single-axis trackers are moved by a single drive unit. This makes the EcoChamp ST 2000 economical and profitable.

Through the movement of a large module surface (up to 390 m²) with just one motor, the investment costs are minimized and an increase in the yield

yields, this system makes it possible to achieve clear yield advantages and increases in profitability due to the dual-axis tracker.

The EcoChamp ST 3000 impresses with its versatility. It is suitable for use on flat roof and open space systems, in electromobility applications, and for fitting on noise-absorbing barriers. The customer's requirements determine the application, in which the orientation of the base surface plays no role. The tracker can be flexibly oriented through 360° to ensure a constantly optimum orientation towards the south.



❶ Elevation ring (control ring)
❷ Traction ring
❸ Control lever with linkage

SYSTEM BENEFITS

Dual-axis tracking system at reasonable costs: the EcoChamp ST 3000 impresses with all its strengths. In the sum of its features, it represents a world first.

› Optimum value for money
– Increased returns (up to 40 % higher output than fixed installations, dependent on location)
– Shorter amortization time compared to fixed installations
– Low installation costs in comparison with conventional dual-axis tracker systems
– Lightweight load installation (14.8 kg/m²)
– Small area requirements (19.2 m²/kWp, with 190 Wp modules)
› Low maintenance
› Shading optimization through low installation height and intelligent backtracking
› Low leverage during wind loads with storm position
› Higher year-round yield efficiency due to snow shedding position
› Flexible installation options, both as a carrier system and without roof penetration
› The trackers are manufactured by an environmentally certified company
› Just one motor for up to 30 trackers (60 modules)

TÜV Süd certified, CE label

++ LEIGHTWEIGHT +++ LOW-PROFILE +++ ROBUST +++ ENERGY-EFFICIENT +++ WORLDWIDE UNIQUE DRIVE CONCEPT

of up to 30 % is achieved through the sun tracking. The EcoChamp ST 2000 impresses with its versatility. It is principally suitable for use on flat roof and open space systems as well as for electromobility applications.

The technology of the single-axis solar tracker enables economically advantageous use of solar energy. The modules follow the daily path of the sun in azimuth direction. The unique drive system allows only one motor to move up to 120 trackers at the same time.

❶ Perforated plate
❷ Traction ring

SYSTEM BENEFITS

Single-axis tracking at reasonable costs for an additional yield of up to 30 %. The EcoChamp ST 2000 combines economy and efficiency in a simple way.

› Optimum value for money
– Increased returns (up to 30 % higher output than fixed installations, dependent on location)
– Shorter amortization time compared to fixed installations
– Low installation costs
– Lightweight and low transport costs
› Low maintenance
› Shading optimization through low installation height
› Low leverage during wind loads with optional storm position
› The tracker are manufactured by an environmentally certified company
› Small area requirements (18.75 m²/kWp, with 240 Wp modules)
› Elevation can be manually set (the basic settings are optimized for the location)
› Just one motor for up to 120 trackers (240 modules)

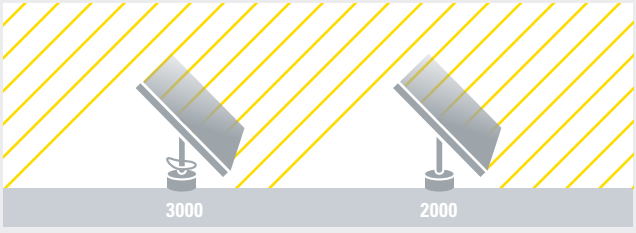
TÜV Süd certified, CE label

The EcoSystem at a glance

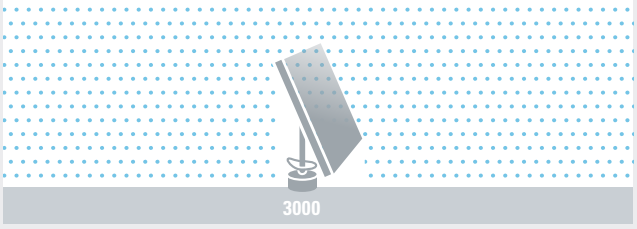
EcoChamp-trackers for an intelligent solar power plant

Intelligent control using the finest sensor technology

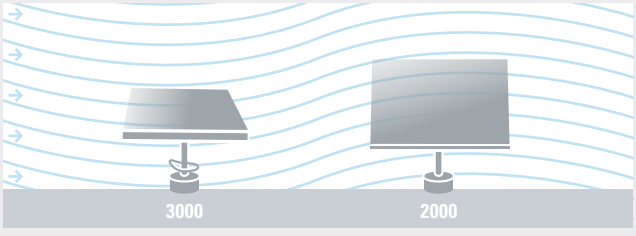
In order to achieve an optimal yield with the best possible system protection at the same time, weather data evaluation is essential. For example, it is very important to detect the wind speed and wind direction for the protection of the solar installation. In addition, snowfall or heavy cloud cover also has a major influence on the performance of a solar installation. This data is also recorded and sent to the control unit, consisting of an EcoBox and EcoTrack. The drives are centrally controlled. The control unit makes continuous use of astronomical sun position data and the measurements from a weather station. Together with the tracking data, the control unit serves to align the modules towards the compass points of the sky. If there is no direct solar radiation (diffuse radiation), the control unit detects this via the solar sensor and moves the modules to the 15° position (EcoChamp ST 3000), which in this case supplies the greatest yield. The anemometer provides safety from strong winds which could damage the system: above a wind speed that is optimally set for the respective location, the control unit moves the modules into the storm position. In case of snowfall, the EcoChamp ST 3000 dual-axis trackers are moved into a snow shedding position.



The EcoChamp-trackers follow the sun in the east-west direction (azimuth). The EcoChamp ST 3000 also optimizes the angle of inclination (elevation).



Snow shedding position with the EcoChamp ST 3000. Steep position in case of snowfall, allowing the snow to slide off.



Storm positions for minimization of wind loads. The EcoChamp ST 3000 moves into the 0° elevation position. The EcoChamp ST 2000 turns itself crosswise to the wind direction.

Highly precise and powerful drive

The EcoChamp-trackers are driven by a low-maintenance AUMA motor. The control signals of the control unit are detected here and transmitted to the drive cable using a finely adjusted trapezoidal spindle. The tracker are then controlled using the drive cable. The motor is encapsulated to be watertight and can be heated, making it extremely low-maintenance and designed for durability. It has an integrated limit switch and can also be manually actuated in an emergency using a handwheel.

Increased yield through low-maintenance EcoChamp-trackers

The trackers are rotated by the drive cable so that a movement about the vertical axis (east-west) occurs on the horizontal level (azimuth). In this way, the trackers follow the path of the sun. With the two-axis tracker EcoChamp ST 3000, in addition to the azimuth movement, a forced elevation occurs at the same time, i.e., a movement about the horizontal axis that causes the angle of inclination to change. This forced elevation is achieved using an elevation ring that is manufactured and customized for the location.

Continuous remote monitoring

The option of remote monitoring allows constant data monitoring via the control system. In case of system malfunctions, the option exists to use a remote computer to gain direct access to the control unit of the tracking system. This can be accomplished worldwide via the Internet or a mobile phone regardless of location. A webcam provides additional live images, allowing visual monitoring of the system as well.

The interaction of components in the EcoSystem

ECOCHAMP-TRACKER
Orients the modules towards the sun

MOTOR
Low-maintenance motor moves the trackers via the drive cables

WEATHER SENSOR
Records temperature, wind speed (electronic measurement), brightness and rainfall

ECOBOX
Control unit of the solar installation

ECOTRACK
Control software for data evaluation and control

LAN

LAN

REMOTE COMPUTER*
Allows remote access to the control unit worldwide, regardless of location

WEBCAM*
Live images for visual monitoring

CONTROL SYSTEM*
Constant data monitoring of the solar power plant

* OPTIONAL

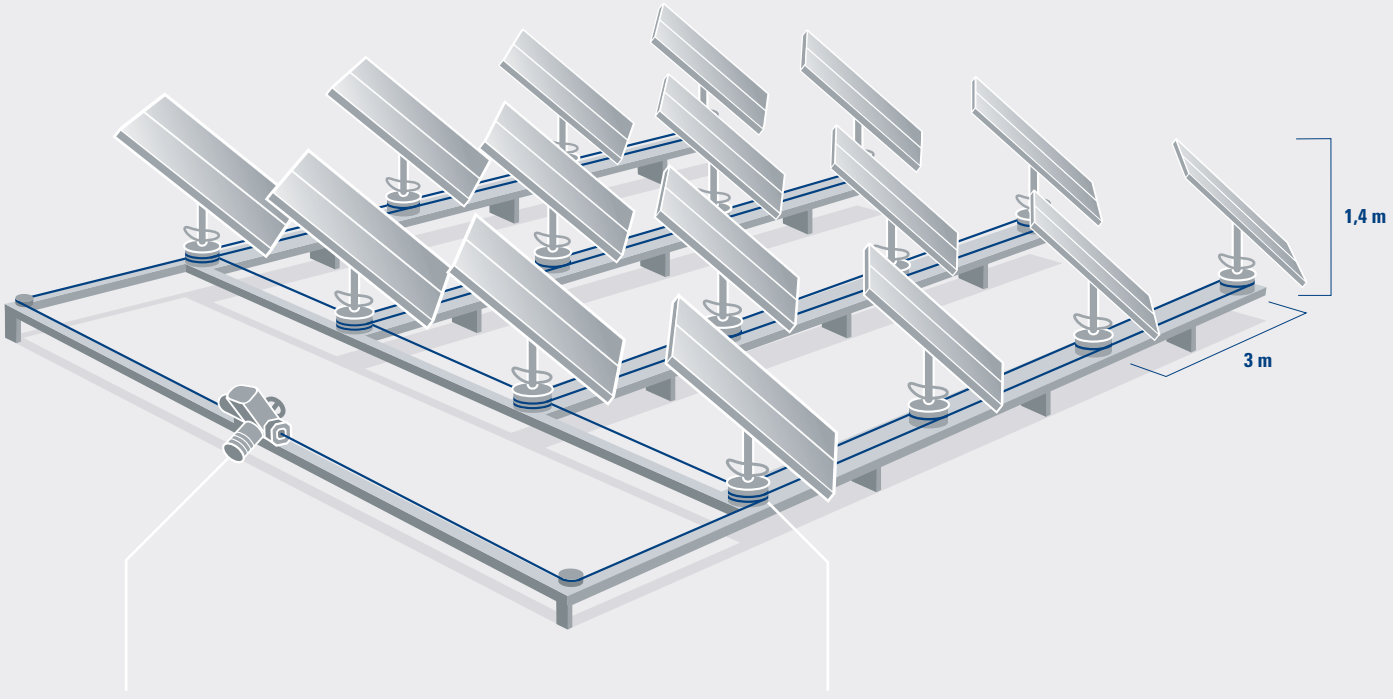
The Winning Components in Brief

Drive and assembly of the trackers

Conventional tracking systems generally work by moving as large a module mount as possible using one or two drives. TecnoSunSolar's drive concept takes a different approach: one drive controls over a hundred trackers. The power is transmitted with the help of a steel cable wound once around each of the separate tracking supports. The drive receives actuating impulses from the electronic control system. Via a planetary gear, these are transmitted to a rotary shaft, which in turn moves the steel cable, the latter directing the individual supports. In this way, the position of the tracking system is continuously adjusted in line with the position of the sun.

The drive is perfectly suited to this use. Extremely robust, it can be used in the most adverse of environmental conditions (protective system to the ISO IP67 standard). The steel cable is extremely stable, with a breaking load of 20 kN. Severe winds of 140 km/h cause maximum forces of 10 kN in the system.

Friction within the system is negligible. Premium industrial bearings from igus GmbH ensure smooth running. On account of the low friction, energy consumption is also kept particularly low at around 25 kWh per year.



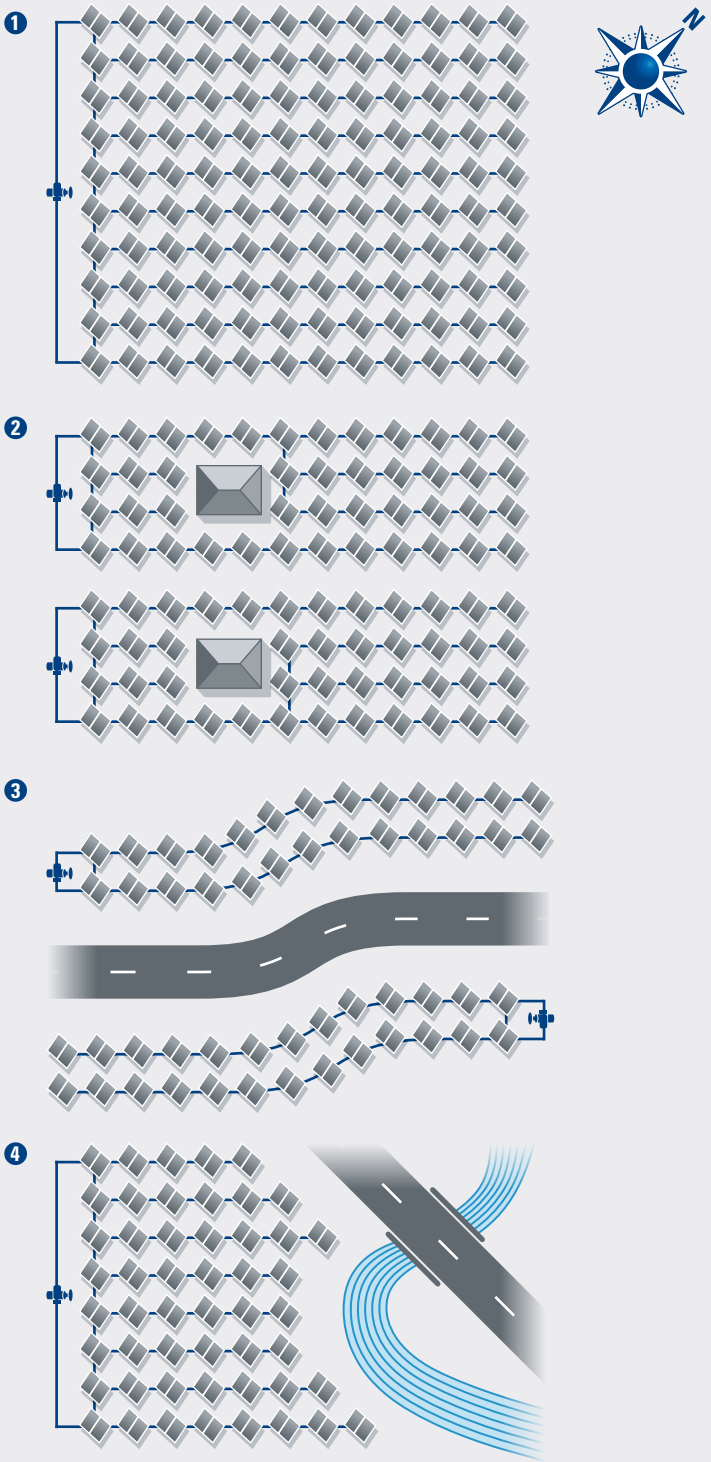
QUALITY ROTARY ACTUATOR FROM AUMA (GERMANY)
The premium AUMA drive ensures reliable operation of up to 120 trackers. Thanks to the smooth-running Safety-Wheel, the system can also be moved to the south-facing position by hand in the event of a complete failure.

HIGH-QUALITY STEEL CABLES ENSURE UNIFORM POWER DISTRIBUTION
Durable steel cables ensure smooth operation. The placement of the drive both within and without the tracker system can be customized to meet local requirements.

TYPES OF GROUPING AND LAND UTILIZATION

❶ Tracker system in standard application
❷ Layout on areas or roofs with large obstructions
❸ Installation along railway lines or roads
❹ Flexible tracker grouping for efficient area utilization

Tracker with two PV modules-panels
Substructure/ Cable
AUMA motor



An ideal surface optimally suited to pv-panels usually has a right-angled basic layout. Maximum use of available space is typically highly feasible here.

Unfortunately, reality often paints a different picture. Surfaces which can be considered for a PV system usually do not exhibit ideal evenness. In addition, only very few sites are situated such that an ideal south-facing orientation is available. The result of this is that there must always be a compromise between installed and actual power output. Either the modules cannot be ideally oriented toward the south or the available area is not used optimally. Both ultimately mean that the operator does not obtain the maximum solar power from his available surface area.

The tracking systems from TecnoSunSolar offer an ideal solution to this problem. The EcoSystems represent great flexibility in their types of interconnection, i.e. the layout and number of trackers which can be operated by one drive. As the individual tracking systems are powered via a drive cable, the EcoSystems are not limited to a right-angled base surface. Whether a hill, a curved railway line or road, or a surface area littered with obstacles, the unique tracker formation of the EcoSystems adapts flexibly.

With its possible 360° installation, the orientation of the base surface is also of no relevance. The trackers can be installed individually and in combination so that an ideal south-facing orientation is always guaranteed. This is the basic condition for maximum system and surface area utilization.

Smart Motion – High Return

The EcoSystems add to your returns

Investment in a solar installation is a decision for the future and needs to be thought through.

In order to make clear the outstanding financial advantages of the EcoChamp-systems from TecnoSunSolar, a sample calculation is shown here. A classic fixed solar installation is compared with the single- and dual-axis tracking systems from TecnoSunSolar under the same basic conditions.

It can be clearly seen that despite a higher initial investment, the time it takes to recoup the costs is reduced considerably with the EcoChamp-systems and the profit is substantially higher.

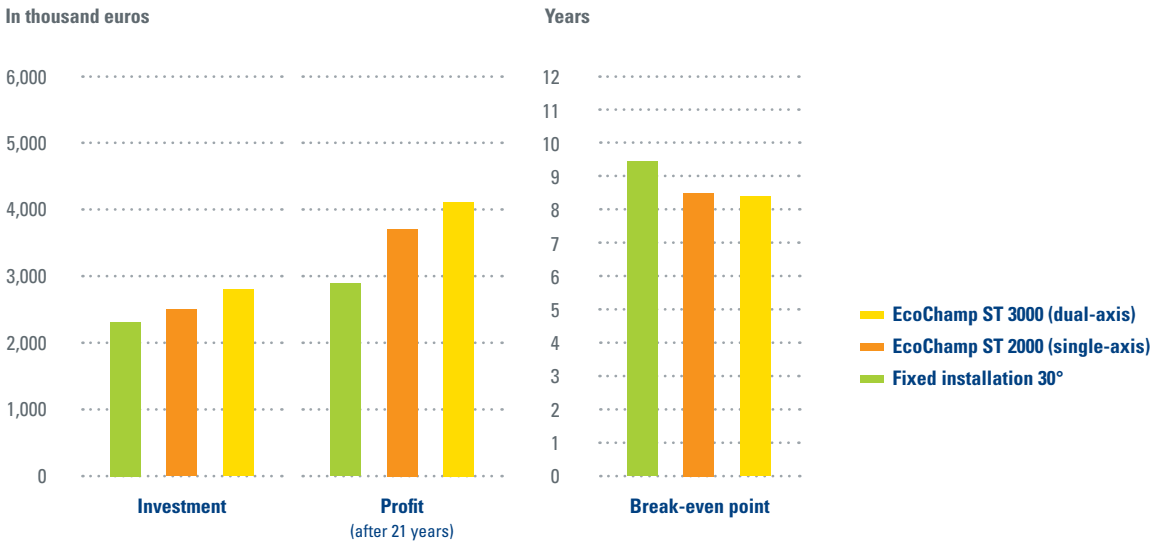
Use your reliable partner the sun and increase your returns to a maximum with the EcoChamp-systems from TecnoSunSolar.

	FIXED INSTALLATION	ECOCHAMP ST 2000	ECOCHAMP ST 3000
Investment	2,300,000 €	2,500,000 €	2,800,000 €
Total revenues	5,200,000 €	6,300,000 €	6,900,000 €
Profit after 21 years	2,900,000 €	3,700,000 €	4,100,000 €
Amortization (years)	9.40	8.50	8.40
Rate of return	8.80 %	10.19 %	10.41 %
Spec. yield per year	1,119 kWh/kWp	1,351 kWh/kWp	1,489 kWh/kWp
Increased output	0 %	21 %	33 %
Modules	REC 240 PE	REC 240 PE	SV-T-190

Assumptions: Location: Munich, free of shading – Inverter: SMA Tripower EEG – Renumeration: 0.2207 €/kW Interest: none – Plant size: 1 MW – Calculated by the EXAPHI planning office

Figures as of January 2011. The figures may be subject to fluctuations

PROFITABILITY AT A GLANCE



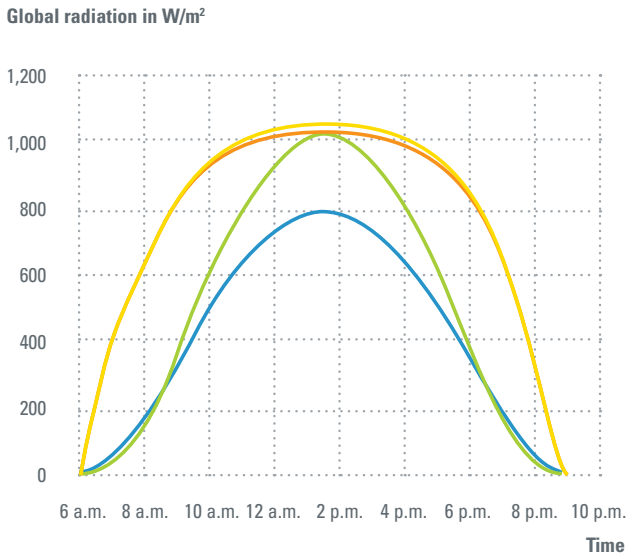
Continuous Power Flow Thanks to EcoSystem

An advantage for personal power use and feed-in

PV-panels achieve their maximum rated output when the sun's rays strike the module surface at a 90° angle. The graphic below shows the differences in the strength of solar irradiation to the panel surface with fixed and tracking panel mountings.
Fixed-mounted solar modules are ideally oriented to the south, enabling optimal use of maximum solar irradiation in the middle of the day. Solar irradiation during the morning and afternoon is only utilized to a very low degree, due to the fact that the sun's rays not only strike the module at an unfavorable horizontal angle but are also far from ideal in terms of compass direction. As a result, many system resources remain unused.

Tracking systems counteract these power output-limiting properties. The trackers follow the path of the sun over the day's course. In this way, the angle between the solar module and the sun is constantly optimized, with the result that a considerable increase in yield is achieved compared to fixed-mounted systems, particularly in the morning and afternoon hours. Up to 40 % extra yield is possible from the use of a tracking system, depending on location and system.

INTENSITY OF IRRADIATION TO THE MODULE SURFACE
(Berlin, September 21)



The EcoChamp-trackers achieve a considerably higher and even power output throughout the entire day. This is of great advantage, particularly where the power is to be used for private purposes, as it enables the steady provision of electricity.

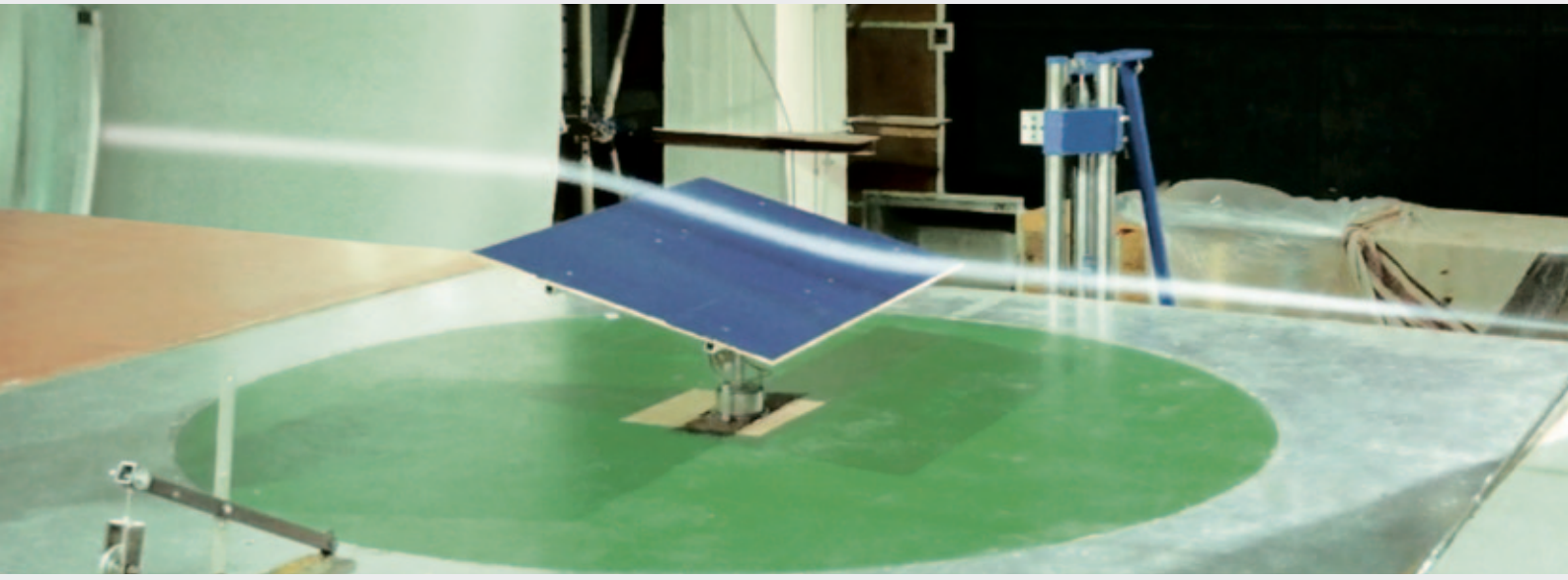
- **EcoChamp ST 3000 (dual-axis)**
- **EcoChamp ST 2000 (single-axis)**
- **Fixed installation 30°**
- **Horizontal installation**

Source: DGS (German Solar Energy Society), Berlin, 2010

Durable and Resilient

Intensive test series as guarantee of quality

Solid evidence is required to make verifiable and valid statements. TecnoSunSolar attaches the greatest value to quality and transparency. Information given on load scenarios is therefore based on data and test results obtained in practice. These test series range from wind tunnel tests to endurance testing with constant data evaluation.



To ensure the stability of the EcoChamp-trackers, they are extensively tested in the wind tunnel at the Dresden University of Technology

Wind tunnel test

The Dresden University of Technology offers outstanding conditions for linking theory and practice with one another. All the tracker systems from TecnoSunSolar, EcoChamp ST 2000 and EcoChamp ST 3000, were tested in the university's wind tunnel. The results form the basis for the statics and certification of the German Technical Inspection Association TÜV.

Endurance testing

An EcoChamp-tracker is subject to intensive endurance tests before being sold in series. Several years can be represented within a far shorter time frame using accelerated testing. In addition to wear, technical data and the system stability are intensively analyzed here.

TecnoSunSolar offer only quality products certified by the German Technical Inspection Association TÜV.

Reference Projects

Trackers which have stood the test of everyday life

TecnoSunSolar tracking systems have been installed on open spaces and flat roofs since 2007. Two pilot projects are presented in brief below.

Open space system, Herrieden near Ansbach (Germany)

Roof system, Wendelstein near Nuremberg (Germany)

OPEN SPACE SYSTEM

- Location: Herrieden near Ansbach (Germany)
- Installed power: 100 kWp
- Area use: 18.75 m²/kWp
- Foundation: grounding screws
- Number of trackers: 288
- Start-up: 2007

ROOF SYSTEM ON FACTORY BUILDING

- Location: Wendelstein near Nuremberg (Germany)
- Installed power: 36 kWp
- Area use: 18.75 m²/kWp
- Foundation: roof penetration
- Number of trackers: 100
- Start-up: 2009

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