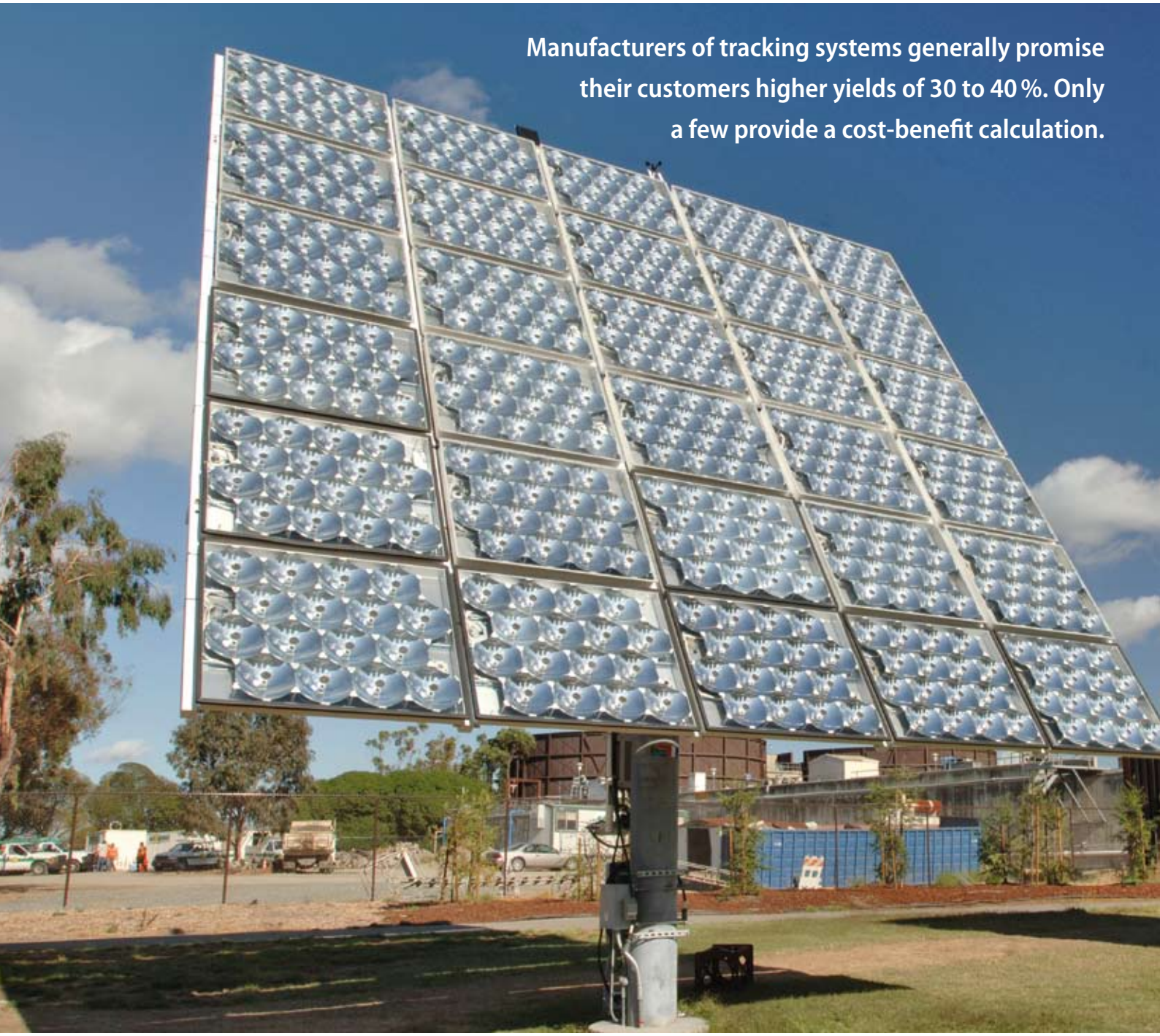
Tracking systems: higher output, higher investment costs

Manufacturers of tracking systems generally promise their customers higher yields of 30 to 40 %. Only a few provide a cost-benefit calculation.

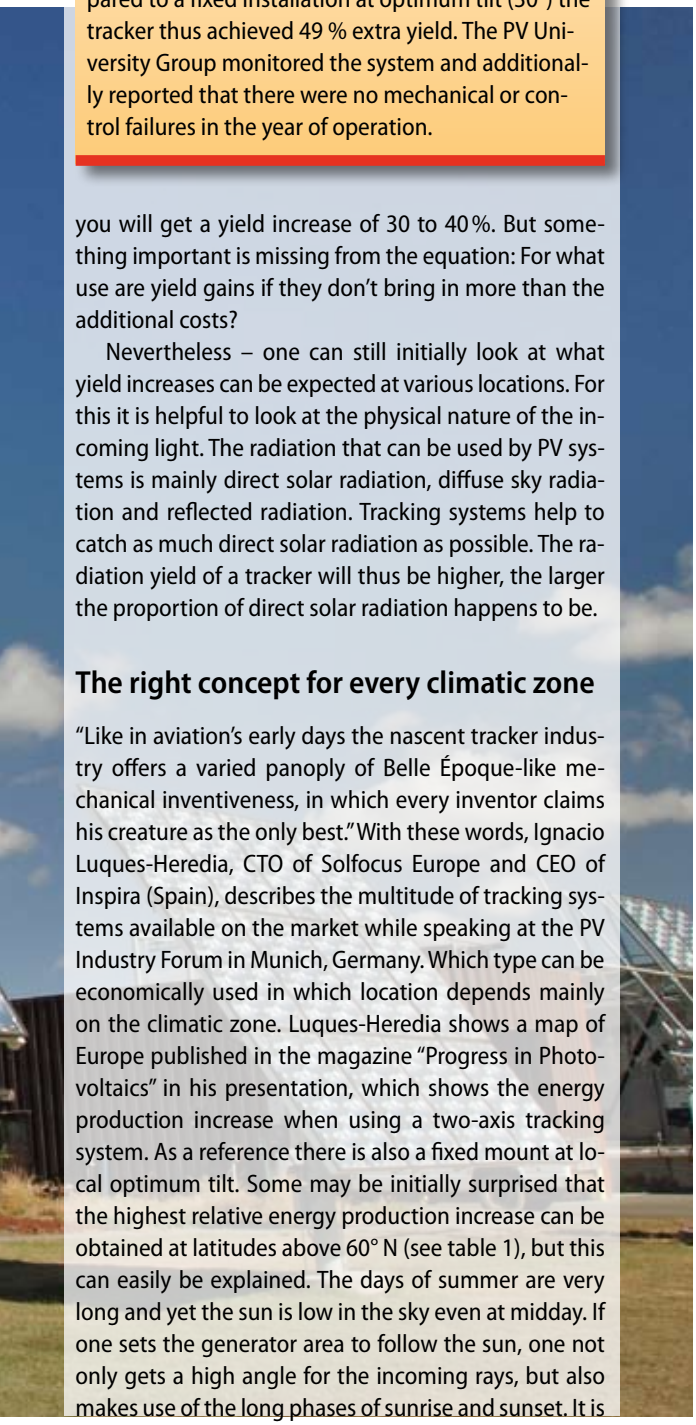


Does the future of tracking systems lie with concentrator technology? Concentrator technology certainly can't do without tracking, that much is clear.
Photo: Solfocus

We assume that the higher investment costs associated with our trackers will have a payback time of around six years." With this statement, Michael Raschemann, managing director of the German company Energiequelle, lifts himself above many of his competitors who manufacture and sell trackers. For the company is both a project developer and plant operator at the same time. It thus studies the economic viability of its self-developed tracking systems on its own systems first, before trying to sell tracker parks to investors. Including operating and land costs plus the country-specific in-feed tariffs when making calculations, seems to be self-evident for project developers. If you ask the suppliers of tracking systems about the economics of their systems, you generally only hear that

Project example: 49 % increased yield

A specific example shows quite clearly what can be achieved in southern Europe. On the University of Jaén campus in Andalusia, a two-axis tracked 9.6 kW_p system (70 m^2 of collector area) achieved a yield of 2,139 kWh/kW_p in its first year of operation. Compared to a fixed installation at optimum tilt (30°) the tracker thus achieved 49 % extra yield. The PV University Group monitored the system and additionally reported that there were no mechanical or control failures in the year of operation.



you will get a yield increase of 30 to 40 %. But something important is missing from the equation: For what use are yield gains if they don't bring in more than the additional costs?

Nevertheless – one can still initially look at what yield increases can be expected at various locations. For this it is helpful to look at the physical nature of the incoming light. The radiation that can be used by PV systems is mainly direct solar radiation, diffuse sky radiation and reflected radiation. Tracking systems help to catch as much direct solar radiation as possible. The radiation yield of a tracker will thus be higher, the larger the proportion of direct solar radiation happens to be.

The right concept for every climatic zone

"Like in aviation's early days the nascent tracker industry offers a varied panoply of Belle Époque-like mechanical inventiveness, in which every inventor claims his creature as the only best." With these words, Ignacio Luques-Heredia, CTO of Solfocus Europe and CEO of Inspira (Spain), describes the multitude of tracking systems available on the market while speaking at the PV Industry Forum in Munich, Germany. Which type can be economically used in which location depends mainly on the climatic zone. Luques-Heredia shows a map of Europe published in the magazine "Progress in Photovoltaics" in his presentation, which shows the energy production increase when using a two-axis tracking system. As a reference there is also a fixed mount at local optimum tilt. Some may be initially surprised that the highest relative energy production increase can be obtained at latitudes above 60° N (see table 1), but this can easily be explained. The days of summer are very long and yet the sun is low in the sky even at midday. If one sets the generator area to follow the sun, one not only gets a high angle for the incoming rays, but also makes use of the long phases of sunrise and sunset. It is less surprising that the energy production increase is lowest over northwest and central Europe as well as the British Isles. The mid-latitudes lie in the frontal zone – which simply means that stable weather conditions, such as in the Mediterranean or the sub-polar regions, are not the norm. At 30 to 40 % in southern Europe, this is in the middle of the pack as far as percentage gain is concerned. As radiation is already high to start with, though, southern Europe has the highest absolute gain in kWh/a.

Tab. 1: Two-axis tracking compared to a fixed mount at local optimum tilt

Source: Inspira / Huld et al.

Region	Energy production increase [%]
Northern Europe (over 60°)	40 to 60
Southern Europe	30 to 40
Western and Central Europe	20 to 30

Tab. 2: Feed-in tariff and DNI in selected countries

Source: Inspira/Solfocus

Country	Feed-in tariff	DNI [kWh/m²d]
France	0.30 €/kWh (mainland); 0.40 €/kWh (Corsica)	3 to 5
Germany	0.45 €/kWh (8% annual decrease)	3 to 3.5
Greece	0.40 €/kWh (mainland); 0.45 €/kWh (islands)	5 to 6
Italy	0.36 €/kWh	4.5 to 5.5
Portugal	0.32 €/kWh	5 to 6
Spain	0.44 €/kWh	5 to 6

Chasing the sun: Tracking systems are most viable in regions with a high proportion of direct solar radiation, but a calculation of economic viability has to take other factors into account too.

Photo: 3M

This is the decisive factor when one is considering whether it makes sense to use tracking in a certain region, as the high relative gain is useless if the absolute yield doesn't pay. The additional yield has to be compared to the higher investment costs in order to see if a tracking system is economically viable.

The localised costs of electricity fall when the yield gain percentage for a tracking system is higher than the increased cost percentage. The calculations contain uncertainties, however, as the solar radiation values used can vary by up to 30 % depending on the source. Additionally, there is a lack of experience as far as the maintenance costs of trackers are concerned. Two general trends can be seen, though: Using modules with a high efficiency increases the viability of tracking systems, but when modules prices fall tracking systems become less viable. The latter is because if tracker prices stay the same, they then make up a larger portion of the total investment. Economic viability for tracked PV systems will thus become ever more difficult in the future.

The return of investment (ROI) depends mainly on the feed-in tariff of the respective country and the Direct Normal Irradiation (DNI) of the location (see table 2). Very good conditions can currently be found in Greece and Spain, where the feed-in tariff lies significantly higher than in Italy and Portugal, and where the DNI can reach values twice as high as in other places in central Europe.

Polar tracker by the Spanish company Feina: Polar trackers should be installed in such a way as to not cast shadows on each other.

Photo: Feina

The maintenance costs of trackers depend mainly on the reliability of the system being operated. Track records for modern tracking plants are still short. One can say that the gearing is not put under much pressure, though. A system which turns once per day only reaches a total of 7,300 revolutions in 20 years. A car transmission turns about that often to travel just 5 km! The control systems are often the source of failure. These should have been tested in terms of electrical safety and their ability to withstand the elements. Investors are advised to pay close attention to what sort of guarantee the manufacturer gives on parts and workmanship. Normal guarantee periods lie between five and ten years.

There is thus a lot to consider if one wants to know whether an investment in tracking systems will pay off. Planners and investors cannot avoid looking around for the right solution for an individual concrete proposal and going through the calculations. Some general points do crystallise out, however; in countries with feed-in tariffs and a high DNI, tracked systems certainly can make sense. Also, the multitude of trackers available on the market helps provide solutions according to local conditions.

In the field of concentrator technology, tracking systems certainly have a future. Concentrator technology requires high tracking precision. A tracker is designed to take structural flexure into account as well as resistance. With an accurate tracking control it is possible to balance out tolerances of structural flexure. Inspira has a proven 0.05 ° average accuracy. The German tracker manufacturer Galaxy Energy GmbH exhibited a controller at the Intersolar which is able to correct mechanical innacuracies down to 0.04 °. The Spanish manufacturer Titan Tracker guarantees a precision of 0.01 ° with its tracking system. Find out more about current developments in our exhibition report on the following pages.

Stefan Trojek

5-MW_p solar farm in Badajoz, southern Spain: The 150 tracked systems by the Spanish manufacturer Badajoz each have a power of 33 kW_p.

Photo: ADES

Intersolar 2008:
new developments in tracking systems

Feina guarantees precise tracking at an attractive price. The Spanish company is providing systems for use with concentrator technology at the Flix solar farm.

Photo: Feina

The Spanish company **Feina S.C.P.**, based in Barcelona, announced shortly before the Intersolar that it would be the provider of tracking solutions to the biggest Fresnel concentrator solar plant worldwide. This plant will be built in Flix (province of Tarragona), 120 km from Barcelona, and is expected to be completed by the end of September 2008. The plant will become a world reference due the concentrator technology to be deployed there.

Feina has been manufacturing and investing in solar tracking systems since 1998. The company has collaborated for a long time with the high-concentration photovoltaics (HCPV) manufacturer Sol3G. The plant in Flix will generate nearly 1 MW_p using HCPV. The trackers will be two-axis and run as a dual system. When the sky is clear three sensors will help provide the high accuracy that the use of HCPV requires. As soon as the system registers that the sun is covered by cloud, it automatically switches to astronomical mode. This guarantees that the generator area always stays aligned with the sun even in cloudy conditions. Feina says that its system is a reliable tracker at a good price. Helping towards this aim is a central controller, for example, which can manage an entire solar plant. Asked about the profitability of tracking systems, sales manager Eudald Camprubí answers: "Our own studies showed 30 to 35 % energy production increase." He also points out that in the end profitability depends strongly on the national laws that are in effect.

Another Spanish company, **Titan Tracker, S.L.** from Torrijos in Toledo province, has also signed a supply contract for the Flix solar farm. It too will deliver two-axis tracking technology to the biggest solar park in Catalonia. The recently signed agreement with Flix Solar covers the supply of 128 two-axis solar trackers with high capacity. The solar farm is to have a total in-

stalled power of 12 MW_p. Flix will thus also be one of the biggest two-axis tracking solar farms in the whole of Spain.

Titan's solar tracking system covers the whole zenithal movement of the sun, beginning at 10 °. From this, Titan promises a considerable return on investment. The generator area may be used for either 211 m² of crystalline modules or 219 m² of concentrator cells.

Also suitable for high concentration photovoltaics: The two-axis model by Titan Tracker.

Photo: Titan Tracker

The structure and non-hydraulic driving systems are totally independent, i.e. the structure supports the panels and the driving system does the tracking. The independent movement of the structure and drives guarantees a long life and reliability, explains Titan and promises an increased yield of up to 40 % compared to fixed installations. Titan Trackers are designed to withstand wind speeds up to 125 km/h in any position. The manufacturer has not only designed the system with high wind loads in mind, but has also calculated in a lifetime of 25 to 30 years.

Exposure on two sides: The double-sided cells of the Traxle 5X receive direct radiation from the sun, but also take up reflected radiation on the underside.

Photo: Poulek

The Czech company **Poulek Solar s.r.o.,** with its headquarters in Prag, was also represented at the Intersolar with its Traxle tracking system. This single axis system was brought onto the market two years ago. A

small control module acts as a sensor for the tracking. Apart from the tracking, a mirror is used to reflect additional radiation onto the generator area. According to company figures, an increased yield of 50 to 60 % over fixed PV systems is possible in central Europe. Apart from central European countries, Spain has so far been an important market for the company.

Poulek is currently developing the Traxle 5X, a new system designed to achieve a 4- to 5-fold concentration. For this purpose the generator area is to be fitted with double-sided cells. These will receive direct solar radiation on the upper surface and the underside will catch radiation reflected and concentrated by a mirror system. A crucial aspect of this development is the cell temperature and the system has been designed in such a way that the cells won't heat up to more than 100 °C. A high-temperature polymer encapsulates the cells. The system is to come onto the market by the end of 2008, according to sales employee Roman Vychodil at the Intersolar.

The German-Chinese company **Sinosol AG**, with its headquarters in Stuttgart, Germany, is an internationally active supplier of photovoltaic systems, as well as a project developer for turn-key solar farms. Apart from beginning to market its shares at the Intersolar, it also presented a further-developed version of its two-axis tracker that it first exhibited at the Intersolar 2007. Sinosol has increased the maximum module area from 140 m² to 153m², which equates to a maximum PV power of approx. 22 kW_p. Depending on the wind zone, the system goes into its protection position at wind speeds of between 36 and 54 km/h. The system can withstand much higher wind speeds, however; according to the manufacturer the „survival wind speed" lies at 120 km/h. Control of the system is via a combination of astronomical and sensory techniques. The system was designed in such a way as to be usable in solar farms worldwide; it has a snow-shifting sensor, for example. The drive system is a mechanically separated unit. Sinosol also puts a high value on the quality of the bearings, as the system is designed to have a lifetime of 20 years. Sinosol provides a guarantee of up to 10 years. The azimuth drive comes from IMO, the linear drive from Servomech. As the drive has four speed steps, the tracker can move into its park position pretty quickly.

Extended module area: Sinosol exhibited the updated version of its two-axis tracker at the Intersolar.

Photo: Wilhelm Breuer

The **Sintesi Industrial Group** from Girona, Spain, exhibited a model of its two-axis tracker system Safetech 125 in Munich. 125 solar modules of 1.6 * 0.82 m² can be accommodated on the system. The whole system is 7 m deep and turns through a circle of 23 m diameter. At a wind speed of 110 km/h the system moves the modules into a horizontal safety position. The company gives a guarantee of three years on faulty mechanical or electronic components, and 10 years on construction faults. The corrosion-protection guarantee is for 20 years.

The Spanish company **Aplicaciones De Energías Sustitutivas** (ADES) has been dedicated to research and development in the energy sector for over 15 years. Apart from developing tracking systems, the company carries out research in the field of hydraulic applications and is currently developing a new generation of wind turbines. According to its own statements, ADES is the solar tracker market leader in Spain, where it has more than 150 MW_p of trackers installed. ADES works for customers such as Endesa (22 MW_p), Gamesa or Isofoton, for example.

The ADES tracker is internationally patented. With a panel surface of 320 m², it is the biggest unit on the market. As a comparison: on the new Suncarrier 6.1 by a+f GmbH, modules totalling up to 287.5 m² may be installed. ADES' production capacity today is almost 150 units a week, with an average installed capacity of 33 kW_p per unit. Thus, approx. 4.5 MW_p are installed on ADES trackers per week.

25-kW_p tracker by ADES in Olite (Spanish province of Navarra): The unit is fitted with 7 rows of modules, with each being 18 m long.

Photo: ADES

Given that the solar trackers perform step-by-step movements and spend more time closed down than actually in action, it is necessary to use a negative brake. For this reason, the ADES R+D department has developed and patented a new traction system, known as a tractor clamp, which eliminates the traditional crown and pinion gear systems. This system reduces the maintenance requirements of the tracker by eliminating the

motor reducers and using the pure tangential force – maximising the tracker's power performance. Thus, instead of braking, the tractor clamp increases the reliability of the system by sliding. The tracker is driven by one hydraulic centre for zenithal and azimuth movements, eliminating complicated maintenance.

ADES is currently working on a 100-kW_p tracker, which will have a surface of 700 m² and three axes. The company aims to unveil it in November.

The Spanish manufacturer **Wattpic energia intelligent** considers wind, hail and humidity to be the most important factors impacting solar installations. Main problem is the resistance of turning axis and movement. The choice was made to eliminate all mechanical components for movement. The FSA-Centaurus double-axis tracker has a solar surface up to 120 m². It is based on an equilibrated triangular structure through which a minimum of energy for rotation is required and no lateral hanging forces occur. The hydraulic subsystem is composed of two pistons for the vertical movement and two motorised wheels. The motorised wheels are placed outside the triangular structure improving both stability and security while rotating. The FSA-Centaurus moves on a decentralised turning and carrying axis which includes an automatic system positioning the module surface area in line with the dominant wind, avoiding damage from excessive wind force. Additionally, in order to avoid hail impact damage the photovoltaic array maintains its vertical position in case of excessive wind value.

The amount of concrete that is used for the installation is almost half compared to traditional trackers, due to the feathering mechanism in case of extreme winds. A protected part of the structures houses all electrical and electronic elements. This includes items as the converter, monitoring, position and control system and protections. All installed during manufacturing process, reducing installation time.

Wattpic's FSA-Centaurus: In case of excessive wind force, its module surface area moves in line with the dominant wind. 1.2 MW_p have been installed in Spain in 2007.

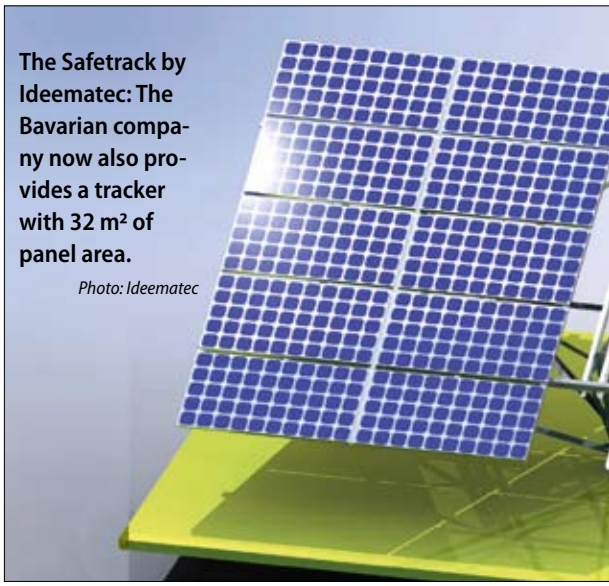
Photo: Wattpic

The German company **Solar Integrated Technologies GmbH** of Mainz, so far mainly active in building integrated photovoltaics (BIPV), is bringing out a tracking system for the first time. Their own development "Follow The Sun" is a modular horizontal single-axis system. It is similar to fixed mountings for systems on the ground: up to 16 modules are placed in a row and moved by a coupling rod driven by a motor. Thanks to its specific weight of just 7.5 kg/m² the system can be used not only for systems on the ground but also for roof systems. A construction height of just 1 m ensures that the tracker remains securely in place even under high wind conditions. The system thus doesn't need to have a park position.

The aim of the development was to achieve an optimum balance between the amount of area used and the yield. During the development the company worked

No weak spot against the wind. With a height of just 1 m, the „Follow The Sun" tracker remains stable at all times and doesn't need a park position.

Photo: Solar Integrated



The Safetrack by Ideematec: The Bavarian company now also provides a tracker with 32 m² of panel area.

Photo: Ideematec

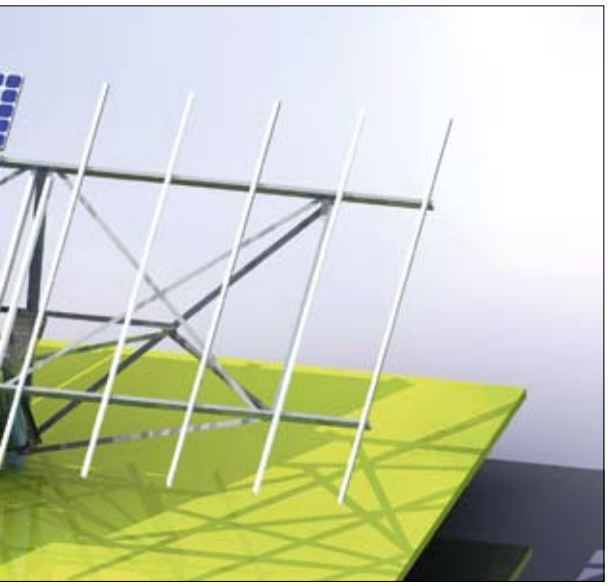
with independent institutes to achieve this. The area required is 22 m²/kW_p. With a central PLC controller for the astronomical tracking, the system can be used with systems of up to 20 kW_p.

That a single-axis azimuth tracker can also make do with 22 m² per kW_p of installed power is demonstrated by **Ideematec Deutschland GmbH**, from Wallerfing in Bavaria, Germany. The company exhibited a further development of its Safetrack tracking system at the Intersolar. With the ST 32, modules with an area of 32 m² may now be installed on a single tracker. This equates to a possible rated power of over 5 kW_p – and this at a construction height of only around 3 m. Thanks to special assembly mechanisms, the systems can be put up with the modules already attached, which saves on installation time. The drive is via a low-maintenance double worm gear. A dual PLC/BUS control system regulates the astronomical control and compares the current position with the desired position. The stability and robustness of the single axis tracker was tested in a wind tunnel at up to 180 km/h and certified by Munich Technical College. The market launch was at the Intersolar 2008.

Degerenergie GmbH from Schopfloch, southern Germany, presented a whole series of new products at the Intersolar. Alongside the common Degertraker 5000NT and 7000NT trackers, comes a new product generation of two-axis trackers with the name Degertraker 3000HD and Degertraker 5000HD. HD stands for Heavy Duty. These systems have been developed specially for installation on buildings and in high-wind zones, such as on islands, for example. Using a dimensioning tool developed by Degerenergie engineers, which can also be used for dimensioning previous systems, each particular wind load zone can be accounted for. The basic configuration covers wind speeds of 170 km/h (+ safety reserve). Individual configuration makes it possible to increase this value significantly, say Degerenergie. The trackers achieve their wind stability through their weight. A Degertracker 3000HD already weighs 500 kg: the 5000 HD a mighty 850 kg. The 3000HD is designed to take up to 25 m² of modules and the 5000HD provides space for up to 40 m² of module area. All normal solar modules may be mounted.

Bernt Lorentz GmbH & Co. KG from Henstedt-Ulzburg, northern Germany, has decided to go for "robust mechanics and reliable controllers". Lorentz trackers thus achieve guaranteed higher yields in solar farms, says the company. The system is a single-axis tracker whose second axis may be manually set to an angle between 0 and 45 °. The net module surface is a maximum of 15 m², which equates to a power of up to 2.5 kW_p. The tracking unit is based on the Etatrack Active, which has been in use around the world for over ten years. This, and the high-quality workmanship, make the company certain that the system will work reliably.

Additionally, Lorentz believes it is important to use an area as well as possible and avoid shading losses, in



order to obtain the highest possible yield from an area. Even with a short spacing, mutual shading should be avoided by using a coordinated tracking movement. At a solar farm in southern Germany the trackers could be installed at a distance of 12 m in a north-south direction and 8 m in an east-west direction. If a solar farm is erected in southern Europe or at a similar latitude, the north-south separation may be reduced to around 10 m. The trackers may be erected on concrete, screwed or rammed foundations.

Galaxy Energy GmbH from Heroldstatt, southern Germany, presented a series of novelties at the Intersolar. Among these was a combined control system for concentrator systems. When the sky is clear the control sensors correct mechanical inaccuracies, achieving an accuracy of 0.04 °. As soon as the sun disappears behind clouds the control system switches to astronomical tracking. The sensor has been newly developed by Galaxy.

Additionally, Galaxy has brought out an off-grid system onto the market this year, in which the tracker is mounted on a trailer. This system is aimed at the Spanish market, where new building development areas often don't have a grid connection for electricity, explains electronics engineer Sven Quietzsch.

In order to protect the system in high winds, Galaxy has developed a wind coupling. This makes it possible to turn the generator surface towards the direction of the wind. As soon as the strong winds subside, the generator surface is pulled back into the initial position by a spring.

The suppliers of tracking systems have one thing in common; they all promise higher yields and present the advantages of their tracking systems convincingly. In the interests of project developers, the wish remains that suppliers should make more concrete statements on the amortisation times of their tracking systems. Although these would be based on example calculations, the parameters of which one would have to check against those of each planned project, one would at least have an initial approximation.

Stefan Trojek