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PV POWER PLANTS 2012

Industry Guide

Cover images

Front
100 MW Perovo Solar Park, Crimea (Ukraine)
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Back
40 MW Waldpolenz Energy Park, Waldpolenz (Germany)
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Industry Guide

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Pressure on Prices and Innovations

By Karl-Heinz Remmers,
CEO of Solarpraxis AG

Dear Readers,

Today's PV market is now completely different to that of one year ago when the previous edition of this brochure was published. Thanks to a dramatic fall in the price of solar modules and an equally significant drop in the price of inverters and other components, solar power is now economically viable in many new areas. Grid parity, which has for a long time been a crucial hurdle to cross in terms of market development, has been achieved far more quickly than expected in many countries.

Additionally, PV solar power is now so much cheaper than electricity from concentrated solar power (CSP) plants that the future of these plants is being brought into question before the technology has even gained a strong foothold. At the same time, international technology introduction programs and market distribution have changed dramatically. While in Europe almost all feed-in tariff (FIT) programs have been significantly reduced, or as is the case in Spain, completely suspended, many countries worldwide have created or adapted market launch programs, meaning that an ever-rising number of countries are installing a continuously higher amount of solar power systems.

Germany was for a long time a step ahead in terms of system prices, but now at least the Chinese have caught up, and it seems that further countries will soon be following suit. In addition to increased efficiency in terms of implementation, the extremely diverse wages play an important role in this. It is usually the case that in countries which have created stable legal conditions for implementing photovoltaics, system prices fall very rapidly in line with the development of the supply chain.

However, there are great regional variations, an issue which, among others, we want to tackle in this brochure, by striving for international transparency in terms of prices and technology. In doing so, we hope to make solar electricity, which in many countries is already available at significantly less than 10 euro cents per kilowatt hour (kWh) (thanks to regulations ensuring the best system prices), even cheaper. Different forecasts suggest that prices between 2 and 3 cents/kWh will be possible in the most suitable locations around the world by 2020 at the latest, making it possible for the market volume to expand significantly. As a result, it has been predicted that an annual worldwide installation of 200 gigawatts peak (GWp) or more is likely.

Even today, solar electricity is lowering Germany's peak load power prices dramatically. On certain days, the currently installed capacity of more than 25 GWp leads to electricity prices of zero at the German Energy Exchange, and even during the winter of 2011/2012, solar power produced in Germany was exported to France to counterbalance an electricity shortage. Despite eight nuclear power stations being disconnected during 2011, Germany has remained a net exporter of electricity and market prices in the day are significantly lower than power prices before the nuclear plants were shut down. This is all thanks to solar power.

The rapid changes have resulted in incredible pressure on prices and innovations, which are a burden on the entire industry and require considerable adjustments to be made in many places. Further technical developments are consequently needed in the large power plants sector to ensure that the ambitious targets are achieved.

As in previous years, we want this brochure to reflect the technical and commercial advances made in the area of large solar installations. In doing so, we hope to pave the way for the installation and successful operation of constantly improving systems at continually lower prices. It is clear that PV power generation lost its image as being "too expensive" at an impressive speed, and it is now seen as the power production technology which is the quickest to install and the most low-maintenance, while also being among the cheapest. It has achieved all this without consuming resources and only produces very low levels of CO_2.

Climate protection and a lower level of dependency on imported raw materials, thanks to the flexibility and stability of the technology, are an added bonus, and form yet another incentive for further developing this technology rapidly worldwide.

Karl-Heinz Remmers

A Period of Increased Competition

By Dr. Winfried Hoffmann,
President of the European Photovoltaic Industry Association (EPIA)

The rapid price decreases and impressive market growth of solar photovoltaics in recent years are well known, but the technology's increasing competitiveness has brought new challenges. As the industry matures it is dealing with increased global competition and falling prices. In addition, the economic crisis has affected access to capital, and regulatory instability has threatened investor confidence.

The solar industry has entered a period of increased competition mainly due to global production capacity and a steep reduction in the average selling prices of all key components. Though in Europe the market trend in most countries has been toward the commercial rooftop segment, large-scale PV installations remain key to growth and to increasing the solar role in the energy mix. An important factor in the competitiveness of this particular segment is that it must compete with prices that are lower than retail prices. It is also worth noting that while large-scale industrial power plants can absorb most of the kWh produced on their premises, greenfield systems will have to find a model for selling kWh in a post feed-in tariff electricity marketplace.

EPIA's 2011 study, "Solar Photovoltaics Competing in the Energy Sector", showed that competitiveness could be achieved in the ground-mounted segment as early as 2014 in Italy, and might then spread to many other countries by 2020. The price decreases we have seen recently have probably moved competitiveness even closer.

These price decreases have also helped offset the difficulty in obtaining cheap financing for large projects. Over the longer term, the future for this segment should be bright, as the technology is scalable and there is no real limit to the size of a power plant. We could theoretically see bigger and bigger projects up to the gigawatt range. The only limits are access to capital and the ability of the grid to handle the electricity produced.

It will be important to develop production along the whole value chain. For Europe to maintain its innovative leadership and competitive edge, the EU needs a strong industrial policy to encourage continued investment in the European PV industry. This means continuing a history of policies that set clear goals for the sector. Further development is needed to provide visibility to investors after 2020, such as by setting a binding EU target for renewable energy for 2030. Ensuring a liberalized electricity market with a new retail market design by 2014 will also be crucial, as will creating a level playing field between energy generating technologies, notably through a phasing out of subsidies for the fossil and nuclear industries and revised market design rules that better reflect the specificities of variable energy sources.

This means changing the prevailing mindset about investment in large-scale PV. The goals should be to facilitate access to capital by lowering the perceived risk, and to emphasize the long-term stability of policies as well as the availability of sizeable, unconstrained volumes for deployment.

Dr. Winfried Hoffmann

Industry

Heading for New Dimensions

Increasing importance of large photovoltaic plants

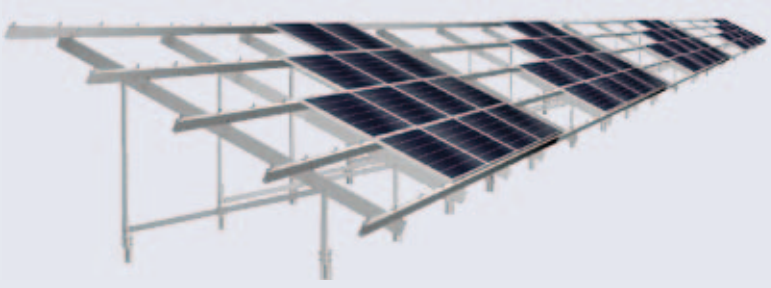
The solar power station in Senftenberg (Germany) has a total output capacity of 148 MW – enough electricity for around 50,000 homes.

Solar plants are increasingly moving into a range which has traditionally been the domain of classic large-scale power plants. In 2008, the solar farm constructed in Brandis, south of Leipzig, set a new record with an output of 40 megawatts (MW). 2009 then saw a solar power plant constructed in Ontario with a peak output of 80 MW. A 290 MW solar farm is being connected to the grid in Arizona in 2012, and the world's first solar power plant with an output of 550 MW is due to be commissioned in California in 2013. Photovoltaic power plants are thus achieving scales equal to those of conventional coal-fired power stations. In Asia there is even talk of gigawatt (GW) power plants, which have so far been the preserve of the nuclear industry.

According to data from the European Photovoltaic Industry Association EPIA, approximately 29.7 GW of solar power were connected to the grid in 2011 – around 40 percent more than the previous year. With the exception of plants in Europe and Japan, this rapid expansion of capacity is chiefly being achieved through large solar power stations with MW-scale outputs.

There are a variety of reasons for the increasing importance of large photovoltaic plants. Rising efficiencies, both in solar cells made from crystalline wafers and in thin-film modules, are juxtaposed with rapidly plummeting system prices. Plant costs have fallen by around 40 percent since 2009, though it is chiefly solar modules that have become noticeably cheaper.

Module prices are expected to drop by another 20 to 29 percent in 2012. And the prices of inverters are also in decline, with a drop of 15 percent calculated by market research company IMS Research. Photovoltaics is becoming increasingly inexpensive, a development that is fuelling the boom in solar power plants and smaller-scale rooftop systems alike. In contrast, the prices for electricity from conventional power plants are climbing. This is making the solar farm market segment progressively more lucrative for financially strong investors – even despite tumbling feed-in tariffs. Photovoltaics offers a profitable, long-term investment with comparatively low risk.



The 5 MW power plant near the Greek city of Drama has a projected annual output of 7,100 MWh.

Top 15 markets 2011 worldwide

	COUNTRY	2011 NEWLY CONNECTED CAPACITY (MW)	2011 CUMULATIVE INSTALLED CAPACITY (MW)
1	Italy	9,284	12,754
2	Germany	7,485	24,678
3	China	2,200	3,093
4	USA	1,855	4,383
5	France	1,671	2,659
6	Japan	1,296	4,914
7	Belgium	974	2,018
8	Australia	774	1,298
9	United Kingdom	784	875
10	Greece	426	631
11	Spain	372	4,400
12	Canada	364	563
13	Slovakia	321	468
14	India	300	461
15	Ukraine	188	190
	Rest of the World	1,371	6,299
	Total	29,665	69,684

Source: EPIA

Economic viability the deciding factor

Project planning and management, installation and the operation of large PV power plants present new challenges for planners, investors and bankers alike. The larger the plant, the more likely it is that the proposed solar plant's profitability, rather than the client's credit standing, will be the deciding factor that determines whether or not the bank will finance the project.

We must also bear in mind that countries such as Germany and Italy are slashing government incentives for solar power (feed-in tariffs). As a result, the photovoltaics power plant market is increasingly playing by the economic rules of the power generation market. The Levelized Cost of Energy (LCOE) therefore decides whether or not an investment in a solar power plant will pay off. The LCOE is stated in either euros or US dollars per kWh and takes into account the total cost of generating power, including investment costs for the plant itself, operating and maintenance costs, and other variable costs for the entire lifetime of the photovoltaic system.

At present, photovoltaics is obliged to compete with peak load power generation from gas power plants. Peak load occurs worldwide around midday when factories are working at full steam and the amount of power required for cooling is at its highest. This is when gas power plants are generally started up, as electricity prices are particularly high at this time of day. In Germany and several regions in the USA, up to 40 percent of the peak load power is provided by photovoltaics on some summer days. At the European Energy Exchange in Leipzig, the falling procurement costs for solar power are striking since, because its yield curve correlates closely to peak demand, it curbs the cost of peak power.

Although solar power generation has not yet reached true profitability, the costs are steadily falling and investment in photovoltaics is rapidly increasing – particularly in installations where grid parity is tangibly close or has even been achieved. This trend was observed worldwide during 2011 and is likely to continue in 2012. By the end of 2011 it was possible to install a 550 kW solar generator for one million euros. Protecting such investments is of critical significance. Precise analysis of all technical, financial, tax-related and legal details is therefore required to ensure the success of a solar project.

Size is not the only thing that counts, however – speed plays a big role, too: Plants with large outputs of 100 MW and above can be installed in a matter of months when using photovoltaics. No other technology is able to match this. Thanks to standardization and high quality levels, solar power plants are becoming ever more financially feasible and are yielding respectable returns – even with falling feed-in tariffs.

In 2012, a 100 MW solar farm at Perovo on the Ukrainian Crimea Peninsula was put into operation.

Connection to the grid presents a particular challenge, since the dramatic expansion of photovoltaics is increasingly creating bottlenecks in the power grids. Restructuring these to accommodate distributed energy supply is a matter of the highest priority. Large solar installations usually feed into the medium-voltage grid, though making feed-in points accessible can sometimes incur considerable costs. The Medium Voltage Directive (Mittelspannungsrichtlinie) issued by the German Association of Energy and Water Industries (BDEW) regulates feed-in in Germany and contains special stipulations on how inverters should function. For instance, it must be possible for grid operators to control them in order to disconnect the plant in the event of grid fluctuations. Solar power plants must therefore obtain corresponding certification for their feed-in management systems.

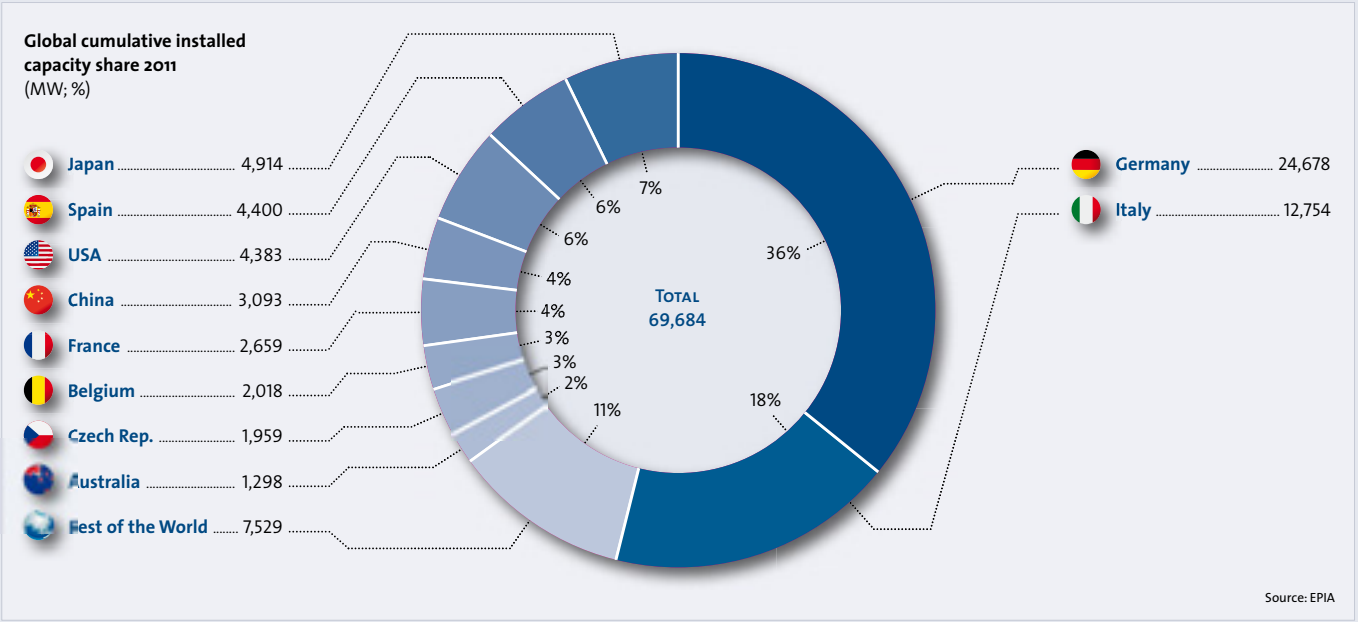
Hybrid power plants that generate both solar and wind power from the same area are drawing ever more attention. Here, the costs of purchasing and developing the land are only incurred once, as are those for the medium-voltage switchgear (transformers, feed-in point). Solar power is generated throughout the day between sunrise and sunset, during which time it evens out the volatile feed-in curves of the wind turbines. In contrast, these turbines primarily produce energy in the evening, morning and overnight. Because both systems operate together at partial load for most of the time, better use is made of the feed-in point. Additionally, it is not usually necessary to expand the grid, since the combination of solar modules and wind turbines will only exceed the full grid capacity for very short, rare periods of the year.

Rising demand

In the summer of 2012, the German government made drastic cuts to the feed-in tariff for large-scale power plants. Henceforth, plants with outputs between 1 and 10 MW will receive remuneration of just 13.5 euro cents per kilowatt hour (kWh). Solar installations with a rated capacity of over 10 MW will receive absolutely no statutorily regulated remuneration. (As the legislative process is in the course of being completed in 2012, these regulations may be subject to change.)

Countries including Italy, France, Great Britain and Spain are following suit and subsidizing large-scale plants less and less. On the other hand, a growing number of communities and companies want to gain independence from the high electricity prices charged by conventional suppliers. They can lower their procurement costs by using large industrial roofs or communal areas to install photovoltaics.

112,000 solar modules with a peak capacity of 31 MWp were installed on a plateau near the French Alps, at the Les Mées solar farm.



But even without any additional stimuli from the state, demand is growing – particularly in Asia and the USA. For example, economic mechanisms are already driving forward the expansion of photovoltaics in the USA, where power plants are financed using Power Purchase Agreements (PPA). In this system, solar power is sold to regional grid operators at a fixed price. In Canada, too, photovoltaics is increasingly becoming first choice for building new peak load power plants, and China's government is currently inviting tenders for a range of new projects. In Africa and South America, solar power vies for precedence with power from distributed diesel engine power stations, meaning that rising fuel prices are giving solar power new economic momentum here, too.

In regions with high levels of insolation such as Spain, the Middle East and North Africa, the Southern states of the USA, India and parts of China, modern solar generators are already able to produce electricity at a price lower than conventional sources (a phenomenon known as grid parity). Even in Germany, the feed-in tariffs for solar power were below the end consumer prices for power from the grid in 2012. Grid parity is also increasingly a matter of consideration for decision makers working on the power generation side. Of course, to be competitive in this market, the costs will certainly have to drop a great deal further.

Market segments

In principle, three key photovoltaics market segments can be distinguished: "Residential PV" is where the investor is a private customer wanting to install solar technology on the roof of his house. Commercial users such as factory owners or public authorities form the "commercial PV" segment, where solar plants produce between 30 and several hundred KW. Major investment projects are described as "utility-scale" plants. They are subject to the regulations on power plant construction.

Left: The Blythe Solar Project (California), one of the first utility-scale PV projects in the United States.

Right: On 140 acres of unused land on Nellis Air Force Base, Nevada (USA), 70,000 solar panels will generate 15 megawatts of solar power by using a solar tracking system.

National Markets

PV power plants, the fastest growing sector

The Finsterwalde solar farm is situated near the former brown coal mine of Klettwitz-Nord in Germany. It has a peak output of 80.7 MWp.

In 2011, the market for large solar farms with outputs over 1 MW developed rapidly worldwide, becoming the fastest growing sector within the solar market. While the European and Japanese markets are dominated by small roof-mounted installations, expansion in Asia, North America and other regions has almost exclusively stemmed from large installations within the utility-scale sector.

According to figures from EPIA, 29.7 GW of new installations were added in 2011, with 21 GW in Europe alone. Analysts at NPD Solarbuzz predict that emerging markets, such as China, North America and India, will also grow further in 2012, accounting for around a third of new PV capacity installed worldwide. In 2011, they were responsible for one fifth. Europe's share will shrink to just over half in 2012, dropping to under 42 percent by 2016.

The market's most important driving forces are the falling system costs of photovoltaics and the increasing price of electricity generated using conventional technologies. As already mentioned, the price of solar modules could also drop by a further 29 percent in 2012. Solarbuzz estimates that by 2016 costs will have fallen by between 43 and 53 percent in comparison to 2010.

The soil at the location of the 1.48 MW solar power plant near Velký Týnec in the Czech Republic was completely renaturalized when the plant was installed.

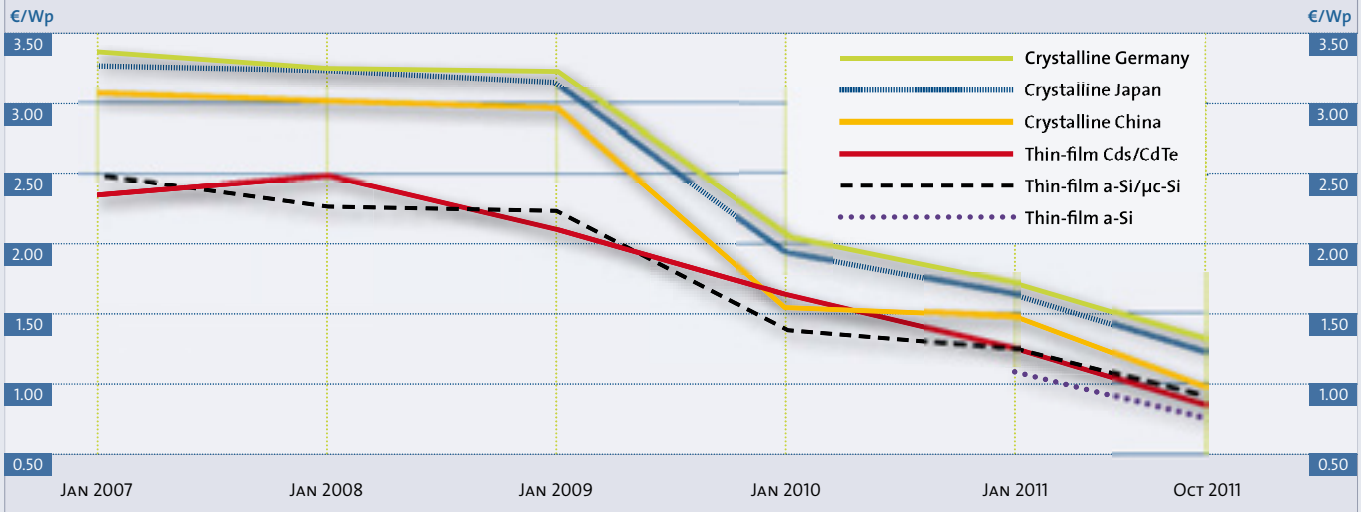
Europe

In terms of global cumulative installed capacity, Europe still leads the way with more than 51 GW installed as of 2011. This represents about 75 percent of the world's total PV cumulative capacity. The European photovoltaics market is dominated by three countries: Italy, Germany and France. Together they accounted for 85 percent of the European market in 2011.

The most important single market was Italy, which installed 9 GW of new capacity (2.3 GW in 2010). 1.5 GW of this was triggered by the new feed-in tariffs for ground-mounted power plants, just one of the regulations introduced by Conto Energia III, which came into force at the start of 2011. Conto Energia IV was announced in June 2011 and gave Italy the impetus to install a further 4 GW of photovoltaic capacity within the space of just seven months. The six billion euros of subsidies set aside for the solar industry had already been allocated by the start of 2012, meaning a turning point is now imminent, especially in the area of large-scale installations. As a result of this level of spending, the government in Rome has decided not to support any further

In 2011, 10 MWp was added to the existing 6 MWp installation in Cigliano near the Italian city of Torino.

Module price trends* 2007 to 2011



*average offer prices on the international stock market

Source: SolarServer/pvXchange; Bank Sarasin, Nov. 2011

ground-mounted solar farms from the middle of 2012 onwards.

Draft proposals for the fifth Conto Energia were drawn up in mid-April: In the future, the installation of additional photovoltaic capacity in Italy is to be capped at 2 to 3 GW. The new regulations are due to come into force in July 2012 or, at the very latest, when the six billion euros of subsidies provided by Conto Energia IV are completely exhausted. In addition, all solar generators with outputs greater than 12 kW must be registered in the future. According to the draft proposals, no restrictions are to be made on the installation of smaller systems. Feed-in tariffs are also being cut significantly: Under the proposed law, 3 kW installations will receive 23.7 euro cents, roof-mounted installations with an output of 200 kW 19.9 euro cents per kWh, and ground-mounted installations 16.1 euro cents per kWh. Experts anticipate that expansion in Italy will almost exclusively ensue from roof-mounted installations, though on roofs with sufficient surface areas, these are able to achieve outputs of several MW.

Germany was the second largest market in both Europe and the world in 2011, with new installations amounting to 7.5 GW, which was almost identical to the previous year's total of 7.4 GW. Despite falling feed-in tariffs, photovoltaic installations still made reasonable returns, with the drop in prices playing into the hands of investors. In December 2011 alone, installations totaling 3 GW were put into operation, including numerous large solar farms with outputs significantly higher than 10 MW.

New regulations regarding feed-in tariffs may lower remuneration to 13.5 euro cents per kWh for ground-mounted solar installations with outputs of between 1 and 10 MW. Nevertheless, market observers expect 2012 to see a similar number of new installations to 2011, especially due to purchases being made in anticipation of even lower feed-in tariffs coming into force. Transitional periods are in place until the end of September 2012 for solar farms built on redeveloped brownfield sites. Following this, the commercial and utility-scale PV sectors are expected to enter a period of recession.

According to figures from EPIA, France connected around 1.7 GW of solar power to the grid in 2011. However, complicated regulations, which sometimes delay connections to the grid for up to 18 months, mean that the lion's share of this was actually installed during 2010. In France, a feed-in tariff only exists for installations with a rated capacity of up to 100 kW. Calls for tenders are used to fund large projects. The government in Paris plans to limit the annual installation of new photovoltaic systems to 500 MW. Interestingly however, France had to import solar and wind power from Germany at the start of 2012 due to the cold winter. French homes are predominately heated using electricity, meaning that increasing electricity costs and a lack of capacity within the country made these imports necessary.

Spain has now completely stopped feed-in tariffs for solar power produced by new installations, meaning large-scale solar power plants are now only possible via the open market. High levels of insolation and reliable solar radiation conditions, combined with a continuous fall in the price of PV components, have opened

Near the city of Ucciani at the center of Corsica (France), a 2.2 MWp solar farm consisting of around 10,000 modules was completed in 2012.

When it was first built in 2007, Viana in Spain was one of the largest solar farms in the world, boasting 24,000 modules (approx. 4 MW).

up this market segment, breathing new life into the Spanish solar market. For example, a solar farm with an output of 250 MW, which is to be installed in the province of Cáceres by 2015, will be solely refinanced by the sale of solar power. Work at the site, which is in a region with very high levels of insolation, is due to begin in 2013. The solar farm will cover an area of 750 hectares and is expected to cost around 250 million euros. It should achieve an annual yield in the region of 400 million kWh.

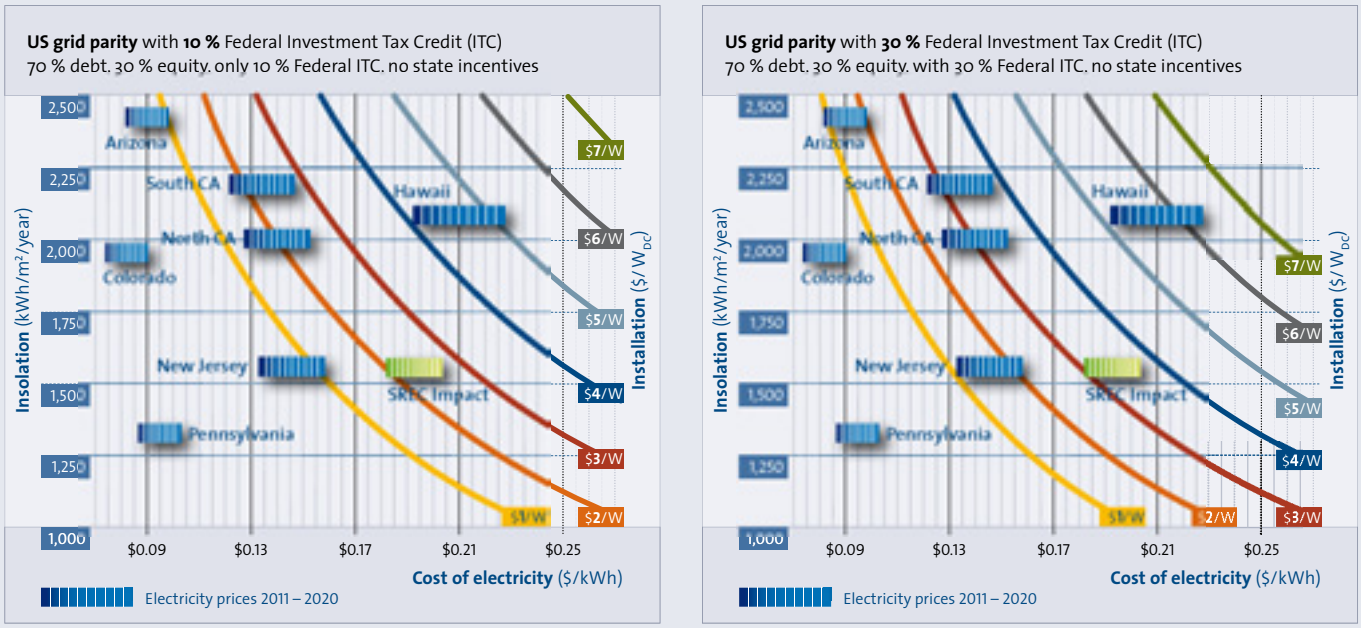
Great Britain has recorded significant market growth, constructing around 780 MW of new solar power installations in 2011. The feed-in tariff introduced by the government in April 2010 was, however, reduced as early as January 2011 for installations with outputs greater than 50 kW. In fall 2011, remuneration for small-scale installations was also reduced. Further noteworthy markets were Belgium (974 MW), Greece (426 MW) and Slovakia (321 MW). A total of around 4 GW was installed in Spain until the end of 2011, but only an additional 372 MW were added in 2011. A feed-in tariff lasting 30 years for large solar power plants was lowered to 13 euro cents per kWh. Additionally, the number of full-load hours eligible to receive remuneration was limited to 1,250 and roof installations now receive 20 euro cents.

Turkey has also introduced feed-in tariffs, as well as increased remuneration for using PV components manufactured within the country. However, the authorities require an extensive amount of supporting evidence before granting these incentives. High levels of insolation of up to 1,500 kWh per square meter in south and south-east Turkey also create favorable conditions for photovoltaics, and the Turkish market is expected to undergo a significant upturn. A bidding process is used to tender for large power plants with outputs greater than 500 kW. Licenses are required to enter this process and the addition of new capacity before 2013 is limited to 600 MW.

The Balkan States are yet to play a significant role in the large-scale installation market. Falling system prices could, however, prompt moderate growth in Bulgaria and Slovenia. Both countries have introduced feed-in tariffs which are significantly higher than those in Germany and Italy.

It can generally be assumed that the market for MW-scale installations in Europe will become increasingly difficult. However, the direct marketing of solar power modeled on the USA's Purchase Power Agreements (PPA) is paving the way towards independence from government subsidies. Solar power in Germany is expected to fall below grid parity in 2013. This has already been achieved in Italy and Spain, where the price of power from photovoltaic installations does not compete with the electricity price for private households, but rather with the stock exchange price of expensive peak load power.

PV plant installation in Hawaii (USA)



Source: Navigant, EIA

North America

Electricity from solar power has already achieved grid parity in Southwest USA and Hawaii. Colossal solar parks capable of delivering a total capacity of up to 550 MW are being planned or are already under construction in California, Arizona, New Mexico and Nevada. In addition to the high prices of peak load power, Investment Tax Credit (ITC) incentives of up to 30 percent are stimulating growth.

In the hot regions of North America, electricity is most expensive around midday, when air conditioning and cooling systems in homes, supermarkets, factories and public utility companies are working at full capacity. Power suppliers usually start up gas power plants to cover these peak periods. Solar power produces its highest yields during the middle of the day, however, meaning its yield curve corresponds perfectly to demand. In the USA, large solar farms are almost exclusively financed by ten-year supply agreements for solar power known as Power Purchase Agreements (PPA). The average price is roughly 20 US cents per kWh, but this varies according to regional provisions.

The graphs illustrate the time when grid parity is reached as a function of the installation costs: The placement of the federal states is explained by their levels of insolation and the (expected) development of electricity prices from 2011 to 2018.

Placement either on or to the right of the graphs indicates when grid parity will be reached, for example in New Jersey, installation costs of 1 US dollars per watt (W) and an ITC of ten percent will give grid parity in 2018 – without SREC (Solar Renewable Energy Certificates or Credits).

SREC are awarded in some federal states. They commit electricity producers to incorporating increasing amounts of power from renewable energy sources into their power plant mix (Renewable Portfolio Standard, RPS). The aim is to step up solar investment in order to lower both emissions and the consumption of fossil and nuclear fuels. The Credits or Certificates are used to calculate the targets that are actually achieved. Power plant operators are able to refinance their investment by selling SRECs on the market in addition to the solar power they generate. This creates investment incentives that are similar to the CO_2 certificates in the European Union.

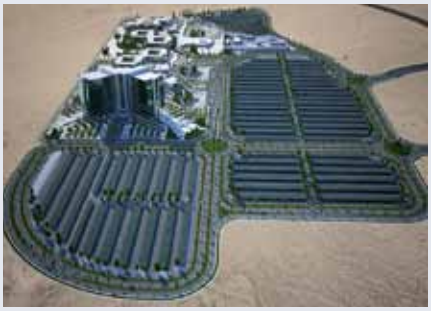
Tax allowances, or Investment Tax Credits (ITC), represent another approach. They allow investors to claim part of the investment for tax relief purposes and offset it against their tax liabilities. ITCs vary according to state (e.g. ten percent or 30 percent).

The effects of both incentive systems can be seen in the supply price for solar power, which is negotiated between the operator of the solar farm and the regional grid operator (often also the region's energy utility). The pricing regime is usually fixed for a period of 10 years and is based on the supply contract, the Power Purchase Agreement (PPA).

Both the market research company GTM Research and the American Solar Energy Industries Association SEIA estimate that 1.85 GW of capacity were installed in the USA during 2011. (EPIA puts this figure at 1.9 GW.) This market has therefore doubled within a year. While in 2009 only two plants with individual outputs of more than 10 MW were installed in the USA, the number rose to 28 in 2011. Commercial photovoltaic systems made up the majority of new installations with an 800 MW share in the total market, while California and New Jersey are the leading states within the market. Utility-scale installations for power plant operators totaled 785 MW, meaning this sector has almost tripled in comparison with 2010. New capacity in California reached around 542 MW in 2011, followed by New Jersey and Arizona with 313 MW respectively, and New Mexico with 116 MW. New installations in New Mexico almost exclusively consisted of utility-scale

In 2010, the Sarnia Solar Project in Ontario (Canada) was expanded from 20 MW capacity to 80 MW.

CIS thin-film modules with 10 MW capacity at the Saudi Aramco North Park Project (Saudi Arabia)



power plants. Analysts expect the US market to grow to 2.8 GW during 2012 and have predicted an increase of 30 percent each year until 2016.

In Canada, the province of Ontario, in particular, has seen a high number of new installations. However, the Green Energy Act introduced in 2009 expired in January 2012, and the government has announced plans to cut the feed-in tariffs, which currently stand between 0.443 and 0.802 Canadian dollars (0.328 to 0.594 euros), by 20 percent during 2012. According to data from the Canadian Solar Industry Association, around 350 MW of solar power were installed in Ontario in 2011. In October 2011, one of the world's largest solar farms with a peak output of 80 MW was connected to the grid in Sarnia.

The Middle East

Photovoltaic markets are still in their infancy in the Horn of Africa, the Persian Gulf and the Middle East. Saudi Arabia's level of insolation is roughly 2,200 kWh per square meter, which is double the average level in the area between the North Sea and the Mediterranean Sea. A significant number of new installations are therefore expected during 2012, particularly since using solar power to remove salt from sea water could provide a solution to the urgent need for fresh water. The government has announced plans to cover a tenth of its energy requirements with solar energy by 2020 and it hopes to install around 5 GW of solar power. Investors have so far pledged around three billion US dollars for photovoltaic generators. There are currently several medium-sized solar farms in Saudi Arabia with outputs of up to 10 MW. Larger solar farms are to be funded through auctions and calls for tenders, and it is hoped that this will lead to between 1 and 2.2 GW being installed by 2015.

A large number of investments are also being made in photovoltaic installations in Qatar and Jordan. A solar power plant with an output of 200 MW is being planned in Oman and will be installed over the next few years. A 1,000 MW solar farm is also set to be installed in Dubai. The Mohammed bin Rashid Al Maktoum Solar Park, which is currently estimated to cost 2.4 billion euros, will cover an area of 48 square kilometers. The first step is to construct a 10 MW photovoltaic power plant, which will be connected to the grid in 2013.

The 1.3 MW PV power plant in Guangming New District, Shenzhen (China) covers about 23,000 square feet of roof space, and is constructed of 13,000 amorphous silicon thin-film modules.

In 2011, China put the Ningxia Tianjingshan PV power plant in Zhongwei into commission. With a capacity of 30 MW, it was the tracking PV power station with the maximum installed capacity in the whole world at the time it was completed.

In Itnal (India) 13,000 solar modules produce over 4,000 megawatt hours of clean energy each year.

China

China may be the most important market of the future for photovoltaic power plants, but it is also the most challenging. According to data from Solarbuzz, the photovoltaic market in the Middle Kingdom grew to 3 GW in 2011, while EPIA puts this figure at 2 GW. The government in Beijing introduced a feed-in tariff for solar power in mid-2011 and from 2012, Beijing will pay one renminbi per kWh (approximately 11 euro cents). The Chinese aim to install around 5 GW of capacity every year until 2015, but given price developments in the field of solar technology, 4 GW are expected to be installed during 2012. Large solar farms make up the majority of new photovoltaic installations in China. While merely a few demonstration projects were installed during 2009 and 2010, the Chinese market is now on the verge of enormous growth. The majority of utility-scale plants are being installed in Western China. Solar power plants belong to the state and are constructed through calls for tenders.

The insufficient state of the power grid is the greatest hindrance to development. In the province of Qinghai, where roughly half of China's large solar farms are located, around 1 GW of capacity was newly installed, but only 50 percent of it was connected to the grid in good time. Above all, there are not enough transformers for the 330 kilovolt (kV) transmission lines. In Tibet the construction of a 220 kV line has been delayed so that additional solar power plants can be connected.

Production in China has been greatly expanded, with plans to build more and more utility-scale plants in the country.

India

India is ideal for solar power, in spite of the high investment costs of 12 to 13 percent which inhibit the market. In India, a great deal of electricity is produced off grid with diesel-driven generators. By the end of 2011, according to EPIA's data, 461 MW of solar capacity had been installed in India and approximately 300 MW of this was installed during the course of that year.

India's electricity supply is the responsibility of the individual states. By the end of 2011, Gujarat had put 986 MW of solar capacity out to tender and by the end of December, roughly 200 MW of this had been connected to the electricity grid. During the fourth quarter of 2011, as part of the Jawaharlal Nehru National Solar Mission, large-scale solar projects with capacities of 350 MW were put out to tender and accepted in the bidding process for 16 to 18 US cents per kWh. Rajasthan has put approximately 100 MW out to tender in power plants with individual outputs of between 5 and 10 MW. The feed-in tariff applicable in Madhya Pradesh amounts to 16 US cents per kWh. The state of Jharkhand aims to install around 500 MW by 2017 and

Constructed with more than 130,000 crystalline modules, the 24 MWp solar park in SinAn (South Korea) produces around 35,000 MWh of clean electricity each year.

Pilot project in Rokkasho Village in the North of the Japanese peninsula Honshu: Photovoltaics and wind power supply local homes with renewable energy. Each household has a storage battery. All energy suppliers, storage units and consumers are part of the same network.

2.2 GW by 2020. In West Bengal, where at the start of 2012 only one power station with an output of 2 MW was in operation, the aim is to install around 500 MW by 2020. Additionally, Chhattisgarh has set itself the target of installing 1 GW by 2017. Further states intend to publicize their subsidization programs during the course of 2012.

Computer simulation of the solar power station in Kagoshima (Japan). With 70 MW, it is the country's largest photovoltaic power station projected so far.

Japan

Following the nuclear reactor disaster in Fukushima, Japan has rejoined the world's largest solar nations. In 2011, around 1.3 GW of new solar capacity were installed. The Japanese market is similar to Germany's, however, in that it is dominated by small roof-mounted installations. The on-site consumption of solar power is playing an increasingly significant role, as Japan has the highest electricity prices worldwide. Since only one of its 45 nuclear power stations is still connected to the grid, production capacities of conventional systems there have reached their limit. The final nuclear power station is to be disconnected from the grid during 2012.

The highly industrial island nation has reduced its power consumption by 15 percent since Fukushima. New feed-in tariffs to be introduced from July 2012 are intended to encourage the construction of large-scale power plants. Ten Japanese energy suppliers are planning to make considerable investments in large solar farms and, in the future, small solar installations in Japan shall principally be used to produce on-site power. Installation owners can sell their surplus solar energy to grid operators. A feed-in tariff has been introduced for both roof and ground-mounted installations of 10 kW and above. The tariffs are graded to ensure that large solar parks and B2B installations with large solar outputs will chiefly be developed. Remuneration is fixed for the solar power from each installation for ten years, after which it is phased out in several stages.

Photovoltaic system in Touwsrivier, near the Aquila Private Game Reserve in South Africa: More than 8,000 trackers facilitate a nominal output of 50 megawatts (MW).

3 MW solar farm in Ayutthaya, 70 kilometers from the Thai capital of Bangkok.

Thailand, Malaysia and the Philippines

Thailand aims to increase its solar capacity by approximately 500 MW by 2020 to achieve its target of covering 20 percent of its electricity requirements with solar power. This market is driven by PPAs. The state has put power plants out to tender, fixing the purchase price of solar power at 19 euro cents per kWh for ten years. The price is set to fall to 15.2 euro cents in 2012. By mid-2011, solar power plants with a total capacity of around 3.4 GW had been proposed in Thailand. The grid is the major hindrance to progress here as well.

A feed-in tariff for solar power was introduced in Malaysia at the end of 2011. Installations with outputs of more than 10 MW can expect to receive around 20 euro cents per kWh. However, solar farms with a total capacity of over 30 MW receive no subsidies whatsoever. A feed-in tariff amounting to around 60 euro cents per kWh has also been paid in the Philippines since the end of 2011. The country has been struggling with rising electricity prices, and discussions on whether to lower the tariff to approximately 30 euro cents are currently ongoing.

Australia

Like the Southwest USA, Australia requires a lot of electricity for air conditioning and cooling systems during the summer. In 2011, electricity during the peak midday period was sometimes offered at record prices of 10,000 Australian dollars per MWh. The standard price is between 35 and 50 dollars. The use of photovoltaics is therefore highly attractive in Australia, since solar installations generate most electricity during the middle of the day. The extreme peak prices yield considerable profits, which is why, according to figures from EPIA, capacity installed in 2011 alone amounted to 774 MW. Increasing numbers of large-scale installations are set to be constructed in Australia to stabilize energy supply and lower electricity prices during the summer.

Africa and South America

As of yet, the photovoltaic markets in Africa and South American have hardly got off the ground. In 2011, Kenya and South Africa became the first African countries to install large plants. The World Bank is one of the most significant sources of funding. In South America, further drops in the price of solar technology should stimulate significant market growth. Increasing attention is being paid to solar power plants in Mexico, Chile and Brazil in particular. Feed-in tariffs have either recently been launched or are due to be introduced in a few Caribbean countries.

State of play: May 2012

The Mallee Solar Park in the Victorian State of Australia with a capacity of 180 MW uses thin-film cadmium telluride (CdTe) modules.

Technology

Striving for increased efficiency

Owing to the relatively high efficiency of cristalline modules, compared with thin-film modules less installation area is needed per unit of output.

Until just a few years ago, solar plants were chiefly built from components that were often only available in limited quantities. This is changing as production capacities are undergoing dramatic expansion. Today, solar power plants are planned, installed and financed as system solutions, and at the end of this chain comes the price per kilowatt hour of solar electricity, which competes with that of other technologies. Return on investment is therefore determined by the efficiency of the entire system, from individual modules to inverters and grid feed-in.

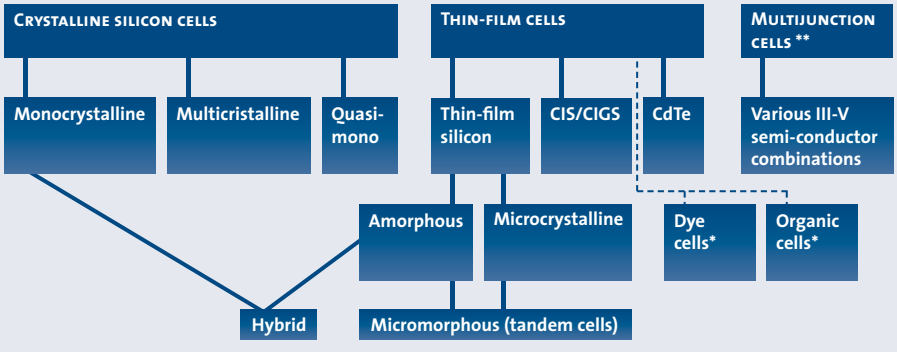
Crystalline silicon or thin-film

Business in megawatt-scale PV power plants is dominated by crystalline silicon and cadmium telluride. Crystalline silicon solar cells have many advantages: Commercial mono- and polycrystalline silicon modules now achieve to just over 20 percent efficiency. Owing to the relatively high efficiency of these modules, less installation area is needed per unit of output, which also means that fewer mounting frames and cables are required. New "quasi-mono" wafers achieve similarly high efficiencies to monocrystalline solar cells thanks to the particularly cheap polycrystalline silicon wafers employed. Manufacturing costs are reduced even further in the string ribbon process, where a thin ribbon of silicon is pulled from a melting crucible between two wires. This technique facilitates the production of ultra-thin wafers just 135 micrometers thick and eliminates the heavy material losses that ensue from sawing conventional silicon wafers, which are 180 micrometers thick. Tandem cells that combine crystalline wafers with amorphous silicon coatings achieve extremely high efficiencies despite the wafers being exceptionally thin.

As thin-film modules are significantly less efficient, they need to cover up to 30 percent more surface area than crystalline silicon modules to achieve the same output. This entails increased costs for installation, support frames and cabling. However, thanks to intensive research and development the efficiency of thin-film modules is currently improving at a faster rate than that of crystalline silicon modules, and the disadvantage of higher area requirements is disappearing as a result.

Since it is now possible to manufacture thin-film solar modules in large numbers,

Types of solar cells



* Research, experimental stage / ** Space travel, concentrator system

Left and below: Solarpark Waldpolenz (Germany)

Below: Inverter housing: Inverters regulate solar voltage and solar power such that the solar generator will furnish the maximum possible output.

the costs of doing so have plummeted. In terms of price per unit of output, thin-film modules now cost the same as crystalline modules.

As a result, large-scale PV plants equipped with thin-film modules can generally produce power just as cheaply as those constructed using crystalline modules. The lower manufacturing costs therefore compensate for the increased outlay incurred for installation.

In addition, thin-film modules perform favorably in diffuse light conditions and at high temperatures. They utilize weak light more efficiently and, compared to crystalline silicon, their output is not so badly impaired when they heat up. This makes them first choice for sunbelt, semi-desert, and desert regions.

Colossal factories for producing thin-film modules with silicon technology or with compound semiconductors of copper indium gallium selenide are currently under construction. Production capacities for inexpensive cadmium telluride (CdTe) modules have experienced the strongest growth. Both CIGS and CdTe technologies have made the successful leap to bankability, demonstrating their reliability in large solar farms. In spite of this, 2011 saw the market share of thin-film technology recede somewhat, as the decline in prices for crystalline modules coupled with their high efficiencies led to a resurgence of crystalline silicon technology in large-scale plant construction. Nevertheless, the new factories being built across the world are virtually exclusively intended for the production of thin-film modules. Significantly smaller investment funds are required here than for silicon cell and module manufacturing technology, so it can be expected that a growing proportion of thin-film modules will be found in large-scale plant business over the medium term.

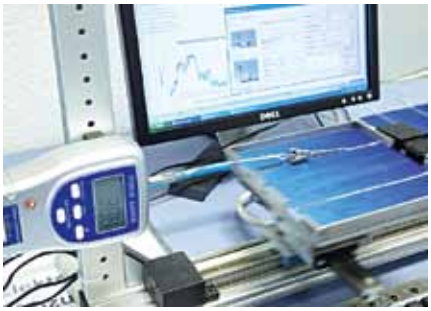
CELL MATERIAL	MODULE EFFICIENCY	SURFACE AREA NEED FOR 1 KWP
Monocrystalline silicon	13–19%	5–8 m²
Polycrystalline silicon	11–15%	7–9 m²
Micromorphous tandem cell (a-Si/µc-Si)	8–10%	10–12 m²
Thin-film – copper-indium/gallium-sulfur/diselenide (CI/GS/Se)	10–12%	8–10 m²
Thin-film – cadmium telluride (CdTe)	9–11%	9–11 m²
Amorphous silicon (a-Si)	5–8%	13–20 m²

The temperature coefficient

The temperature coefficient indicates the percentage by which a module's output will drop as its temperature increases. With crystalline silicon modules, output falls by around 0.5 percent

Cells made from different materials have different efficiencies. PV array surface area depends on the type of cell used.

Pull-off tests ensure that all connections on the module are safely soldered together.



A sun simulator insolates modules with light from a spectrum close to that of the sun under laboratory conditions. Shading can also be simulated.

Process steps in quality control

Quality control is not only applicable to modules, but to the entire installation:

Project development and planning
- yield assessment
- inspection of details with respect to grids, site subsoil, shading etc.
- review and optimization of DC and AC planning

Module quality control
- precise module specification
- technical consulting
- factory inspections
- before shipment or after receipt:
  - high level of spot checks to assess performance (flash testing by an accredited test laboratory)
  - high level of electroluminescence sample imaging
  - destructive testing
- extra audit

Quality control during construction and acceptance of work
- construction management
- training for installers
- sample electrical measurements (output, characteristic curve, open-circuit voltage, short-circuit current)
- function testing and acceptance measurements (thermal imaging under load)
- test reports

Prior to warranty expiry
- visual check of entire installation
- thermal imaging under load

Monitoring
- string monitoring
- 365-day monitoring

for every degree of increase in temperature. This value is just 0.25 percent with thin-film modules. To calculate this, the output under standard test conditions at a module temperature of 25 °C is used as a starting point.

To illustrate, a solar power plant with monocrystalline solar cells and a rated output of 1,000 kW will only generate 800 kW , even under maximum insolation, if the solar cells reach a temperature of 65 °C. In contrast, a power plant with the same rated output but equipped with CdTe solar modules will yield 900 kW.

Quality assurance from factory to construction site

The long-term yield stability, operational safety and thus investment security of a photovoltaic system are primarily dependent on the longevity and reliability of the modules and system technology used. These qualities are examined in complex test procedures as laid down in industry standards or technical guidelines. Test certificates and additional quality marks provide evidence that a module meets the necessary requirements.

Independent institutes certify solar modules using test samples supplied by the manufacturers. For the “PV+Test” (www.pvtest.de) introduced by Solarpraxis and TÜV Rheinland, on the other hand, samples are bought on the open market and the results published as high-score listings in the trade magazines “photovoltaik” and “pv magazine”, as well as at www.pvtest.de. Increasing importance is being attached to both testing for potential induced degradation (PID) and electroluminescence cell and module inspection, as these analyses reveal weak points in production and allow flaws to be detected fast.

In addition to these type approval tests, spot checks at photovoltaic power plants ensure that the manufacturer data corresponds to the components that are actually delivered. Such quality testing can involve different levels of complexity and cost, from visual checks and performance measurements to electroluminescence and thermal imaging. The purpose of testing is always to safeguard the anticipated long-term yield and minimize the risks of technical failure. Drones are increasingly being employed to fly over

Left: An electroluminescence test reveals even the smallest module damage.

Right: Test for potential-induced degradation, one of the main causes of drops in the output of photovoltaic modules

The flash test measures the output performance of a solar PV module to ensure its operability.

large-scale, multi-MW plants in order to gather thermal images of the module arrays. Solar farms with outputs in excess of 10 MW can be inspected using helicopters.

Extra audit

When buying a large quantity of modules, it is always sensible to place the products delivered, their manufacturers, as well as the components and materials used under closer scrutiny. An audit helps to validate the results of various module tests and estimate the risks of a project. As certificates from different test institutes may vary considerably, results are more meaningful if manufacturers subject their products and components to more stringent testing, and not simply to that specified in the standards. There is no such thing as absolute security, but reasonable assessments can be made. Checklists can also prove useful in analyzing the risks of a product.

Standardization

At present, manufacturers supply products with highly specific features in an attempt to make them as distinct as possible from those of their competitors. If the wide variety of solar modules could be reduced through standardization, it would open up enormous scope to bring down the costs associated with systems technology. This is why large project developers are changing their strategy to offer only standardized power plant units equipped with just one specific module type. These modular units allow the solar plant output to be scaled up rapidly with the greatest of ease.

Inverters

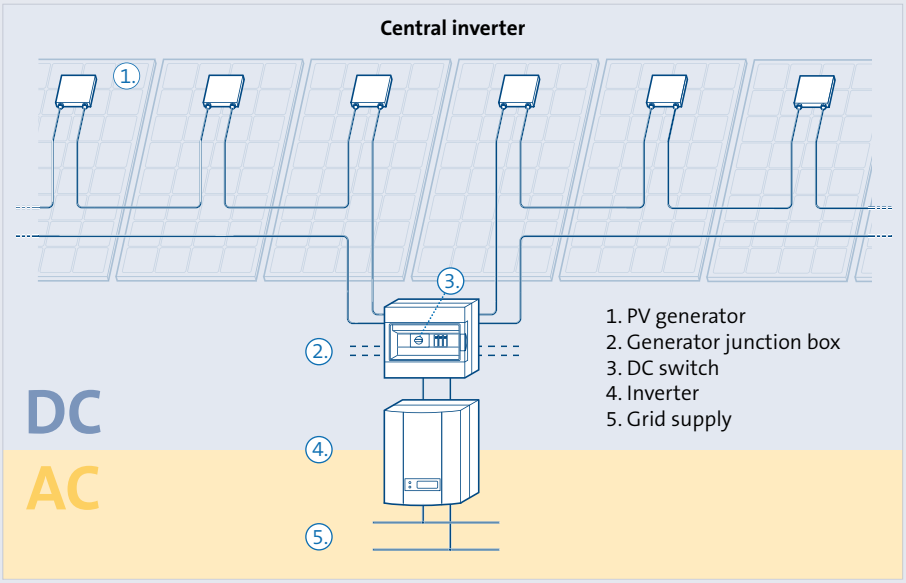
Solar generators are a combination of solar modules connected in series and in parallel: Depending on the voltage of a given solar module, up to 30 of them may be connected in series to form a string, so the electrical voltages of the individual modules will add up. Connecting 20 to 30 modules in series produces a string with a system voltage of up to 1,000 volts (V).

In very large solar farms, it can sometimes make sense to increase the DC voltage to 1,500 V, as this allows for lower current in the DC cabling. Consequently, smaller cable sizes can be used, which in turn significantly lowers the cost of cabling. At the same time, thermal losses are reduced owing to the low DC current. On the other hand, the junction boxes must be equipped with fuses certified for these voltages, which are more expensive than those for lower voltages. The inverters, too, must be approved for the higher DC input voltages, and thus require power electronics that are designed for such purposes. Suitable transistors are even more expensive. The major advantage of having a higher system voltage is the option it provides to combine solar arrays with wind energy systems. Such hybrid power plants take up the same area and feed power into the grid via a joint switching station.

Inverters regulate solar voltage and solar power such that the solar generator will furnish the maximum possible output, even with constant fluctuations in temperature and insolation. They convert the direct current generated by photovoltaic systems into alternating current that can be fed into the grid. While smaller systems feed single-phase power into the low-voltage grid (grid voltage of 400 V), larger solar power plants with outputs of 100 kW and above feed three-phase current into either the low-voltage or me-

String inverters of a large PV plant

Installation of a central inverter



The PV array consists of several strings of series connected modules. The whole of the installation is served by a single central inverter.

dium-voltage grid, which can have a voltage of between 20 and 50 kilovolts (kV), depending on the national grid standard in a given country.

Not all inverters are suitable for every type of module (DC voltage window, with or without transformer, with or without grounding of the DC circuit). It should therefore be checked when planning whether or not the inverter is approved for the chosen modules

Central inverters versus string inverters

In a central inverter design, several strings are connected to one inverter with an output of up to 2 MW. The device is usually made up of several output units of say 500 kW. These units operate in a master/slave configuration where one is responsible for controlling the system (master) and switches on the inverter's additional output units (slaves) as insolation and generator output dictate.

As a result, inverter operation under partial load – unfavorable owing to the low conversion efficiencies achieved – becomes less frequent, which increases the system yield by several percentage points. The inverter units regularly exchange roles (master/slave) in order to balance out the operating times of the device parts and increase service life.

In a string inverter system, just a few strings are connected to an inverter with a lower output. In the case of solar generators, where strings track the sun on individual tracking units, it can prove beneficial to equip each tracker (i.e. each string) with its own inverter.

Assessments of technical and economic viability will determine which option will best improve a given system. When performing such assessments, the impact of an inverter and its efficiency on plant yield is given the same consideration as how the choice of system design will affect the system and installation costs. Ultimately, preference will be given to the system with the lowest energy generation costs.

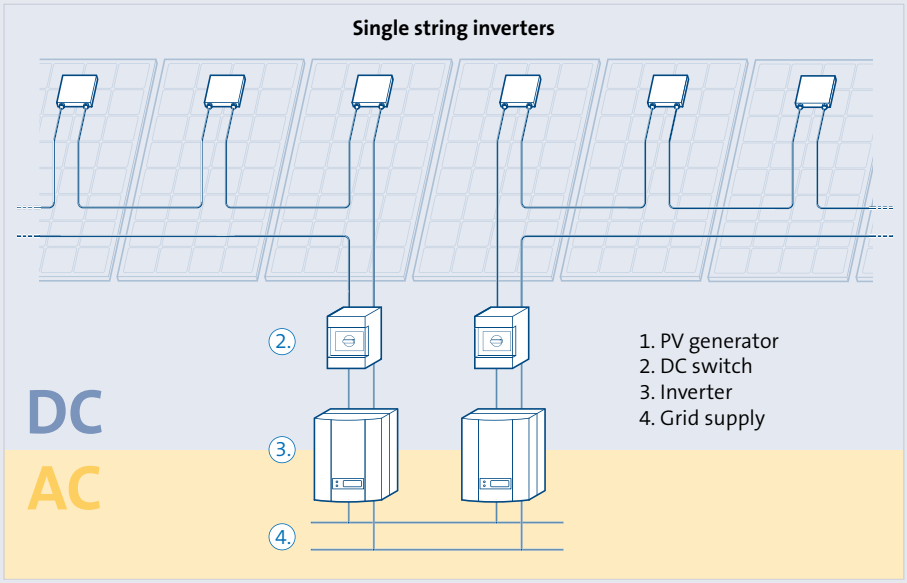
Module Level Power Management

Of late, module level power management (MLPM) solutions have increasingly gained precedence. Known as power optimizers, they are intended to increase the output of individual modules. They enable maximum power point tracking (MPPT) for each module and minimize mismatches arising from production tolerances or shading. Micro inverters, also known as module inverters, take things a step further. They convert direct current from the module directly into grid-ready alternating current. This eliminates losses and avoids a whole series of additional technical problems which can result from complex DC cabling in large inverter systems. Long-term experience with these new technical solutions is yet to be gained, and it therefore remains open as to whether they will bring economic advantages.

An enhanced version of the power optimizer was recently launched onto the market as the Module Maximizer. This device not only tracks the MPP, it also records the output data of a module at

Left: Central inverter

Right: View inside a central inverter



Module inverters connect single modules or pairs of modules directly with the grid.

any given moment and sends this to the central monitoring system. This allows drops in the performance of individual modules to be detected straight away.

European and Californian efficiency

Inverters operate less efficiently if low insolation means that they can only feed in a portion of their rated output, as is the case, for example, in the morning or afternoon, or in cloudy conditions – operation under partial load thus results in lower efficiency. Weighted efficiency enables a comparison to be drawn between the efficiency of different devices. European and Californian weighted efficiencies are two commonly used comparison standards that correspond to the differing insolation conditions in Central Europe (weaker, more diffuse insolation) and California (stronger, more direct insolation).

Good inverters operate with peak efficiencies of almost 99 percent. 98 percent is taken as a guideline for solar parks with outputs of over 1 MW. The amount of power consumed by the inverters themselves is an important factor which largely determines the feed-in period over the course of the day.

Above all, high efficiency and high plant availability mean higher yields: If the average inverter efficiency or annual availability can be increased by around three percent, a 1 MW solar park will generate approximately 86,000 US dollars of additional revenue within ten years.

The capacity of the inverter should be adequately proportioned to allow peaks in insolation to be fully exploited without the device becoming overloaded. Here, too, it is important to carefully plan the optimum technical and economic solution. Recent findings based on insolation readings taken at short intervals provide clues as to how additional yields can be harvested.

The key to the grid

The greater the output a solar farm feeds into the grid, the more important protection against grid failure becomes. The new directive on medium voltage grid feed, which came into force in Germany in April 2011, takes this requirement into account. If grid stability is threatened, the grid operator can either disconnect a plant or use it to stabilize the grid. This may include maintaining grid voltage and grid frequency, balancing real and reactive power in the grid and phase shifting at the feed-in point. Inverters must also be able to ride through short grid interruptions of 200 milliseconds without shutting down the plant (fault ride through). This capability allows them to support the grid, meaning that large-scale PV plants have great potential for stabilizing power grids. New central inverter models are even capable of stabilizing the grid with reactive power and freeing up grid capacity during the night. To do so, they take

Efficiencies

Efficiencies calculated under laboratory conditions for different outputs (partial load efficiencies), which can be employed in various formulae, are required to make the calculations. The following formula is used for European efficiency (in regions with total annual solar irradiance of around 1,000 kWh/m² on the horizontal plane):

$$\eta EUR = 0.03\,\eta 5\% + 0.06\,\eta 10\% + 0.13\,\eta 20\% + 0.1\,\eta 30\% + 0.48\,\eta 50\% + 0.2\,\eta 100\%$$

For regions with high solar radiation – approximately 1,200 kWh/m² annual global irradiance upon a horizontal surface as in southern Europe – Californian efficiency gives more appropriate results. In accordance with the different conditions of radiation, the formula is:

$$\eta CEC = 0.04\,\eta 10\% + 0.05\,\eta 20\% + 0.12\,\eta 30\% + 0.21\,\eta 50\% + 0.53\,\eta 75\% + 0.05\,\eta 100\,\%$$

Left: To avoid energy losses, the cabling must be carefully designed.

Right: Modules are supported by systems made of wood, aluminum or steel.

real power from the grid and then feed it back into the grid at an efficiency of 99 percent, though when this happens a dramatic phase shift is seen in the current and voltage, which manifests itself as a high level of reactive power.

Permanent monitoring of plant operation is also essential for investors and operators alike, as it permits faults and failures to be recognized and rectified quickly, keeping yield losses to a minimum. Automatic operation monitoring and error diagnosis systems, which can either be integrated into inverters or installed separately, send alerts to operators via e-mail, text message, smart phone or cell phone and identify potential causes of error.

Grid feed-in guidelines

In the US, IEEE standard 1547 (voltage and frequency tolerance) applies to grid feed-in. There, inverters must also be able to identify when the subgrid is shut down. If power generation and power consumption balance one another out in this subgrid, a photovoltaic plant may continue to work independently – the grid will therefore remain live. In the event of "islanding", as this is called, a solar installation's inverter must therefore disconnect it from the grid. In Spain, the technical connection requirements must be regulated by contract between plant operators and grid operators (Art. 16 Real Decreto 661/2007).

The economic and technical requirements for feeding solar electricity into the utility grid vary across the European Union, and even within member states. In Germany, the Renewable Energy Sources Act (EEG) provides a legal and economic framework, while the Medium Voltage Directive of the German Association of Energy and Water Industries (BDEW) lays down technical specifications. In fact, it must be possible for grid operators to control all the inverters in a solar park centrally. The BDEW Directive came into force in Germany 2011, and the Low Voltage Directive, containing special requirements on feeding into the low voltage grid, was introduced soon afterwards. Inverter manufacturers must provide certificates to demonstrate that their devices meet the new guidelines.

Since 2012, large-scale solar plants in Germany must be issued with a certificate proving their compliance with the technical specifications of feed-in management before they can be connected to the grid. The certification process is conducted by independent test institutes. In mid-2012, these test institutes were not numerous enough to process the backlog of applications forcing the German Association of Energy and Water Industries (BDEW) and its partners to implement transitional provisions.

Steady ground

Solar parks should reliably generate electricity for 20 years. They are generally built on open land, such as former military sites, landfill sites, former mining fields or hitherto unutilized fallow land.

Planning starts with a survey of the relief, solidity and the quality of the ground. Local wind and snow loads must also be taken into account when designing a photovoltaic plant.

Just like bridges, large-scale solar installations are vulnerable to wind-induced vibrations, though frameless modules exhibit different elastic properties to their framed counterparts. The simplest types of foundation are ones that use piles driven into the earth. Alternatively, piles are also available that are screwed into the ground (screw pile foundations). Concrete foundations made from either ready-mixed or in-situ concrete provide a further alternative for applications such as tracking systems.

The modules are supported by systems made of wood, aluminum or steel. Wooden structures are comparably light but will warp in the course of 20 years. They must be waterproofed and should not come into direct contact with the soil. Aluminum is also an extremely light material. Systems made of this are easy to install and hardly corrode, but the price of aluminum fluctuates greatly. Furthermore, owing to the thermal properties of aluminum, heat and frost cause greater stresses in the structure.

Secure anchoring

The mounting system must be capable of supporting the solar modules securely for a long period of time. Mounting a free-standing PV power plant is frequently easier than many other types of installation, as the construction area is more easily accessible than, say, a slanted roof. A big disadvantage of free-standing plants, however, is that they lack a truss to which to screw the assembly system. This is why anchoring the mounting frame safely into the ground is a factor which should be given adequate consideration, as it will need to keep the equipment stable for decades.

Tracking systems

Depending on their location, crystalline silicon modules can furnish up to 35 percent higher yields if they are able to follow the path of the sun mounted on "trackers". Nevertheless, the higher investment costs and additional maintenance required are more likely to pay off in southern regions which receive a high proportion of direct insolation. In northern areas of Central Europe, financing this additional expenditure is becoming less and less worthwhile given the falling module prices.

Single axis trackers rotate PV arrays so that they follow the sun's daily path from east to west. Dual axis (hemispheric) systems also tilt on a vertical axis to follow the sun's movement.

The use of trackers entails considerable additional preparation work on the foundations; the ground must also be sufficiently stable. Furthermore, the surface area required for tracking systems is larger than that for non-tracking PV installations as, to avoid shading, trackers must be positioned at a sufficient distance from each other.

Losses due to cabling

Losses due to cabling are often underestimated. If the plant is badly planned, total energy losses in copper cables can add up – anything over one percent is unacceptable. To avoid high losses, the cable cross section must be relatively wide, while cable lengths should be as short as possible. During installation and operation of the PV plant, the plug connectors on the solar module cables must be checked to ensure that they are water tight and that the connections are not prone to fault voltage or short circuits.

Cables should not be exposed to direct solar radiation, so should be laid in shaded areas. This is because every degree of temperature increase in the copper material increases electrical resistance and multiplies losses as a result. What is more, sunlight (UV light in particular) can degrade the cable insulation material.

Lightning and overvoltage

Large ground-mounted PV plants always need their own protection system against lightning and overvoltage. Overvoltage is caused by electromagnetic induction in cable loops. According to TÜV Rheinland, in Germany almost 50 percent of all damage to PV plants is caused by overvoltage. Protection against direct strikes (direct strike lightning protection) or coupling as a result of strikes elsewhere in the grid (indirect strike lightning protection) must be taken into consideration during the initial stages of planning. Shutdown systems should also be integrated that allow the PV system to be swiftly disconnected from the grid in the event of fault voltages or fires.

Storage systems for solar power

Industrial-scale batteries are needed to buffer peak power outputs from solar power plants. The two most commonly used types are redox flow and sodium sulfur batteries, though commercial use of these systems has not yet been adequately tested. Lead-acid and lithium-ion batteries are currently only supplied for small-scale systems, to optimize energy use in private households. Synthetic methane (power to gas) is opening up a promising new path for technological development that will allow solar power to be stored on a major scale. Here, surplus solar power is used to generate methane. This combustible gas is then used in conventional gas power plants to generate peak load power.

Operation and maintenance

In addition to costs of the technology itself, the cost of operation and maintenance is another important factor to consider. These costs do not figure in construction of the installation, but can add up quite considerably over the service life of a solar power plant. For each kilowatt hour of solar power generated, between one and ten euro cents fall to the costs incurred during the 20- to 25-year operation of a plant. This large spread is owed to the wide range of potential costs: For example, these can include wear caused by extreme weather or vandalism. Expenditure is also incurred for monitoring plant safety and protection against theft. In the case of off-grid systems, battery costs are the real killer. Currently, investors can expect to pay around 10,000 to 14,000 euros for operation and maintenance on top of the costs for the technical system.

Financing

PV becomes increasingly attractive for the finance industry

Technical due diligence: Independent engineers scrutinize the technical plant design.

Until 2009, manufacturing and sales of technical components were the focus of solar business. For this reason, photovoltaic systems were valued first and foremost according to the system costs per kW of peak power. Now, however, photovoltaics is gaining an ever larger presence in the energy industry, and must therefore begin to gauge itself by the cost price per kilowatt hour. This not only includes the system costs, but also every bit of expenditure on realizing the solar project, the operating costs and financing.

In the past, the prime focus of photovoltaic business was on technical components. Today, trade centers increasingly on projects, financing and exploitation rights, which makes photovoltaics attractive for the finance industry. Financing models taken from classic manufacturing industries are directing a significant flow of money into the solar industry. These include trading in turnkey projects, project rights and other forms of participation in companies that operate solar power plants – right through to the purchase and sale of entire power plants.

Banks provide financing in various ways. They either grant project loans via their house bank, meaning that the full risk will be shown on that bank's books, or they form syndicates to spread the risk exposure. Private capital is also being used more and more to fund solar projects. Club deals are common, where several banks pool a loan together as part of a skeleton agreement, with each of them on different terms. One of the banks coordinates the syndicate and acts as a contact with the client (borrower). However, with this model, the time between application and approval is longer meaning that investment costs are higher.

Thin-film plants are at the bottom end of the scale, while monocrystalline silicon parks with tracking systems sit toward the top. New module technologies (thin-film silicon, CIs or CIGs) are now also increasingly being classed as creditworthy, particularly if they are used in projects that mix them with proven technologies such as crystalline modules.

The Lüptitz citizens' solar power plant (Germany) is run by a cooperative of private persons.

Banks require the quality of the installation to be inspected by external experts.

Opportunities for financing

Financing stands or falls with the actual annual solar power yield fed into the grid. Banks expect a return on project investment of at least eight to nine percent. Private investors take between four and five percent if they conclude long-term deals where the degree of risk is low. The strong market for large-scale plants that prevailed at times in Spain (2008), Germany (2010 and 2011) and Italy (2011) created unrealistic expectations of the returns that solar power was able to yield. The eurozone crisis and the withdrawal of state subsidization are therefore forcing photovoltaics to take a more realistic view of things – and enabling it to exploit its long-term advantages more successfully. Ever more investors are recognizing the fact that the technology has matured and the risk of default is low. The investment, and thus the prices it can achieve on the power market, is not linked to the uncertainties of the oil market. And the sun supplies its energy for free, which gives photovoltaics a fundamental advantage.

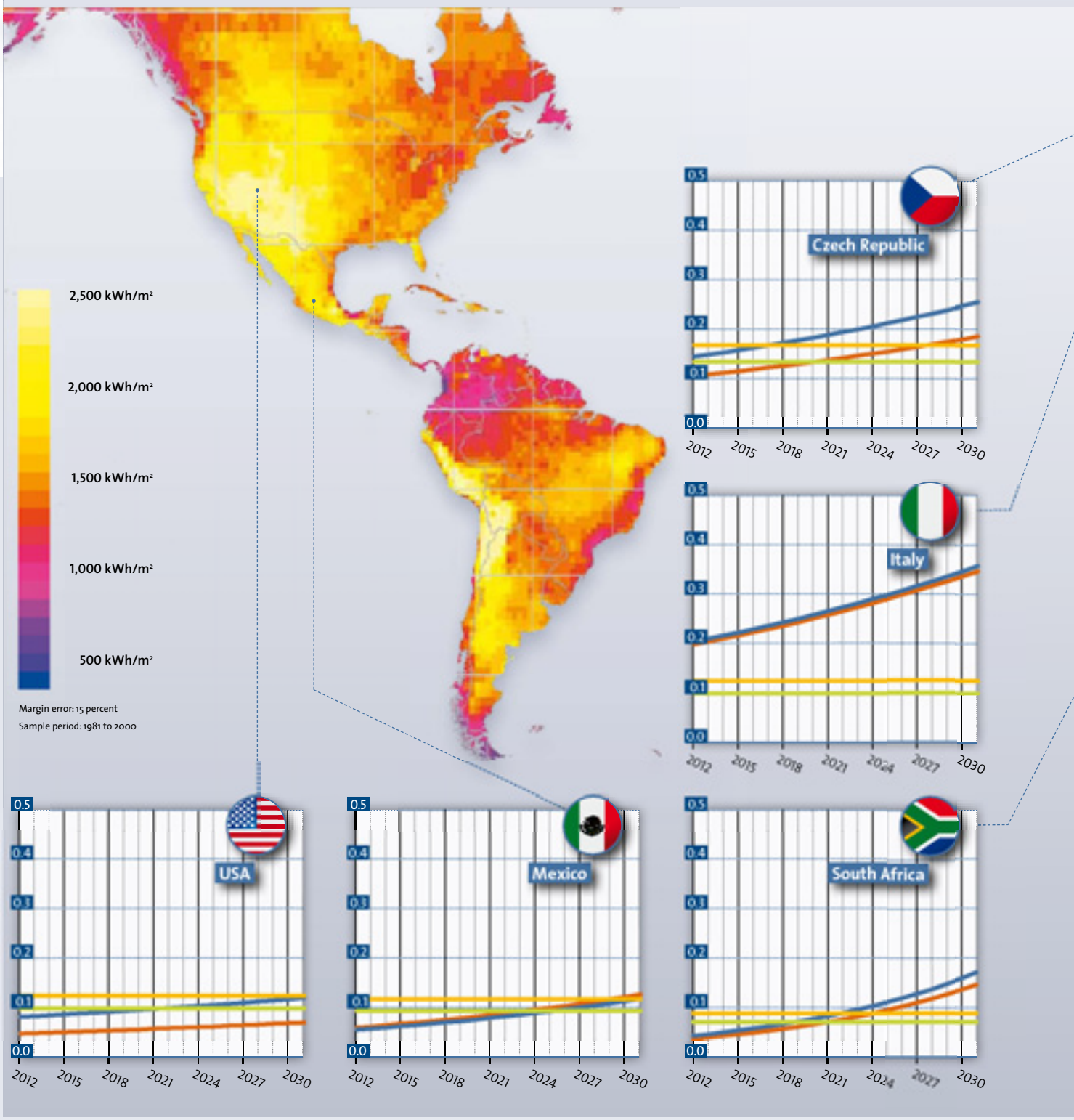
The benefit gained from minimal financial risk should not be underestimated, especially with large solar farms. These can be installed in small, modular units and financed, refinanced and traded in stages. This valuable aspect of photovoltaics means that it could soon drive out solar thermal power generation. Photovoltaics is being used more and more to create new power plant capacity, particularly in sun-rich countries of more southerly climes, where the hunger for energy grows day by day and where technology capable of grid-connected and stand-alone power generation is sought.

Thanks to the expansion of production capacities for modules and inverters across the globe, there are practically no further bottlenecks that could limit the growth of photovoltaics as an industry, and solar parks in particular. From now on, area and capital will be the critical factors. One consequence of this is that many module manufacturers also operate as developers of large solar parks, as technology is usually bought directly from producers in this business segment.

Price cuts

In 2011, the average cost of a turnkey solar power plant in Germany was 2,200 euros for each newly installed kilowatt of rated power (net, excluding sales tax). During the course of 2011, prices then fell by around 30 percent In the case of large-scale installations with capacities of 1 MW and above, prices are cheaper, at between 1,300 and 1,500 euros per kilowatt.

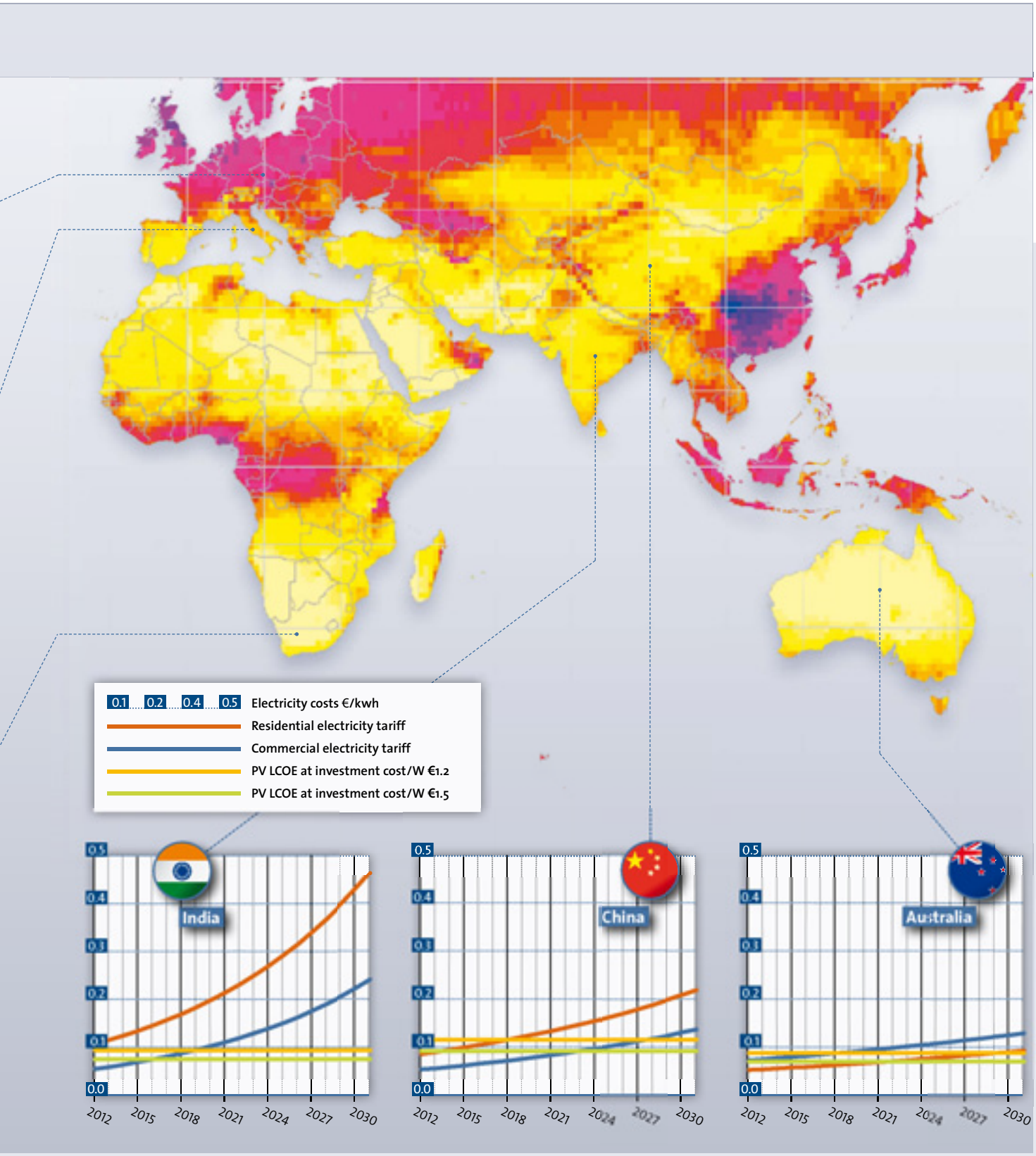
Annual global irradiation and solar electricity potential



Levelized Cost of Energy (LCOE)

Before we are able to assess the competitiveness of photovoltaic power compared to conventional energy sources, consideration must be given to the Levelized Cost of Energy (LCOE), which determines precisely what costs are incurred when generating solar power. The LCOE is stated in either euros or US dollars per kWh and takes into account the total cost of generating power, including investment costs for the plant itself, operating and maintenance costs, and other variable costs for the entire lifetime of the photovoltaic system.

According to the report titled "Solar Photovoltaics: Competing in the Energy Sector" published in September 2011 by EPIA, the cost of capital – expressed as the weighted average cost of capital (WACC) – is a key factor in the LCOE. The report states that the cost of capital has a greater impact on the LCOE than mod-



Source: Meteonorm 6.0 (www.meteonorm.com)/Solarpraxis AG

ule prices, insolation at the site and plant lifetime. An academic paper on the importance of LCOE calculations for photovoltaic project developers and market stability was published in early 2011 in Energy and Environmental Science. The paper gives an insight into how photovoltaics would compete in the energy sector if LCOE calculations were applied to the cost side of the grid parity equation and then comparisons made between the actual electricity prices and those that are forecasted.

No money without security

Loans are never granted without security. Examples of securities include the transfer of ownership of the PV plant, the transfer of rights from project contracts (delivery contracts, operating and maintenance contracts, contracts of use and occupation for the site, insurance

Left: The Helbra solar farm (Saxony-Anhalt, Germany) has a total output capacity of 11.7 MW.

Right: The PV plant is situated on a 18,000 m² property on the outskirts of the German town of Adorf and generates 1.2m kWh of electricity per year.

contracts), encumbrances, pledging of the operator's account or pledging of shares in the business. In the past, project financing was sometimes too tight, which led to non-performing loans. For this reason, banks often set requirements for the content of project contracts, or place stricter demands on the use of cash flow (reduced profit distribution). In addition, they require the quality of the installation to be inspected by external experts (technical due diligence). It is not uncommon for two independent yield reports to be requested.

Due diligence

A due diligence assessment serves to analyze the strengths and weaknesses of a project, as well as to evaluate its risks and estimate its economic value. The analysis particularly focuses on technical and material defects, legal and financial risks, and circumstances that stand in the way of a project being realized or being profitable. If risks are detected, this could lead to contractual allowances being made in the form of price reductions or guarantees – or in extreme cases, could trigger the abandonment of negotiations.

RES-LEGAL

The free RES-LEGAL database provides an overview of the manifold subsidization models in Europe and well as the stipulations and guidelines on grid connection. It contains all important legal regulations on subsidies and the feed-in of power from renewable sources within the EU. The collection of models for remuneration, tax incentives and certificates as well as grid access comprises 27 countries. A search assistant enables users to analyze and compare legislation in the different countries.

www.res-legal.eu

Assessment may, for instance, follow these four steps:

Legal due diligence

This step examines the legal basis of a project from purchase or rental of property to feeding in. Checks are made on the application to the utility as well as on the operating, maintenance and insurance contracts. Experienced project developers use standardized templates to exclude major risks.

Tax due diligence

Experts check the tax aspects of a project, such as corporation income tax, trade tax and income tax, value added tax, tax on profits, real property tax and land transfer tax, as well as taxes incurred during operation. Such an analysis includes tax incentives and depreciations.

Technical due diligence

Independent engineers scrutinize the technical plant design. This includes: system planning (yield forecast, plant layout, inclination and alignment of modules, ground survey, distance from feed-in point, number of feed-in points, grid capacity), specification and selection of components, tenders and order placement, installation, technical quality management and building quality management, operational monitoring and safety, manufacturers' and installers' guarantees and warranties, creditworthiness of suppliers, theft and vandalism protection (fencing, CCTV), and the costs of maintenance and land management (for example mowing and pruning).

Financial due diligence

The last phase before a loan is granted concerns financial aspects: required investments (capex), costs for the property and yields from any future sale, expected solar yield, costs for operation and maintenance (opex), liquidity reserves, insurance, costs for dismantling and recycling the plant after the end of its service life. The cash flow, taxes and debt services are used as a basis for evaluating profitability, which is the deciding factor in granting loans.

New business segment: power plant operation

To date, solar power plant project developers have commonly also assumed responsibility for maintaining and operating plants on behalf of investors. However, for the duration of the warranty period, a conflict of interests arises that is typically settled at a disadvantage to the investor. As a result, the fields of planning and operating large-scale power plants are increasingly going their separate ways, not least because ever more attention is being paid to expenditure on operation and maintenance (O&M) in a bid to limit the overall costs of investment.

Estimating the yield of an investment (SPX Index)

The specific yield of an investment can easily be quantified using an empirical formula that illustrates the key operating parameters of the installation. This formula was devised by analysts at Solarpraxis AG in order to optimize plant configuration and the use of financial resources. If the specific yield of the plant is then multiplied by the availability of the inverter to the grid, this gives the total yield taking into account every euro spent.

Political conditions in Europe

In Germany, many other EU countries, and in several others besides, solar electricity is sold to grid operators at a statutorily guaranteed feed-in tariff. During the first half of 2012, these feed-in tariffs were dramatically reduced, and in some cases stopped altogether, particularly for large-scale power plants.

The market for large solar power stations is therefore likely to mature within a short space of time. The era of statutorily

Left: The PV sound barrier is located on a motorway in Germany, close to Munich's airport, with a length of 1.2 km and a capacity of 500 kWp.

Right: The Reckahn Solar Park has a capacity of 37.7 MWp and is located in Reckahn, Southwest of Berlin, Germany.

guaranteed feed-in tariffs will soon be dead, and the dawn will rise on that of directly marketed photovoltaic power. The solar industry has reached this stage within just a few years. Throughout 2012 and 2013, solar power plants are likely to be subject to compensatory pricing before they finally become governed by the free interplay of market forces in the energy sector.

In many countries, expansion quotas are capping growth. Examples of this can be seen in Spain and Italy, where total spending on feed-in remuneration is limited to six million euros per year. In a different model, the German government is making all further development of feed-in tariffs dependent on an annual expansion corridor of between 2.5 and 3.5 GW. If feed-in tariffs were to disappear completely in the near future, however, the state would have virtually no grounds for capping photovoltaic expansion.

Incentives outside Europe

The picture outside of the EU is also heterogeneous. India is considering a feed-in law with guaranteed remuneration. The picture outside of the EU is also quite diverse. India is considering a feed-in law with guaranteed remuneration. China intends to designate large areas for solar power plants with capacities of several GW, though so far has only introduced uniform feed-in tariffs for small-scale installations. There, projects are controlled exclusively by the state and put out to tender through auctions.

Tax incentives play an important role in the USA (Investment Tax Credits: ITC), and can reach up to 30 percent. These sums can be directly offset against tax liabilities, and if no tax is due, the ITCs are paid out to investors as negative tax. In addition, some states pay out for every kWh fed into the grid, while others offer tax bonuses and subsidies. Power Purchase Agreements (PPA) are the preferred business model for large-scale solar power plants. As part of these agreements, the solar power is sold to one energy utility or one large customer for ten or 15 years. The project tenders commonly invited at auctions in many Asian, Arab and some European countries basically work on a similar financing model, only the price is decided during the auction. It is not uncommon for lengthy negotiations to ensue afterwards due to investments being only barely covered. Little is likely to change in this practice in China, as the country has no private energy utilities. In countries such as India and Thailand, however, an economic mindset will increasingly win through and spur the markets on.

New feed-in tariff in Germany

The savage cuts to feed-in tariffs did nothing to dampen the photovoltaics boom in Germany during 2011. In March 2012, the German parliament voted in favor of drastically lowering the tariffs again from April 1, 2012. Now only three power classes remain: small rooftop systems with outputs up to 10 kW (19.5 euro cents per kWh), larger roof-mounted installations with outputs between 10 kW and 1 MW (16.5 euro cents) and plants with outputs of 1 to 10 MW installed on roofs or on the ground (13.5 euro cents). Starting in May, remuneration for solar power fed into the grid will be reduced by one percent every month. Operators of small installations will be required to consume 20 percent of the power they generate on site or to sell it independently. A figure of ten percent is required from medium-sized plants with an output of up to 1 MW. Although power from larger MW-scale installations is remunerated in full, very large plants with outputs over 10 MW no longer receive any remuneration whatsoever. Transitional provisions are in place for rooftop and ground-mounted plants that apply until the end of June 2012, and for redeveloped brownfield sites until late September 2012.

Furthermore, in future the outputs of all MW-scale plants within a four-kilometer radius of one another will be added together. If they are found to have a cumulative capacity of over 10 GW, these sub-generators will no longer receive remuneration, even if they belong to different owners. This rule will apply for an interim period of two years. And even the concept of commissioning a solar installation has been reformulated. In future, it will no longer be possible to put solar arrays into operation that do not have inverters. However, the connection to the grid will continue to have no impact on the feed-in tariff it receives.

(As the legistlative process is in the course of being completed in 2012, these regulations may be subject to change.)

Project Planning

Ensuring technical and financial feasibility

To enable inspections, helicopters or service drones are employed.

Good and thorough preparation by experienced planners can make or break a large solar park project. Owing to the size of the project, neglecting small points may soon lead to large quantities of money being lost. Careful planning does not only concern the assessment of yields and capacity or building permits. Other significant factors that determine the success of a project include on-site support, grid access inspection and certification of the feed-in management system.

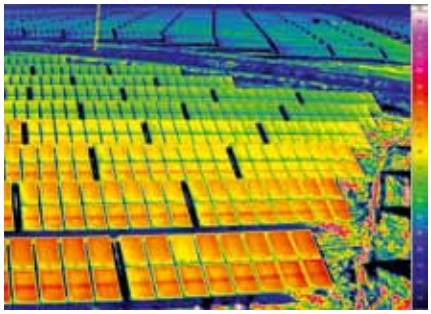
Optimizing a plant's performance ratio is given top priority.

Performance ratio

The ratio of actually generated power to the theoretical yield in a certain location is decribed by the performance ratio (PR). It serves as a measure of plant efficiency for evaluating different plants in different locations.

Optimizing a plant's PR is given top priority. A good value in Germany would be over 85 percent, with really excellent plants achieving over 88 percent.

Based on the values for a 1 MW PV plant in the South of the USA (PPA: 0.2 US dollars/kWh, specific yield: 1,800 Wh/Wpeak, performance ratio 80 percent), an increase of ten percentage points in performance ratio will earn an additional 396,000 US dollars annually.



Thermograms provide information on PV generator operation.

I-V curve measurement

Comparable calculations can be made for Germany. For instance, a PV power plant with a peak output of 1 MW, connected to the grid at the beginning of 2010 with a performance ratio of 75 percent, would produce 863 MWh of electricity each year. If the performance ratio were to be increased by ten percentage points to 82.5 percent, this total would have been 949 MWh. At a remuneration tariff of 13.5 euro cents per kWh, this would yield increased profits totaling 232,200 euros.

Expert opinion

Planning always starts with a survey to help determine what the solar yield, the foundations, the best modules, inverters and mounting technology will be. If the installation is planned on a former military or brownfield site, extensive preparatory work is needed to remove any ammunition or hazardous substances that may be present. Ensuring that the land is safe has top priority. Yields from the PV plant must be able to cover the purchase price or the rent for the land.

Certification of feed-in management systems

Before a solar farm can be connected to the grid, the future operators or project developers must submit a certificate issued by an authorized, independent test institute. This confirms that the plant technology complies with all technical specifications and grid-feed management guidelines issued by the German Association of Energy and Water Industries (BDEW). Other important documents must also be submitted, the installation must be simulated and an expert report must be commissioned. The whole procedure lasts several weeks. Grid authorities in China impose strict regulations on plant operators, who must provide proof that these have been met (inverter certification). Stringent requirements are also laid down in the USA. For example, inverters must be able to recognize when subgrids continue to operate independently despite higher grid levels being shut down and maintain the voltage. This can happen when generation and consumption are equally balanced in the subgrid (active islanding). Solar power plants must prevent this from happening.

How to start a project – Some important questions

Assessment of yield and capacity
Which technology is necessary to achieve the highest possible yield? What is the module area required? Is it possible that additional shading from new buildings or plant growth will occur at a later point in time?

Local support
Will the project be supported by representatives from local government and the local community? How can skeptics be won over?

Building permits, development plans and compliance testing
Has planning and building permission been granted? Does the land development plan permit the installation of a photovoltaic plant? Does the project conform to the national feed-in requirements?

Grid connection testing
Is a suitable grid connection terminal available on site? How long will it take to obtain grid-related information and to process the application?

Involving grid operators in planning at as early a stage as possible is a must.

On-site support is crucial for the success of a project.

Early involvement of utilities

Rough technical planning is followed by submitting the feed-in application to the local utility. This has the purpose of determining the location of the entry point and whether it will actually be possible to feed the projected yield into the grid. Involving grid operators in planning at as early a stage as possible is therefore a must. If it is later discovered that additional investment is needed for grid feed-in, this can become very costly and jeopardize the entire project. If there are several possible entry points, the most cost-efficient point will be selected – no matter which part of the costs must be paid for by the plant investor, and which by the utility. The basic principle is: Grid connection costs must be borne by the investor, grid development costs by the utility. The utility also sets specific parameters for keeping the grid stable when power is fed in.

The sooner grid operators are involved in the planning process, the quicker and more smoothly different connection scenarios, and the costs associated with them, can be investigated to find the optimum solution.

A word on logistics

Solar parks are complex building sites covering a large surface area. Transport logistics for modules alone requires careful planning. Crystalline modules, for example, are delivered in containers of 500 each (appr. 100 kW). A 25 MW solar park thus requires around 250 containers which can only be moved with the help of a crane. Just-in-time delivery is vital to avoid costs for idle periods. The handling of frameless modules in particular calls for extreme care so as to avoid breakage or damage.

String inverters with monitoring system

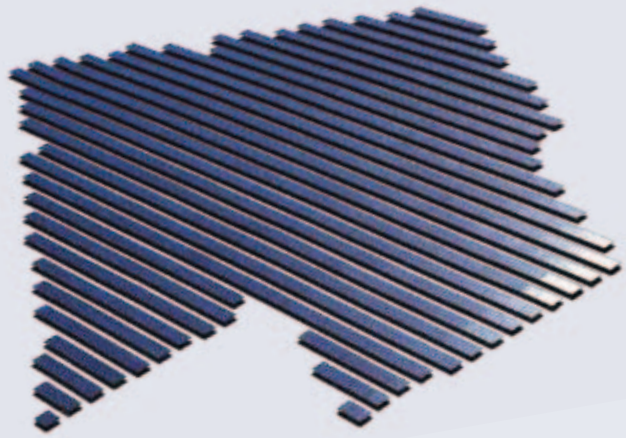
Video monitoring (left) or mechanical locking devices (below) are just two examples for theft protection.

Monitoring

The operation of a solar park also necessitates great care. First of all, the smooth running of the plant must be ensured to avoid any interruptions. A sophisticated plant monitoring system will document operation, providing the basis for quarterly reports to investors and helping to identify the causes of any shortfalls. Faults at the entry point or the inverter are particularly critical, and engineers must respond quickly to minimize any yield losses. Since modern inverters provide remote monitoring options, faults do not always require a trip to the site.

Regular checks

PV plants in the megawatt range also require regular checks by staff. Regular visual checks, on-site thermal imaging, remote monitoring of strings and inverters as well as the evaluation and storage of data are indispensable. Operation and maintenance costs account for between three and five percent of the solar yield. If well planned and executed, they can increase the yield by a significant amount. To enable inspections to be carried out in a single day, it can make sense to employ helicopters or service drones.



Protection against theft

Ground-mounted systems need to be protected from theft and vandalism, the minimum requirements being a fence with climb-over protection and a secured access gate. Video monitoring and microwave or infrared sensor barriers with alarms via cable or radio complete the security concept. Of course, costs and benefits must be weighed up against each other in each individual case. Investment in such equipment will have paid for itself if it prevents just one occurrence of large-scale module theft. In the event of such theft, not only components are lost; consequential damage to the electrical system is common, as are significant yield losses.

If such occurrences become frequent, there is a risk that insurance cover will be withdrawn, meaning that the investment will no longer be protected. At the very least, costs will be incurred to fit expensive anti-theft systems or employ additional security staff.

“A new set of challenges”

An interview with Dr. Winfried Hoffmann, President, European Photovoltaic Industry Association

Large photovoltaic systems with outputs ranging from one to several megawatts have gained growing market shares in the photovoltaics industry. In which regions in Europe do these play a special role?

The trend in Europe is moving toward rooftop segments (residential, commercial, industrial), even in countries where the ground-mounted segment has, in the past, been the main market driver. This latter category includes Spain and the Czech Republic, where the initial strength of the ground-mounted segment (in Spain it accounts for 90 percent of the cumulative capacity; in the Czech Republic for more than 80 percent) has waned. Because the uptake has not been as strong in the residential segment in those countries, public acceptance of the technology as a whole has not been as easily won.

Similarly, PV’s rapid development at the utility scale has drawn increased competition from conventional players. This is a lesson going forward in markets in Europe and beyond: A better balance of development in all market segments is more sustainable in countries where political support remains key to short-term success. This can be seen in Germany, Italy and France, where there is more of a balance among the three main market segments.

Free-field solar parks are leading in the competition for the lowest system prices. What role do they play or have they played in enforcing grid parity?

We should not always and only talk about “grid parity”, which can mean different things to different people – and is sometimes wrongly seen as a Holy Grail. Rather, we should talk about the “competitiveness” of PV. Specifically, for the ground-mounted segment, we define generation value competitiveness as the moment at which, in a specific country, adding PV to the generation portfolio becomes equally attractive from an investor’s point of view as investing in a traditional and normally fossil-fuel based technology, for example a CCGT power plant. Thanks to the intense competition among suppliers, this segment has helped drive prices down and added to the momentum towards competitiveness.

Generation value competitiveness is not the end of the story, however. Wholesale price competitiveness will be the key to sustainable market development in this segment. The current trend that shows wholesale prices going up fast could be offset by the fact that PV pushes prices down (or at least reduces the growth) during the midday peak when it produces power. Depending on how the electricity market design evolves, wholesale competitiveness is not expected to be reached before generation value competitiveness.

What significance do solar parks have for added value in regional areas?

By its very nature, PV is a decentralized technology. It creates jobs and economic benefit in places where it has not always been beneficial for utilities to install power plants. This economic value is over and above the other benefits PV brings to any region in which it is part of the electricity mix: energy independence, environmental protection and climate change mitigation.

64,000 thin-film modules on 193,000 m²: roof-top installation in Hassleben (Germany) with a capacity of 4.64 MW

Solar parks are also gaining in importance in Asia and North America. Will Europe remain leading in this field or will the project designers migrate overseas?

Again, the economics are different depending on the region. In areas outside Europe, the focus is less on individuals and small businesses (who typically have less ability to invest in PV) than on large projects. These are driving the market for the time being in the developing world. Even with all the remarkable growth in recent years, it's fair to say the industry is now at a crossroads and faces a new set of challenges.

Europe can remain a leader but it will be important to develop markets outside of Europe if PV is to continue its remarkable growth trend. The industry will have to continue improving technology and economies of scale. Equally important, policymakers will have to provide more regulatory stability going forward in order to encourage continued investment in PV – both downstream and upstream.

The most powerful voice of photovoltaics in Europe

EPIA – the European Photovoltaic Industry Association – represents members active along the whole solar PV value chain: from silicon, cells and module production to systems development and PV electricity generation as well as marketing and sales. EPIA's mission is to give its global membership a distinct and effective voice in the European market, especially in the EU.

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Companies

Companies and brands presented at a glance (in order of appearance)

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46	abakus solar AG	●							●								
48	Advanced Energy		●							●	●		●				
49	AE Photonics	●							●		●						
50	AEG Power Solutions GmbH	●	●							●	●		●				
51	AVANCIS GmbH & Co. KG				●												
52	AXITEC GmbH			●													
54	BELECTRIC Solarkraftwerke GmbH	●							●	●	●	●	●	●			●
53	Bonfiglioli Riduttori S.p.A.		●														
56	Creotecc GmbH Freiburg								●								
57	Danfoss Solar Inverters A/S		●														
58	Diehl AKO		●							●							
59	EGing PV			●													
60	Elettronica Santerno S.p.A.		●														
61	Emerson Solar		●					●		●							
62	ET Solar Group	●		●													
63	Farnell element14		●					●		●	●						
64	First Solar	●			●												
65	Fronius Deutschland GmbH		●						●								
66	GOLDBECK Solar GmbH	●									●						
67	GP JOULE GMBH	●															
68	Hilti Group								●								
69	Ingeteam Power Technology, S.A.		●								●						
70	Kirchner Solar Group	●						●	●	●	●		●	●			
71	Krannich Solar GmbH & Co. KG	●	●						●	●			●				
72	Masdar PV GmbH				●												

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73	meteocontrol									●	●	●	●	●		●	
74	Mounting Systems Group								●								
76	PADCON GmbH	●								●	●	●	●	●			
78	PerfectEnergy			●													
77	Power-One		●														
80	REFU*sol* GmbH		●														
81	Schneider Electric	●	●					●			●	●					
82	SCHOTT Solar AG	●		●	●				●		●						
83	SFS intec AG, FasteningSystems								●								
84	Siemens AG	●	●			●	●	●		●	●	●	●				
86	SiG Solar GmbH	●					●				●		●				●
87	Sinosol AG	●	●				●		●	●	●		●				●
88	skytron® energy GmbH									●	●		●	●			
89	SMA Solar Technology AG		●							●		●	●				
90	Solar Frontier				●												
91	Solare Datensysteme GmbH									●							
92	SolarMax		●							●							
94	SOLARWATT AG	●		●													
95	SolarWorld AG	●		●					●	●	●	●	●				
96	Solectria Renewables		●														
97	Sopray Energy Co., Ltd			●													
98	TÜV Rheinland												●			●	
99	TÜV Süd															●	
100	Würth Solar GmbH & Co. KG	●							●		●		●				

abakus solar
solar AG
energizing a clean future

abakus solar – Sun with Know-How

Solar Park Gnötzheim II – abakus solar´s currently biggest reference project with about 10 MWp

abakus solar is a leading international provider of photovoltaics. Since its foundation in 1995, the company has applied its comprehensive know-how to thousands of reliable PV power plants.

abakus solar AG is a leading, internationally operating provider of photovoltaics (PV). Its comprehensive technical expertise covers small-scale plants on residential roofs to large-scale commercial and logistics roofs, as well as multi-megawatt solar parks. The company was established in 1995 and is headquartered in Gelsenkirchen. This is an industrial city located in the Ruhr Valley of North Rhine Westphalia, a region with a long-standing technological tradition in energy generation. The PV expert runs further offices in Cologne, Munich and Berlin. It currently employs a total of about 85 people in its home country and is constantly expanding.

In Germany, the core business activities concentrate on planning and constructing turnkey PV power plants, and providing wholesale quality PV components and complete systems. Another business sector is the implementation of architecturally challenging solutions for building-integrated PV.

Installation of photovoltaic modules for a roof top plant

abakus solar AG
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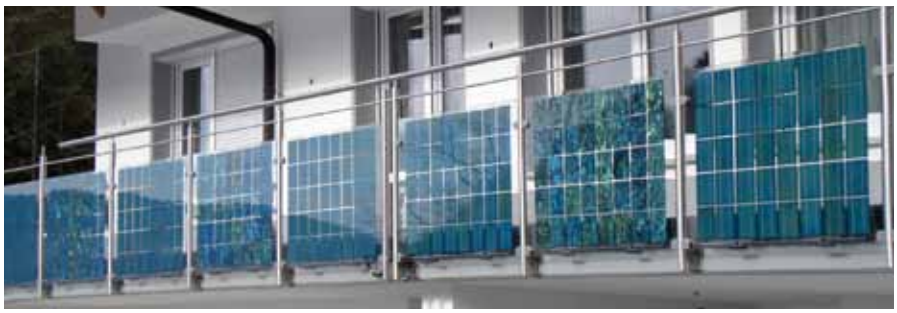
www.abakus-solar.de
Founded: 1995
Approx. 85 employees



Façade design plus power generation: colored cells act as eye-catcher.

touch fix, the in-house developed mounting system for flat roofs, can be installed without penetration of the roofing.

Workers install PV modules at Westmill Solar Park, United Kingdom.

In-house product development

Furthermore, abakus solar can also draw on the know-how of its own product development department. In 2011, for example, the team launched touch fix, an aerodynamically optimized mounting system. It is fixed without roof penetration and can be installed easily and quickly. Its basic elements are made of recycled plastics, which can be easily recycled again after dismantling.

Thanks to these new and user-friendly features, touch fix convinced the expert jury at the 26th Symposium on Photovoltaic Solar Energy in Bad Staffelstein, Bavaria, and was awarded an innovation prize. The development department continually optimizes touch fix in order to keep up with the latest market demands.

Project development in Germany and abroad

abakus solar also acquires and develops project rights and licenses for electricity generation for the development and marketing of selected PV projects in Germany and other countries. In this context, the company's project development department offers business models such as the "rooftop partnership for local communities". As part of this cooperation, abakus solar develops concepts for urban administrations that provide a basis for them to profitably equip their maximum possible roof area with photovoltaic plants. As an EPC contractor, abakus solar is responsible for all aspects of project execution, including finding a suitable investor in case the local authorities do not want to operate the plants themselves. The leasing of all the roofs to only one investor reduces the administrative effort required from the municipalities. Furthermore, roof areas that cannot be marketed economically as single sites due to their alignment or inclination are ideal as part of a package solution combined with more adequate roofs.

International branches and shareholdings

In addition to the four offices in Germany, abakus solar has an international presence with several branches and shareholdings across the globe: In Europe, the PV expert is active in Italy and Greece, as well as in the USA. In 2011, a joint venture with a local partner was established in India.

PV modules can ideally be integrated into greenhouse roofs.

Energy Delivered™

AE's power stations generate electricity dependably, optimize Levelized Cost of Energy (LCOE) and help stabilize grid operation.

Inverter manufacturing team

20 MW solar field with AE inverters

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www.advanced-energy.com/solarenergy
Founded: 1981
1,500 employees

AE's solar energy business delivers highly reliable inverters, complementary Balance of System (BoS) products, and robust Operations and Maintenance (O&M) services that allow its customers to secure more solar projects and increase their earnings.

Customer experience

AE Solar Energy enables utility-scale, commercial, and residential solar project stakeholders to offer system owners a lower Levelized Cost of Energy (LCOE) and confidence that their PV system will deliver on long-term production goals. With more than 30 years of leadership in innovation and in delivering energy solutions combined with a legendary reputation for customer service, AE has become a trusted partner for solar project developers, financiers and beneficiaries around the globe.

Innovation

AE is never satisfied: From our roots in reliability and LCOE to continually improving our quality, systems and people, we ensure that energy is delivered, period. We pioneer improvements in distributed generation, grid interactivity performance, utility interactive functionality, and energy management solutions.

Energy Delivered™

AE delivers highly reliable and efficient inverters designed with an architecture optimized to deliver the lowest possible LCOE. Our simplified BoS solutions reduce system design support, project management time and increase savings on installation. Simply put, AE delivers life-cycle performance.

Solar site services

AE delivers whole-site operations and maintenance service plans that increase the reliability of customers' PV systems. AE global services are dedicated to responding quickly to issues, whether that means rolling a truck, providing phone support or anything else. We provide application engineering support and warranties for up to 20 years, partnering with customers for the entire project life-cycle.

AE Photonics Power Plants: Profitable Energy – Module by Module

Top left: PV power plant near Tufara, Italy (2.6 MW)
Top right: Roof-mounted PV power plant in Zwickau, Germany, built on diverse flat and pitched roofs (0.7 MW)
Bottom right: PV power plant near Castronovo, Sicily, Italy (0.9 MW)
Bottom left: PV power plant near Castellaneta, Italy (5 MW), consisting of five individual plants with about 1.0 MW each

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www.ae-photonics.com
Founded: 2008
> 70 employees (worldwide)

AE Photonics was founded in Dresden in 2008 and successfully develops, plans and constructs high-performance photovoltaic power plants with outputs of up to several MW across the globe.

AE Photonics was founded as a wholesaler for photovoltaic components and rapidly developed into a reliable, professional and flexible supplier to installers. Since the company's foundation, professional consulting and engineering services for major photovoltaic projects have been an important part of its core competencies.

Turnkey photovoltaic power plants

In the large-scale project segment of our business, we take care of all services and responsibilities from project development and EPC services to grid connection. We cover all aspects of project management and can provide investors with "turnkey" solar power plants which are ready for operation and revenue generation.

Extensive range of services:

- competent advice
- project development
- structured finance solutions
- system design (plant layout, electrical engineering)
- development of safety schemes
- material procurement, material logistics
- construction, site supervision
- start-up of operations, grid connection
- maintenance and system monitoring

Unlimited commitment to customer requirements

AE Photonics is dedicated to meeting the requirements of a wide variety of customers in several markets: We cover off-grid applications, like solar pump systems in Morocco that ensure the ecological irrigation of agricultural land, and off-grid systems for decentralized power supply. For the benefit of its customers, AE Photonics develops and consistently improves its own solutions, such as the aerodynamic FLUXsol® substructure system that enables efficient use of flat roofs without penetrating the roof.

On-site for the project

The AE Photonics Group is represented in Italy, Morocco, Greece, California and India through its subsidiaries. Our success is directly linked to our international presence. The advantages are clear: proximity to customers and investors, and direct contact with the local authorities and all construction partners.

AEG Power Solutions

Lecce/Italy, 5.71 MWp
AEG PS assumed overall project management responsibility and installed AEG PS inverters, containers and monitoring system.

AEG Power Solutions –
Competence Center Warstein-Belecke

Central Inverter Protect PV.500

For decades, the demanding industrial sector has turned to AEG Power Solutions for products and services. Now the renewable energy sector can benefit from the same quality and expertise.

Building on its proven track record in supplying utilities and grid operators with reliable, fully-compliant solutions, the PV.250, PV.500, and PV.630 solar inverters from AEG PS provide quality and efficiency for large-scale PV installations. With an efficiency of more than 98% and compliance with European and American standards, AEG PS solar inverters exceed the expectations of their power class. The innovative FPGA circuits ensure the flexible, precise and rapid control needed to meet virtually all national grid standards.

In addition to solar inverters, AEG Power Solutions offers two completely integrated stations. The first is the TKS-C container solution, which includes PV.250, PV.500, and PV.630 solar inverters along with a medium-voltage transformer, switch-gear, and a monitoring, measurement and control system. The second is the Compact Station, which places the solar inverters in metal housings that are separate from the transformer, switch-gear, and MM&C system. These single-source solutions ensure smooth PV power plant operation, in close cooperation with the grid operator.

Both integrated systems include intelligent combiner boxes installed in the PV array's field. These combiner boxes are fully integrated via communication links to field sensors for temperature, radiation and weather, and the collected data is stored in data loggers. The monitoring software, called PV.GuarD, ensures that the status updates needed by PV plant operators are always available over the Internet.

Backed by decades of field experience, AEG Power Solutions has built its worldwide service reputation by constantly exceeding customer expectations throughout the product lifespan. AEG Power Solutions' service starts right from the beginning of any project installation. Clients can rely on AEG PS for service and support over the entire life-cycle of the plant. With facilities across Europe, the Middle East, Asia, China and North America, AEG Power Solutions is on hand for collaboration with all potential partners, including EPCs, consultants, operators and investors.

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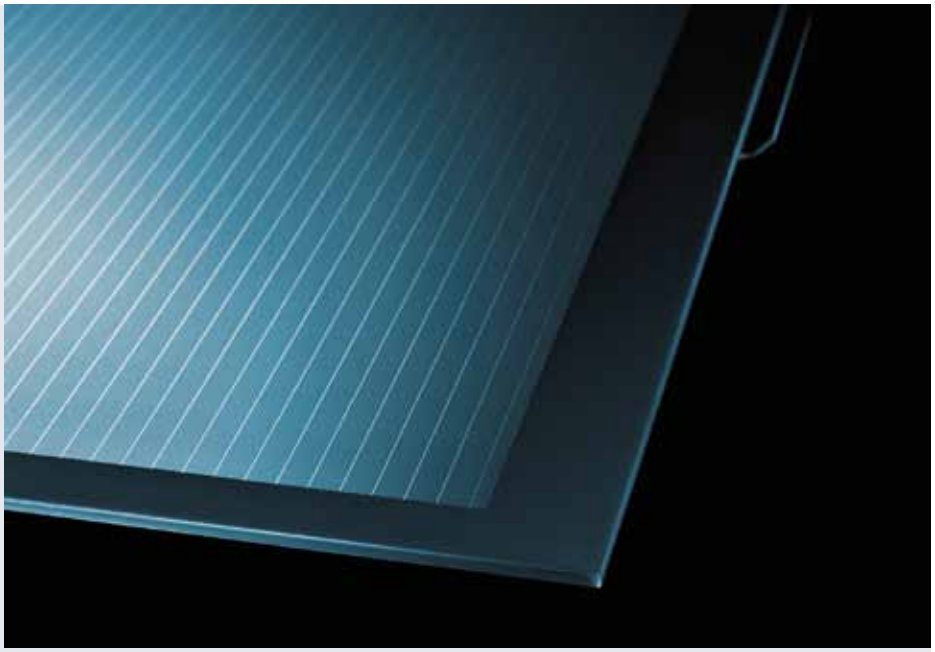
www.aegps.com
Founded: 1946
Turnover: 428 million euros (2011, worldwide)
> 1,650 employees (2011, worldwide)

AVANCIS GmbH & Co. KG

AVANCIS: The avant-garde of photovoltaics



Specifically developed for use in open spaces: PowerMax® SMART modules from AVANCIS (top)
Ground mounted system with AVANCIS modules in Italy (bottom)

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Germany
Phone: +49 (0)3421 7388-0
Fax: +49 (0)3421 7388-111
info@avancis.de
www.avancis.de
Founded: 2006
500 employees

As a manufacturer of premium-class CIS solar modules, AVANCIS offers extremely high standards of quality, performance and durability: That's everything an investor in utility-scale projects is looking for.

The first manufacturer of CIS photovoltaic modules

Since the early 1980s we have been pioneering research into high-performance solar modules with our scientists. As a pioneer of CIS technology, we were the first company in the world to start commercial series production of CIS solar modules. Today, AVANCIS is the most experienced researcher and producer of CIS solar modules in the world. With our innovative history and our multiple world efficiency records, we are extremely proud of a track record that is clear for all to see, with numerous references in the field of photovoltaics. As a subsidiary of Saint-Gobain, the world leader in the habitat and construction markets, we are part of a trustworthy corporation and are sure to keep on growing.

PowerMax® – advanced solar modules

The successful AVANCIS brand is well known on the market under the name PowerMax®. Under this umbrella brand, all of our product lines are brought together and have one very important thing in common: an extremely high energy yield (kWh per kWp), which is possible due to broad spectral sensitivity, excellent low light performance and a low temperature coefficient. All PowerMax® modules not only meet the highest technological and aesthetic requirements, they are also among the most economical on the market. The basis for this success is our fully integrated industrial production process with production sites in Germany and South Korea.

Simply smart: PowerMax® SMART for open spaces

Our new PowerMax® SMART modules were specifically developed for use in open spaces: frameless CIS solar modules that use an intelligent mounting profile of two steel backrails allowing fast, simple and safe installation. The rear ventilation and cooling of the frameless modules continually optimizes the initial high energy yield. With this new product line AVANCIS offers the perfect solution for utility-scale solar plants. For more information feel free to contact us.

www.axitecsolar.com

AXITEC
high quality german solar company

A Leading Module Manufacturer with Headquarters in Germany and Worldwide Production Locations

Spain: utility power plant (right)
Spain: Expo Zaragoza 2008 (top left)
Germany: system installed on logistics center roof in Hamburg (bottom left)

Member of PV Cycle

Brands of AXITEC: "Made in Asia", "Made in Europe"

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Germany
Phone: +49 (0)7031 6288-5186
info@axitecsolar.com
www.axitecsolar.com
Founded: 2001
20 employees

With 200 MWp of solar modules installed across the globe, German company AXITEC GmbH has been established for years as a high-performance and quality module manufacturer.

AXITEC GmbH was established in 2001 and has been one of the leading global manufacturers of quality solar modules for years. The core expertise covers the complete process chain for solar modules from development and manufacturing through quality assurance to sales and service.

High-performance solar modules by AXITEC are sold all over the world under two different brands. They are manufactured in accordance with their respective labels – "Made in Europe" and "Made in Asia" – in the respective production facilities of certified OEM partners. AXITEC grants identical warranties for all of them:

- positive tolerances
- 10-year manufacturer's warranty
- exclusive linear AXITEC performance guarantee

Global production processes

Years of close partnerships with several OEM manufacturers enable AXITEC to always use the latest technology in the manufacture of solar modules, making it one of the leading global providers in terms of technology and cost. AXITEC customers can therefore purchase solar panels with an excellent price-performance ratio.

Quality assurance and certification

AXITEC solar modules are certified according to IEC, UL and MCS. AXITEC is certified according to ISO9001, ISO14001 and OHSAS18001.

Recycling of used solar panels

Thanks to AXITEC's active membership of PV Cycle, used AXITEC modules can be disposed of free of charge at all PV Cycle collection sites and fed into the recycling process.

References and installations

All over the globe, AXITEC solar modules successfully produce clean energy.

Bonfiglioli Riduttori S.p.A.

Bonfiglioli
power, control and green solutions

Bonfiglioli – Partner in Large Projects. Worldwide.

SunEdison, 2012: This 60 MWp field in Parvomay (Bulgaria) is equipped entirely with Bonfiglioli inverters.

Bonfiglioli RPS Station

Bonfiglioli RPS TL

Bonfiglioli offers 25 years of experience in renewable energies and a consolidated international presence.

Thanks to our wide range of high efficiency solutions, investors all over the world have chosen Bonfiglioli inverters and components to realize large scale PV arrays in Europe, Asia and the USA.

In 2008 Bonfiglioli supplied inverters to what was then the world's largest photovoltaic array (51 MW) in Spain. Bonfiglioli also supplied systems for Europe's largest PV array (70 MW) in Italy in 2010. In March 2012, a 60 MW field equipped with Bonfiglioli inverters came on line in Bulgaria.

Bonfiglioli's RPS Stations, available with a vast range of power ratings from 280 to 1,660 kWp, provide turnkey solutions for full management of all large-scale, ground-mounted installations. RPS Stations are produced and tested directly at Bonfiglioli's own plant to ensure the highest standards of quality and efficiency along with reduced costs. As a result, customers can take delivery of fully equipped, ready to connect systems within impressively short timeframes. In addition, an ample choice of innovative solutions combined with intelligent control panel configurations and cabin layouts ensures easy maintenance and repairs, thus extending inverter life expectancy.

The RPS TL modular inverters at the heart of every Bonfiglioli RPS Station guarantee high system yield thanks to the modular engineering and German technology that characterizes all Bonfiglioli inverters.

To maximize return on investment, Bonfiglioli helps customers find the best possible solutions at the design stage, and later ensures excellent service with prompt assistance provided by specialist personnel.

In-depth understanding of markets and market dynamics, 16 commercial subsidiaries, four photovoltaic production plants and a wide range of inverters, designed at the group's own center of excellence and research in Germany, make Bonfiglioli the ideal partner for photovoltaic field developments anywhere in the world.

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www.bonfiglioli.com
Founded: 1956
3,300 employees

Photovoltaics 2.0: the Next Generation of Solar Energy

The standardized and grid-integrated BELECTRIC 2.0 MegaWattBlock forms a ground-mounted solar power plant in 2 MWp steps.

The next generation of photovoltaic systems generates solar power that is commercially viable in relation to fossil energy sources and provides additional grid services. Today, BELECTRIC is already using innovative power plant technology that can stabilize our power network day and night. This generates new capacities for renewable energy sources and prevents the unnecessary construction of new line routes.

A company full of energy

BELECTRIC is the world market leader in the Engineering, Procurement and Construction (EPC) of solar power plants and photovoltaic rooftop installations (2010 and 2011). The company has subsidiaries in 15 countries. In 2012 BELECTRIC has achieved a historic milestone and became the first company in the world to install 1 GW of solar power.

BELECTRIC designs, manufactures and constructs photovoltaic systems. The company offers a wide spectrum of solar energy solutions ranging from utility-scale ground-mounted solar power plants to photovoltaic roofing systems for large parking lots. Engineers and technicians conduct interdisciplinary research in all areas of photovoltaics and develop innovative technology that forms the basis for the environmentally-friendly power supply of our future. With over 25 patents filed every year, BELECTRIC continuously puts its great innovative spirit to the test. In 2011, the company was able to look back at a success story involving 70 patented innovations in the field of photovoltaics and has since then implemented over 2,600 photovoltaic rooftop installations and 160 solar power plants worldwide.

BELECTRIC realizes photovoltaic solutions with a degree of almost 100% integration. This applies particularly to the field of complex solar power plants, and ranges from system engineering and manufacturing of Balance of System (BoS) components through to services after construction is complete.

By covering and optimizing virtually all areas of solar business, BELECTRIC is able to achieve the lowest LCOE (Levelized Cost Of Energy) of photovoltaics.

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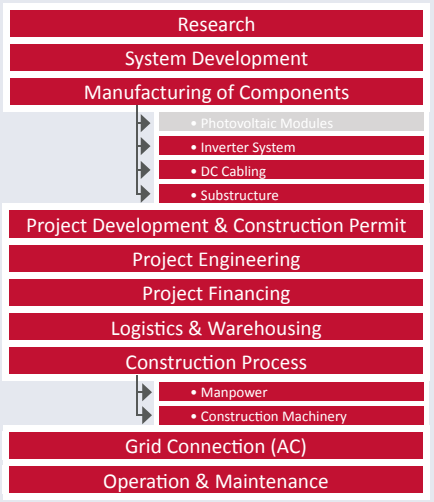
www.belectric.com
Founded: 2001, BELECTRIC renaming 2011
Turnover: 540 million euros
> 1,900 employees (company group, worldwide)

Inhouse manufacturing of BoS components

PV-Greenhouses – Food & Energy: combination of an integrated PV system with a standardized greenhouse structure

BELECTRIC's own construction team members installing solar modules in California, USA (below)

More than just EPC:
BELECTRIC's core capabilities at a glance



BELECTRIC's Power Conditioning Unit (PCU) combines an intelligent inverter and transformer system with active grid stabilizing technology.

The BELECTRIC charging box infrastructure combines solar power production with e-mobility.

Control center with real-time power plant management system

2.0 MegaWattBlock®: the new unit

The 2.0 MegaWattBlock is a new plant unit developed to form ground-mounted solar power plants, either independently or in series. The standardized modular design is the result of many years of experience in implementing solar power plant technologies. Precisely tailored to the area and customer's requirements, the 2.0 MegaWattBlock achieves an optimum cost-benefit ratio – to safeguard investment in the long run.

High energy yield through professional operation management

Producing electrical energy from sunlight is almost wear- and maintenance-free. However, continuous monitoring of the solar power plant makes sense. Not only to detect any deviations in the system's performance, but also to ensure reliable operation over the entire life-cycle. The long operating times necessitate professional operation management in which BELECTRIC is responsible for all technical tasks. The real-time monitoring system facilitates reliable remote monitoring of the photovoltaic plant, allows access to the current yield data and provides extensive analysis functions.

Photovoltaics meets e-mobility

The BELECTRIC charging box for electric vehicles intelligently combines photovoltaics with e-mobility. From the system design through to the software, BELECTRIC pursues a flexible, modular concept that can be quickly adapted to new standards. The intelligent charging infrastructure facilitates local load management in the e-car fleet and maximizes the proportion of solar power in the vehicles.

BELECTRIC – A Better Electric

Creotecc: ROOTS OF ENERGY

Creotecc firsts:
Samedan – St.Moritz, Switzerland
From top to bottom:
First time ALUTEC: 1989, Uetli-station, Zurich, Switzerland
ZKM, Karlsruhe, Germany
CREOTERRA, Sardinia, Italy

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www.creotecc.com
31 employees

Creotecc GmbH is a product developer and manufacturer of photovoltaic mounting systems. The company has over 25 years experience and is based in Freiburg im Breisgau, Germany.

The company was founded by pioneering members of the solar industry: The Fraunhofer Institute for Solar Energy Systems initiated the establishment of various companies, out of which Creotecc grew.

In as early as 1985, Creotecc products were mounted on a landmarked building and in 1989 the company's own insertion system was installed for the very first time. In 1995, five different Creotecc technologies were installed on the ZKM (Centre for Art and Media), Baden-Württemberg's largest landmarked building.

Today the name Creotecc is still synonymous with innovative solar technology: Ten patents were registered in 2011 alone. The constantly expanding company is particularly active in the development of new kinds of systems, such as high-quality mounting and fastening systems for pitched roofs, flat roofs, façades and ground-mounted systems.

In collaboration with trade, industry and independent institutes, its products are continuously optimized and adapted to the market's growing needs.

Creotecc also provides support with planning and assists project developers during plant construction. The company is RAL-certified and selected products are also continuously tested by DEKRA.

In 2010 Creotecc became part of the Würth Group. The Würth brand stands for outstanding system quality, short mounting times and reliable service.

Creotecc continues to grow and offers new, innovative mounting systems every year. Evidence of its expertise abounds, with countless reference projects worldwide.

Danfoss Solar Inverters A/S

Invest with Confidence

Danfoss string inverters offer an ideal solution for every PV power plant – without extra costs or compromises.

TLX Pro powers 80+ MW facility in Eggebek, Germany; one of the largest PV plants in the world

The TLX Pro series offers control of up to 100 inverters from a single self designated inverter.

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Founded: 1933
23,000 employees (worldwide)

Danfoss String Inverters means: easier planning, less installation effort, and integrated master functionality, three aspects that combine to reduce costs – both now and through the operational life of your PV plant.

With Danfoss string inverters, the flexibility of the inverters enables optimal system planning, even for very large systems. Country-specific DNO requirements are fulfilled by the inverter; from power level adjustment to the provision of reactive power. The integrated master inverter technology enables you to control up to 100 inverters from a single inverter. Likewise, the master functionality means that data warehouse services can easily be utilized if desired.

Proven concept

Many leading installations are powered by the TLX Pro, such as the 80+ MW facility in Eggebek, Germany – one of the largest PV plants in the world – and the plant in Busenwurth, Germany, a ground-mounted installation with a capacity of 12 MW. These installations profit from using Danfoss inverters which are designed to reduce the effect of shading, allowing for more PV per m^2, by placing module rows closer together. Additional benefits and profits are gained from the integrated master functionality, easy commissioning and service.

SmartTechnology

With a powerful suite of tools, including EnergySmart™, DesignSmart™, TrackSmart™ and ControlSmart™, achieving maximum yield has never been easier. From planning and installation, to trouble-shooting and service – in addition to having one of the industry's most experienced support teams, Danfoss offers clean and efficient solar energy solutions for all applications.

About Danfoss

Danfoss is a global company with over 40 years of experience in power electronics. Danfoss Solar Inverters develops and manufactures a comprehensive range of grid-connected photovoltaic inverters for all PV applications, and is represented in more than 20 countries worldwide. The Danfoss inverter range (from 1.8 to 15 kW) provides the smart solutions needed to develop your PV power plant.

For a comprehensive overview of our products and services, please visit us at www.danfoss.com/solar.

PLATINUM® – The Premium Brand for Solar Inverter Technology

Right: Manufacturing plant of PLATINUM inverters

Below: Diehl AKO headquarters in Wangen im Allgäu

The new PLATINUM R3M: constantly evolving with peak efficiency

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www.diehl.com/photovoltaics

AKO founded 1945, Diehl AKO since 1994
2,800 employees (worldwide)

Diehl AKO, a company of the Diehl Group, is one of the world's leading electronics companies. A long tradition and a guaranteed production volume in Germany alone of more than 20,000 electronics a day form the basis of an outstanding inverter technology. With conversion efficiencies of more than 98% PLATINUM inverters are among the best of their type.

In addition to a wide range of string inverters with power ratings between 2 kW and 22 kW, the PLATINUM product portfolio includes smart devices for monitoring photovoltaic systems. The WebMaster Home is an excellent example of a smart energy regulation device. The convenient energy management solution visualizes and controls any number of consumers, and enables self-consumption to take place at optimum times of day.

Thanks to the patented DIVE® technology, PLATINUM inverters have a peak efficiency of 98% and are manufactured to the highest level of industrial quality. All inverters undergo an intensive, six-stage quality control test before leaving the factory. PLATINUM inverters are therefore extremely robust and highly reliable. These characteristics, alongside an especially low failure rate make the PLATINUM products completely solid system components. As a result, Diehl AKO offers a 10-year warranty off works for the majority of its PLATINUM products and there is an option to extend the warranty up to 20 years. All PLATINUM inverters are also CE compliant and meet the corresponding appropriate standards.

Training sessions on all PLATINUM products are regularly held for distributors, sales representatives and installers in the training center at the company's headquarters in Wangen im Allgäu. Furthermore, the PLATINUM service experts offer advice on designing and starting up monitoring solutions, as well as giving general support. They also quickly and competently help find solutions to complex situations over the phone or by sending a sales representative directly to the client on-site.

EGing PV, Your Reliable Partner

EGing PV headquarters and manufacturing plant

Module assembly

System energineering

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market@egingpv.com
www.egingpv.com
Founded: 2003
5,000 employees

EGing PV is a leading, internationally-recognized, vertically-integrated solar PV company that focuses on expanding renewable energy by developing solar photovoltaic technology and manufacturing high-efficiency PV module products.

It started silicon ingot production in 2003 and has achieved fast and steady growth since then. EGing raised capacity to 1 GW by the end of 2011 and was successfully listed on the Shanghai Stock Exchange.

EGing PV produces ingots, wafers, cells and modules, and its everything-under-one-roof business model helps to maintain total quality management and to achieve reliable supply chain control.

EGing PV holds 36 patents for its own DRXF-85 monocrystalline silicon furnace which operates with high reliability and consumes less power.

By working with leading wire saw partners, EGing PV has a guaranteed internal supply of high-quality wafers of any size and type for solar cell production.

EGing PV uses highly automated cell production lines with the latest production process control. EGing PV R&D staff continuously upgrades cell efficiency and performance.

EGing PV guarantees to deliver to its customers high power solar modules with reliable and stable performance. Highly automated production puts EGing PV in a unique position to provide customers with consistently high-quality module products.

EGing PV has obtained IEC 61215, IEC 61730, TUV II, CB, CE, UL, MCS as well as ISO 9001 and ISO14001 certifications. EGing PV provides both mono and multi solar module products to both roof systems and solar farms.

EGing PV has set up a global sales network in Europe and Asia. EGing PV's international team provides clients with prompt, professional service and support.

Elettronica Santerno S.p.A.

Santerno: Giving Energy More Value

The Santerno Sunway Station

The photovoltaic plant in Ravenna, Italy, 124 MW with Santerno Sunway Stations

The Sunway TG 800V

Headquartered in Italy since 1970, Santerno has subsidiaries and sales offices in Spain, Germany, Brazil, Russia, India, China, the USA and Canada. A wide commercial network, with over 42 distributors and service centers all over the world, ensures complete and high-quality service.

A successful approach started in 1994, when the 3 MW plant in Serre was set up. That plant remained the largest in the world for three years. Since then, Santerno has accomplished many great projects: In 2008, 26 MW were installed in Fuente Alamo, Spain; in 2010, 10 MW were installed in Golmud, China, and 124 MW were installed in Ravenna, Italy. In 2011, 20 MW were installed in India (Kutch Project), whilst a rooftop plant with an output of 50 MW was installed on Renault factories in France, becoming the largest PV plant in the world serving the automotive industry.

These are just some of the goals achieved by Santerno over the years!

The Company offers a comprehensive range of solar inverters with power ratings from 2 kWp to 770 kWp. Its products are all compliant with the technical regulations and the standards in force worldwide, they all meet the strict LVRT (Low Voltage Ride Through) requirements as well as the control requirements of the SMART grids.

For large-sized plants, Santerno offers the Sunway T Line, one of the widest ranges of three-phase inverters.
The Sunway T line comes with the Sunway Station line, a complete cabinet solution offered from Santerno.

Equipped with an external or a built-in transformer, the Sunway T line is very robust and features easy configuration and maintenance, thanks to easy-to-reach components and the enhanced remote monitoring service.

The Sunway Station, ranging from 420 kWp to 1500 kWp, is a complete plug & play, modular solution: compact and versatile, it is tested for transportation and installation directly on the plant, with no need for demanding civil works.

Furthermore, Santerno backs up its customers by offering comprehensive assistance and engineering support necessary for on-site configuration and commissioning.

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Italy
Phone: +39 0542 489711
Fax: +39 0542 489722
info@santerno.com
www.santerno.com
Founded: 1970
> 200 employees

Ten Mission-Critical Reasons to Bank on Emerson's PV Inverters

58 MWp solar plant, Avenal, California (left)
Emerson's multi-million US dollars UK R&D center (below)

Emerson 1 MWp grid-tie inverter

Emerson Solar Europe (HQ)
The Gro
Newtown Powys SY16 3BE
United Kingdom
Phone: +44 (0)1686 612900
solar@emerson.com
www.emersonpvsolutions.com

Emerson Solar Asia
117 B Developed Plot Ind. Estate
Perungudi, Chennai, 600 096
India
Phone: +91 (0)44 2496-1123

Emerson Solar Americas
7078 Shady Oak Road
Eden Prairie, 55344 Minnesota
USA
Phone: +1 952 995-8000

Employees: 127,000 (worldwide)

1. The resources to deliver on our promises
Emerson is a Fortune 500® corporation with outstanding bankability in the eyes of the financial community.

2. Designed for long life
Emerson uses standard mass-produced inverter modules that are used in both industrial and PV applications. The modules have a stable design that is proven to be robust.

3. Higher efficiency, more of the time
Emerson PV inverters are efficient (>98% Euro η), and because of our unique modular inverter solution, we switch on sooner and off later, efficiently generating more energy with lower irradiance levels than single inverter solutions.

4. Energized to meet your deadlines
Emerson understands the time pressures associated with PV plant installations; our project management teams work tirelessly to ensure you meet your start-up deadlines.

5. Tolerant to faults
Emerson inverters are fault-tolerant: In the event that an inverter module trips, the inactive module is automatically isolated so that the system can continue generating. System redundancy can also be specified.

6. Wherever you are, so are we
Emerson employs more than 140,000 people, of which the majority are located within engineering centers around the world, providing project engineering and support for our energy conversion products.

7. As much or as little as you need
Emerson can provide as much or as little of the PV inverter system as you need, from a single inverter to a complete solution incorporating string connection boxes, transformer, shelter, medium voltage switch and SCADA.

8. Complete peace of mind
Extended warranties and service contracts of up to 20 years are available to ensure the highest energy yield is maintained over the lifetime of the plant.

9. Ready for PV industry growth
Emerson is geared up to mass produce standard modules with high availability to support the growth of the PV industry.

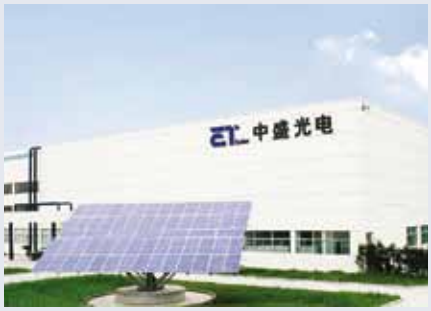
10. In service around the world
Emerson inverters and PV solutions are truly global in coverage. Large-scale projects like our recent 58 MW DC solution in California are being developed around the world.

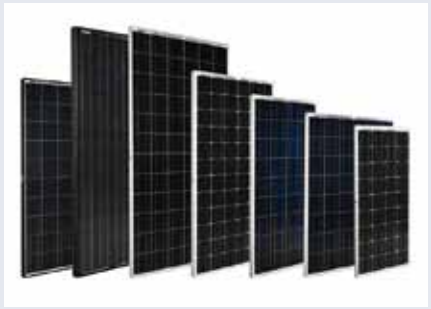
Towards Excellence

ET Solar: Becoming a Leading Creative Solutions Provider

Harbke, the 4.8 MW ground-mounted PV power plant is located in Börde, Germany. ET Solar acted as both solar module supplier and EPC contractor.

ET Solar Group's manufacturing base in Taizhou, China





ET Solar produces a wide variety of PV modules ideally suited for all types of installations: residential, commercial, industrial and utility.

Established in 2005, the ET Solar Group was the first Chinese company to engage in EPC service. After many years of development, ET Solar is one of the world's leading solar one-stop solution providers. Our integrated manufacturing capacity includes silicon ingots, wafers, cells, modules and a variety of BoS component products from tracking systems through residential rooftop kits to power cabinets. The ET Solar Group has over 2,500 employees worldwide. We have three manufacturing bases in Taizhou and Nanjing, and maintain a balanced, vertically integrated production capacity of over 1 GW per year. Over the past few years, our products have been used in a large number of residential, commercial and utility PV projects in many countries around the world where we have demonstrated strong performance. ET Solar is present in Europe, the Asia-Pacific region and North America.

ET Solar is committed to providing excellent products and services to its customers. One of the latest product innovations is our Moly modules, which are high performance PV modules that employ new mono-like solar cells. With a cell efficiency of up to 18.2%, the module efficiency peaks at 16.1% and is directly comparable to conventional monocrystalline modules. Furthermore, the mono-like solar cells contain substantially lower amounts of oxygen – far less than their conventional monocrystalline counterparts.

In addition to its wide range of products, ET Solar also offers high quality and cost efficient turnkey system solutions and services to specialized PV investors. Established in 2008, ET Solutions AG is a turnkey solar system EPC provider, which is a 100% subsidiary of the ET Solar Group. As an experienced EPC contractor for a number of international ground-mounted and roof-mounted projects, ET Solutions has gained experience developing projects and managing the construction of plants with a total capacity of more than 50 MW.

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Nanjing 210009
China
Phone: +86 (0)25 8689-8098
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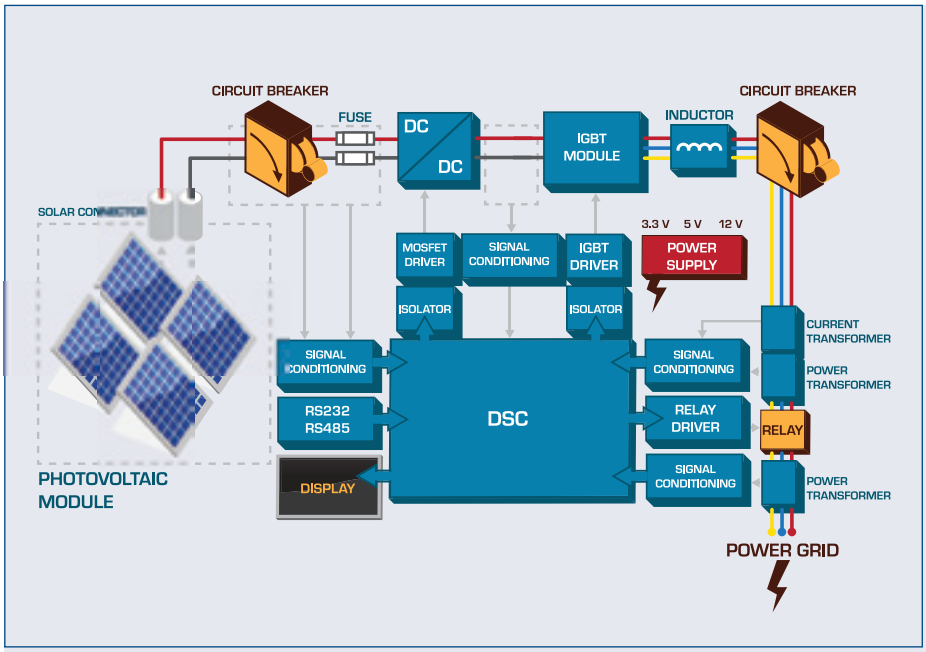
sales@etsolar.com
www.etsolar.com
Founded: 2005
Approx. 2,500 employees



Farnell element14 is a high-service distributor of products and solutions for electronic system design and electrical maintenance and repair.

With options to suit every customer, from visionary engineers to volume manufacturers, we bring speed, efficiency and reliability to global technology supply

- over 500,000 stocked products
- same day despatch
- no minimum order quantities
- engineering expertise and free technical support 24/5
- fast, easy access to the latest technology – www.farnell.com
- reliable service in person, by phone or online in local language
- software and services to complete your design solutions

We are playing a lead role as the global alternative energy market continues to grow. Our clients include inverter, module and tracker manufacturers, wind turbine manufacturers, SCADA and monitoring system manufacturers, EPCs and installation/maintenance contractors.

We have a leading range of over 2,500 solar and wind products from industry-leading suppliers trusted within the renewables sector

- ICs, power discretes, MEMS and passives
- fuses and circuit breakers
- cabling, connectors and tooling
- testing & measurement

Our dedicated alternative energy micro-site enables you to quickly select and purchase the products you need for a wide range of solutions, all backed up by a comprehensive set of design resources, application notes and training materials – www.farnell.com/solar

Farnell element14 brings together the latest products, services and development software – all in one innovative, future-thinking, market-leading business. At the heart of what we do is element14 – a truly global online community where purchasers and engineers can access peers and experts, as well as a wealth of independent technical information and helpful tools. Whether researching a new technology, designing a product or looking for parts to repair an existing system, Farnell element14 can help you to find the answers and parts you need to keep your project on the fast track, right from the start.

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sales@farnell.co.uk
www.farnell.com

A World Leader in Innovative Solar Solutions, from Modules to Complete PV Systems

58 MW (AC) Copper Mountain solar PV plant in Nevada, USA

290 MW (AC) Agua Caliente solar PV plant under construction in Yuma County, Arizona, USA

First Solar, Inc.
350 West Washington Street
Tempe, Arizone 85281
USA
Phone: +1 877.850.FSLR (3757)
info@firstsolar.com
www.firstsolar.com
Founded: 1999

First Solar GmbH
Rheinstraße 4b
55116 Mainz
Germany
Phone: +49 (0)6131 1443-0

First Solar's vertically integrated, world-class technology and service capabilities combine to offer the industry's most comprehensive end-to-end photovoltaic system solutions.

As a leading manufacturer of photovoltaic (PV) solar modules and a premier provider of integrated solar solutions, First Solar creates value-driven renewable energy solutions that protect and enhance the environment. Our unique capabilities in module production, project development, engineering, procurement, construction, operations and maintenance (O&M), and project financing enable us to focus on creating synergies that drive down costs across the entire value chain. The knowledge and experience we've gained in realizing many of the world's largest PV power plants also translate into the lowest solar energy prices while delivering maximum returns for our energy buyers.

First Solar continues to develop successful strategic partnerships with leading utilities, power producers and project developers around the world. With more than 2 GW of utility-scale power plants constructed or under construction today, we have demonstrated our ability to design, engineer, and construct solar PV power plants to the exacting standards of the utility industry. Construction has commenced on three projects that truly represent the impact First Solar is making on the industry: the 550 MW Topaz Solar Farm in San Luis Obispo County, the 550 MW Desert Sunlight Solar Farm in Desert Center, and the 230 MW Antelope Valley Solar Ranch One Project in Los Angeles County.

Solar PV assets are long-term assets, lasting 25 years and longer. Understanding this, First Solar currently manages the O&M of many of our power plants. Our O&M capabilities maximize our customers' financial returns while complying with the requirements of utilities and transmission operators.

Environmentally speaking, First Solar's systems operate with no water, air emissions, or waste stream. On a life-cycle basis, they boast the smallest carbon footprint and the fastest energy payback time of any PV technology. First Solar has also set the benchmark for product life-cycle management with the industry's first prefunded, comprehensive collection and recycling program for solar panels.

Fronius Deutschland GmbH

Fronius: Reliable Solar Solutions

Open field PV power plant, 2.1 MWp, 148 Fronius IG Plus 150 inverters (picture: Eurosol GmbH)

Fronius IG Plus – maximum earnings in any weather

Fronius production plant & logistic center in Sattledt (Austria)

Fronius Deutschland GmbH
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36119 Neuhof-Dorfborn
Germany
Phone: +49 (0)6655 91694-0
Fax: +49 (0)6655 91694-50
pv-sales-germany@fronius.com
www.fronius.de

Fronius CL – modular system with maximum yield

State-of-the-art technology in high-performance electronics, the use of high-capacity processors and the interconnection of stand-alone devices are the keys to success for Fronius.

Fronius, with its headquarters based in Austria, has been conducting research into new technologies for converting electrical energy since 1945. That means more than 60 years of experience, progress and constant innovation. Its outstanding products and services have made Fronius a technology leader on the world market.

The German subsidiary – Fronius Deutschland GmbH – was founded in 1993. Since 2006, its headquarters have been based at Neuhof in the middle of Germany where all three Fronius divisions are consolidated under one roof: Solar Electronics, Battery Charging Systems and Welding Technology.

Quality and high-tech

Fronius' solar electronics division has been in existence since 1992 and its products are sold through a global network of sales partners. The division develops and produces high-powered inverters for mains-coupled solar power plants of any size. The product range is rounded off with an extensive selection of components for professional plant monitoring, data visualization and analysis.

In the development of PV inverters, Fronius has thought out new technologies, searched for innovative solutions and found completely new answers. The result: highly functional mains-connected inverters, which interact optimally with all solar modules.

Whether an open field PV power plant with a challenging topographic structure or a complex rooftop system, Fronius provides individual systems which reduce the cost of ownership. This results in low maintenance, minimized downtime and a longer lifespan of the implemented solar electronics. This guarantees stability of yield and an attractive return on investment from the project.

The inverters in the Fronius product families Fronius IG Plus and Fronius CL are perfectly suited for solar systems in the upper megawatt range as they ensure economical operation with maximum yield.

GOLDBECK – Your EPC and O&M Partner for Commercial and Large-Scale Photovoltaics

The GOLDBECK Group:
founded in 1969, 3,000 employees

Open land project with 6 MWp

Joachim Goldbeck:
CEO & founder

GOLDBECK: EPC and O&M services for commercial and large-scale solar power plants throughout Europe

As a subsidiary of the GOLDBECK Group, GOLDBECK Solar is in a unique position to provide customers with proven construction experience and a strong balance sheet. As an owner-operated company, GOLDBECK is one of the driving forces in the commercial construction sectors, offering a full spectrum of design, construction and ongoing services for buildings and solar power plants.

GOLDBECK:
- Engineering, Procurement and Construction
- Operation and Maintenance
- 38 subsidiaries in Europe
- commercial rooftop PV plants
- open land PV plants
- 10-year track record in PV

EPC
Since 2001, GOLDBECK Solar has helped its customers realize more than 250 projects. Our system-driven approach to design and construction allows for a shorter construction schedule and immediate yield potential. The company's "know-how" provides reliable technical and commercial solutions for site-specific rooftop installation on a variety of commercial and industrial buildings. In the field of open land systems, investors benefit from over 40 years of experience gained by the GOLDBECK Group in realizing ambitious engineering projects.

O&M
The Operation & Maintenance division provides clients with a user-friendly monitoring portal, ensuring successful operation of the plant and stable yields. The Operation & Maintenance services range from inspections of the systems to tailor-made solutions for complex projects.

On site for you – across Europe
The GOLDBECK Group has 38 locations throughout Europe. For clients, this means the nearest GOLDBECK subsidiary is never far away. Property consultation, turnkey construction and individual management services are ensured by your GOLDBECK team – locally.

GOLDBECK Solar GmbH
Goldbeckstraße 7
69493 Hirschberg
Germany
Phone: +49 (0)6201 877755-01
Fax: +49 (0)6201 877755-09
www.goldbeck.de
Founded: 1969 (GOLDBECK Group),
2001 (GOLDBECK Solar)
3,000 employees (GOLDBECK Group)

GP JOULE
Simply energy!

GP JOULE – Catching the Sun
A New Dimension in Natural Energy

A 14.37 MW solar park with 62,766 modules installed on around 28 acres in Richelbach

Once an airfield, now sun country – Ammerland, the largest solar park in Lower Saxony at 20.8 MW

photo: Oldenburger Luftbildarchiv (OLAR)

GP JOULE founders Ove Petersen and Heinrich Gaertner

GP JOULE is an expert in MW-class solar projects and covers the entire value-added chain from concept development and design, planning, project management and implementation through to operational management.

GP JOULE has a highly qualified team to help shape the future of energy generation while offering investors an attractive investment opportunity in both financial and environmental terms. This is a winning concept that has delivered the goods – currently, GP JOULE is ranked eleventh amongst the world's largest solar project planning specialists, with 125 MW installed in 2011 alone.

Set for expansion – international activities

Headquartered in Reussenkoege in the north of Germany and with branches in Geislingen and Augsburg, the activities of the ground-based PV specialists have spread well beyond Germany's boundaries, focusing in particular on markets such as the USA, Canada and France.

A broad field – the company's services

Investors benefit from energy concepts completed to specification, with concepts supported by GP JOULE from the planning stages through to the commissioning of turnkey installations. GP JOULE draws on experience from a wide variety of large-scale projects, world-class expertise, excellent contacts and a powerful network of partners in services that encompass every stage of the process – from site acquisition and assessment through legal and technical audits to project planning, financing, system configuration, installation and finally going on stream.

It does not end there – even after commissioning, plant owners can rely on GP JOULE's services; comprehensive technical and commercial services are just as much a part of the energy specialist's portfolio.

Reaping the rewards of synergy – other business areas

The GP JOULE Group also provides services for wind, biomass, investment and future concepts in addition to solar energy, a combination of skills which fulfills GP JOULE's vision of a sustainable energy mix.

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Germany
Phone: +49 (0)4671 6074-0
Fax: +49 (0)4671 6074-199
info@gp-joule.de
www.gp-joule.de
Founded: 2010
70 employees

Outperform. Outlast. In the PV Industry.

83 MW solar park with Hilti mounting structure in Northern Germany (top right)
Hilti headquarters in Schaan, Liechtenstein (top left)
1.1 MW solar park with Unirac ISYS™ Ground Mount in New Jersey (bottom)

Hilti Corporation
Feldkircherstraße 100
9494 Schaan
Liechtenstein
Phone: +423 234 3607
solar@hilti.com
www.hilti.com/solar
www.unirac.com
Founded: 1941
20,000 employees

Hilti Corporation – more than two decades of experience

Hilti is a well-known supplier to the construction industry and started its solar business only five years ago. Right from the beginning, Hilti was able to base this new segment on more than 20 years of experience – both in the development of installation solutions as well as in international project management.

Since the start in 2007, Hilti has been able to capitalize on its profound know-how in the development, testing and production of installation systems. This has resulted in a comprehensive portfolio of value-adding PV panel mounting systems. In combination with the on-site support of Hilti's direct sales force, customers worldwide have therefore been assisted with optimizing the output of their PV projects. Consequently, around 3.5 GW worth of photovoltaic projects have been realized using Hilti mounting systems over the last two years.

In order to further meet customers' needs worldwide, Hilti acquired one of America's leading system suppliers, Unirac, in 2010.

Unirac, Inc. – engineered for the North American market

Unirac is an Albuquerque-based Hilti company and one of North America's largest providers of infrastructure for solar power systems for utility, commercial and residential installations.

With a 30% share of the North American solar racking market, Unirac already has over 100,000 installations representing 1 GW. Major commercial customer wins include the Google campus, Mineta San Jose International Airport, BJ's Wholesale Club, Universal Studios Hollywood, the Orange County Convention Center and the Minneapolis-St. Paul Convention Center.

The company provides its products through distributors in California, New Mexico, New York, Vermont, Arizona, Rhode Island, and Australia, as well as its subsidiary Unirac Canada. Unirac designs and tests its solutions in Albuquerque, New Mexico, and manufactures them across the USA and in Ontario, Canada.

Innovation and Technology for Our Customers

Right: 8 MW PV plant in Sicily (Italy)
Above: 20 MWp PV plant on a greenhouse roof in Sardinia (Italy)
Below: Ingecon® Sun Power Max 625TL

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corporacion@ingeteam.com
www.ingeteam.com

Ingeteam Power Technology, S.A.
Avda. Ciudad de la Innovacion, 13
31621 Sarriguren (Navarra)
Spain
Phone: +34 948 288-000
Fax: +34 948 288-001
solar.energy@ingeteam.com
www.ingeteam.com

Founded: 1972 (Ingeteam Group)
3,500 employees (Ingeteam Group, worldwide)

Ingeteam designs and manufactures a wide range of inverters under the brand Ingecon® Sun, with output powers ranging from 2.5 to 880 kW for grid-connected systems, and under the Ingecon® Hybrid brand for stand-alone systems.

Ingecon® Power Max inverters feature power ratings from 100 to 880 kW and have been designed for medium voltage applications. They offer increased availability thanks to the independent operation of the power stages, higher efficiency and also ease of maintenance, which are fundamental factors in large-scale PV power plants. In addition, Ingeteam has developed a factory integrated, medium voltage solution with complete integration of the power conversion (up to 1.76 MW), step up transformer, switchgear, low voltage distribution panels and monitoring equipment, customized to fit the requirements of each particular market. It is delivered in a pre-manufactured housing or skid for plug and play integration on site.

Thanks to a 1 GW production capacity at its headquarters in Spain, new manufacturing facilities in China and the USA (a 100,000-square-foot combined production facility and office complex in Milwaukee, WI, with up to 500 MW capacity for the photovoltaic industry) and subsidiaries in Germany, Italy, France, the USA, Czech Republic, Brazil, Mexico, South Africa and China, Ingeteam can satisfy the needs of its clients worldwide.

Furthermore, in 1999 Ingeteam created its own Service Division to meet the needs of operation and maintenance in the renewable energies sector, positioning itself as a specialized services company and working alongside customers to offer all the necessary support for their developments.

With a staff of over 3,500 employees, Ingeteam boasts a long, proven track record in the industrial and energy sectors, which stretches back to 1972. Thanks to its sustainable growth policy and division-based structure – Energy, Industry, Marine, Traction, Services and Basic Technologies – Ingeteam enjoys a privileged, competitive position and has strongly established itself as one of the leading companies in the electronics/electrotechnical sector. Ingeteam's core business is based on power and control electronics, generator, motor and electric machines.

Leading Tracking Technology

Tracking systems in a large-scale solar plant in Italy

The multi-use approach makes "sonnen_system" trackers a perfect fit for integration into agricultural land and parking lots.

Concentrator photovoltaics – ready for future technologies

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36211 Alheim
Germany
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Fax: +49 (0)5664 93911-39
sales@kirchner-solar-group.com
www.kirchner-solar-group.com
Founded: 1991
250 employees

About the Kirchner Solar Group

The Kirchner Solar Group is a pioneer in the solar industry. The company's products and services include the design and installation of PV systems, the production of its own solar tracker systems, the production of independent off-grid systems, trade of high-quality PV components and public funding concepts, as well as customized solar power plants. The group employs more than 250 people at 13 locations in Germany, Africa, Italy, Canada, the USA and Greece. In addition to its worldwide solar park projects and implementation activities, the company has for years dedicated itself to the field of sustainable and environmental education. The Kirchner Solar Group was awarded the German Solar Award 2010 for its work and commitment in the PV sector.

sonnen_system

A product of Kirchner Solar Group

About PV tracker parks

The "sonnen_system" PV tracker, a Kirchner Solar Group product, is an astronomically controlled biaxial system. This innovative technology makes sure that the incidence angle of solar radiation on the module is optimal at all times. This way, the solar tracker parks will deliver up to 45% more yield compared to solar plants mounted on fixed structures.

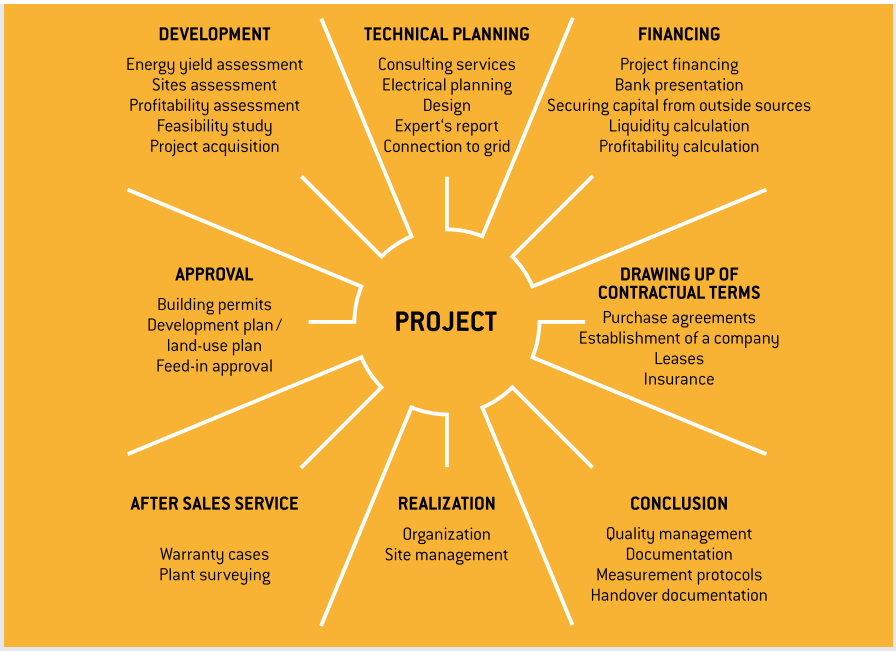
About CPV trackers

Within the solar industry, CPV will be the leading edge technology providing outstanding high module efficiency from 30% to 40% in the near future. In the earth's sunbelt, CPV offers the lowest solar electricity production cost combined with the best temperature characteristics.

The "sonnen_system" CPV tracker always aligns with the sun at the optimum angle. Optimal solar alignment is made possible by a precise astronomical control system developed specifically for this purpose. The "sonnen_system" CPV tracker is constructed to the highest quality, which is an absolute necessity for concentrator module applications in high DNI regions.

From Carports to Solar Farms – Krannich Solar Project Support for PV Power Plants

Krannich Solar Project Support – competence in all project phases



Below: Corsica Verde – Solar farm in Corsica which supplies around 750 4-person households with electricity

Radelstetten solar farm – 1.7 MW tracked PV plant on converted land

Krannich Solar was one of the very first pioneers of photovoltaics. With more than 350 staff and 22 branches across the globe, the company is among the top 5 photovoltaic system providers within Europe.

Kurt Krannich, owner of Krannich Solar, has been following a clear set of visions ever since forming the company in 1995. He believes that providing 100% of the world's energy supply using renewable energy is not only desirable but also truly feasible.

Right from the very start, Krannich Solar has focused on a wide range of projects. "From Carports to Solar Farms" – that is what this company stands for. Generally speaking, the company is interested in any type of project, whether it be developing a 2 kW roof system or indeed a 2 MW open country system. Every single kilowatt helps to reduce global CO_2 emissions.

The concept

Krannich Solar Project Support assists customers during every phase necessary for implementing their photovoltaic systems. From project development right through to starting system operation, Krannich Solar Project Support stands beside them as the perfect partner – either for individual project stages, if required, or for the entire project duration.

Krannich Solar is also perfectly positioned for international projects thanks to having established a wide-reaching international network. Its truly global presence, with numerous international branches, and its international team, which possesses country-specific industry knowledge, are factors which have helped to make Krannich Solar a true global player during the many years in which it has been operating. To date, the company has developed countless megawatt solar systems both at home and abroad.

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Fax: +49 (0)7033 3042-222
info@krannich-solar.com
www.krannich-solar.com
Founded: 1995
350 employees

Masdar PV GmbH

MASDAR PV
A MASDAR COMPANY

Photovoltaics. Solar. Ideas.

Transparent modules allow architects to build futuristic, façade-integrated PV installations. (top)
Masdar PV constructed the largest solar park with thin-film modules in Thuringia (Germany) with a size of 11.7 MWp. (bottom)

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info@masdarpv.com
www.masdarpv.com

Founded: 2008
200 employees

Masdar PV GmbH was founded in April 2008. Over the course of the past few years, Masdar PV has laid down solid foundations which will enable the company to establish itself as a world known provider of thin-film PV modules.

The main focus of our future company development will be on ground-mounted solar parks, industrial roof installations and façade-based integrated photovoltaic systems. We will also use our headquarters in Ichtershausen as a base for continuing to strengthen our international activities in the field of sales in particular, and to tap into new growth markets. Germany, Italy and Canada are just three of the countries in which highly reputed system integrators have deployed our silicon-based thin-film PV modules in large-scale solar parks over the course of recent years.

We see ourselves as a flexible and reliable partner able to bring comprehensive know-how to the table for joint projects. As a 100% subsidiary of Masdar, the renewable energies future initiative from Abu Dhabi, we have the benefit of secure financial backing, and can guarantee high-quality results for the long term.

These two factors have produced a considerable degree of success for Masdar PV, both at a national and international level. The key to all our projects is the practical experience our team is able to provide.

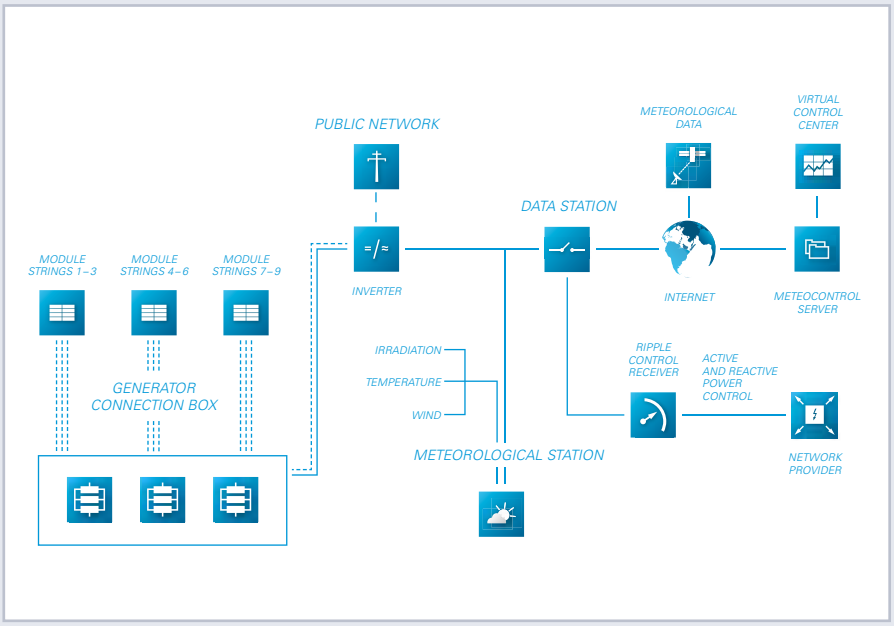
Our staff already have proven track records at leading companies within the sector and now bring all their enthusiasm to bear in implementing the ideas and visions of Masdar PV. They are familiar with the demands which system integrators make of high-performance modules and know what investors in solar plants expect.

We understand that our customers wish to operate in an efficient and cost-effective manner and that they require highly specific modules for this purpose. For this reason, we devote all our energy and strength to collaborating closely with them on the development of solution-oriented concepts.

meteocontrol
Energy & Weather Services

Independent Consulting and Intelligent Solutions for Your PV Project

With large-scale systems or PV power plants in particular, monitoring must be optimally coordinated.



Intuitive and appealing design – the datalogger for monitoring your private PV system

meteocontrol is a technological leader and has been one of the most innovative service providers in the solar energy sector for more than 30 years.

Dates and facts

The company's headquarters is in Augsburg, Germany; further offices are located in Moers, Germany, Milan, Italy, Madrid, Spain, and Lyon, France. Its sister company, meteocontrol North America, was set up in 2010 for the North American market. 100 employees now work at these sites.

Independent consulting

The construction and operation of solar systems relies on high investments. The competence and experience of independent experts are indispensable in securing these investments and minimizing risks. As a consultant and technical service provider, meteocontrol supports solar projects with technologically leading solutions throughout the entire project life-cycle, such as reliable forecasts which incorporate all relevant parameters and form the basis for sound and solid planning. An extensive range of services enables implementation and allows meteocontrol to ensure proper, planned commissioning for large-scale projects.

Competence in energy and weather

meteocontrol is able to draw on the most modern information technology and years of experience in monitoring renewable systems: 24,000 solar systems with a total power of over 4.3 GWp are currently monitored. With a global market share of over 10% in professionally monitored systems, meteocontrol is a global market leader in this segment. meteocontrol's product portfolio now offers monitoring solutions for every operation size – from private systems through to solar power plants. The recording and analysis of highly valid solarization data from satellite measurements enables precise energy forecasts for PV systems. These solar power forecasts allow energy suppliers and network operators to precisely plan their network loads and solar share of the energy mix.

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www.meteocontrol.de
Founded: 1976
100 employees

Mounting Systems Group

the base for solar power
Mounting structures as the foundation of every PV power plant

Sigma II open terrain system, reference: Eberswalde, Germany, 84.5 MWp, 2010–2011

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www.mounting-systems.com
Founded: 1993
250 employees

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www.mounting-systems.us

For 19 years, Mounting Systems GmbH has been one of the largest and most experienced ISO-certified manufacturers of photovoltaic substructures.

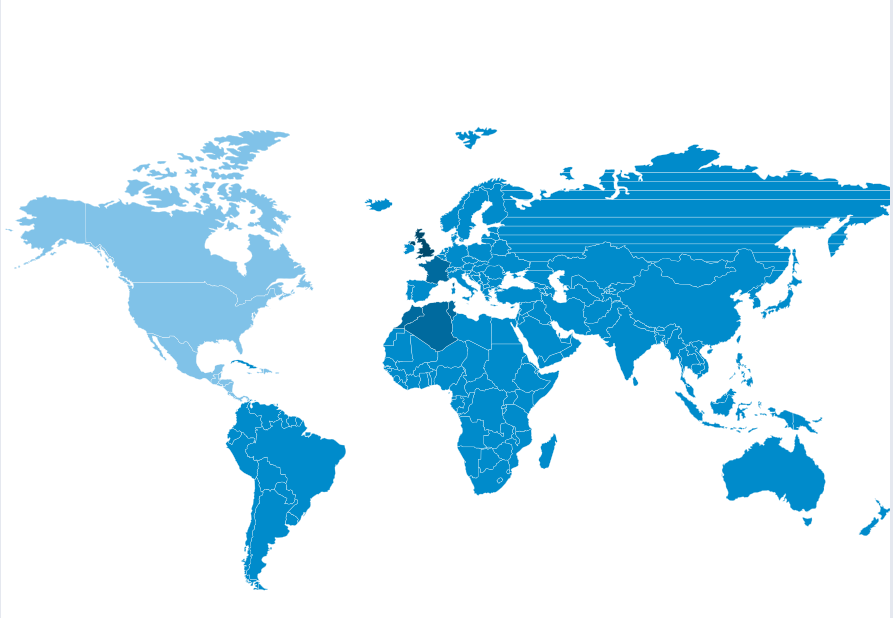
Top: Mounting Systems GmbH, Rangsdorf, near Berlin, Germany
Bottom: Mounting Systems, Inc., West Sacramento, California, USA

In 2010, Mounting Systems opened a representative office in Lyon, France. Since 2011, the company has established its own sales and production site in West Sacramento, USA. In March 2012, another representative office also opened for customers in Milton Keynes, UK.

The comprehensive product portfolio includes several racking systems and components for photovoltaic and solar thermal installations, as well as module frames. The company offers customized solutions with leading-edge technology, professional project support and flexible production capabilities in aluminum processing. An experienced team of engineers is available to provide customers with exceptional technical product development and individual solutions for each project. Mounting Systems' products are delivered from the Rangsdorf and West Sacramento sites to over 40 different countries.

Omega – when size matters

Omega was specially designed for use in large photovoltaic systems in harsh



ground and soil conditions, e.g. former waste disposal sites. The modules can be arranged in any number of rows and columns on the module table in an area of up to 45 m² (portrait and landscape).

- True innovation: short installation times guaranteed
- Environmental win-win: One meter minimum module elevation above ground surface prevents waste and allows secondary use of the terrain as pasture land

Sigma I – the specialist on uneven terrain

Sigma I was designed as a ground mounting system for installations where cost is of primary concern. Whether portrait or landscape, the system is also well-suited for framed modules. The use of driven piles eliminates the need to level the ground and makes the Sigma I system aesthetically pleasing and economical – ideal for large projects.

- Intelligent design allows installation on uneven terrain parallel to the ground surface
- Time and cost savings from use of driven piles and high level of pre-assembly

Sigma II – the space-saving open terrain professional

Sigma II allows the arrangement of several rows of modules either in portrait or landscape orientation. Depending on the project requirements, the Sigma II system is connected to the ground with driven piles, screw foundations or foot plates. The system is characterized by a simple, functional design and reduced use of tools during assembly on site. For large projects, this means high cost savings with respect to assembly time.

- Maximum performance through optimal use of space
- Easy dismantling allows for re-use or regeneration of terrain

Helge Tost, Director of Sales & Marketing: "The day-to-day incentive is to develop, produce and supply innovative products, system solutions and services for all customers, especially in the PV plant market. We provide customized product solutions quickly, with proven structural analysis and an accurate cost/performance ratio. Our competent project teams create large PV plants to fit the

PADCON GmbH

Future technologies.

PADCON GmbH specializes in energy distribution systems, monitoring and communication systems for photovoltaic power plants. The comprehensive product portfolio includes solutions for roof-mounted PV systems as well as for large-scale ground-mounted PV power plants worldwide.

High quality standards combined with the use of exclusively high-quality components guarantee long service life, safe operation and high efficiency. The comprehensive PADCON product range offers perfectly matched components and solutions for every project. These range from string combiner units and inverter stations right up to full monitoring and park regulation systems, all from a single source.

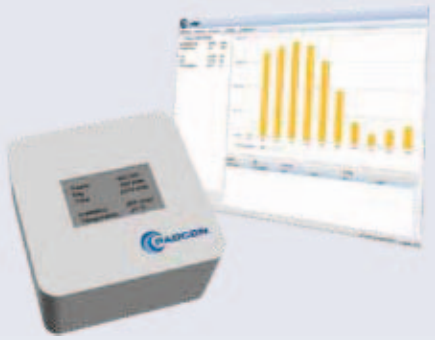
Large-scale projects with outputs of up to 80 MW and worldwide monitoring of PV plants with a total capacity of more than 1.4 GW reflect the trust of PADCON customers.
An innovative research and development team, high quality and cost-efficient products are the basis for photovoltaic systems of the next generation.
PADCON – Future technologies.

Energy distribution systems

High-quality string collection including protection and measurement devices on both the AC and DC sides – PADCON products guarantee easy installation and high standards of system reliability.

Monitoring and park regulation

From measuring technology, data loggers and visualization right up to remote control and regulation of the PV system – PADCON offers monitoring solutions, hardware and software setup, and plant supervision from a single source.



PADCON Log & Control Box
Monitoring, control and communication for PV systems with string inverters in one unit

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www.padcon.de
Founded: 2007
105 employees

Power-One: A World Leader in Energy Efficient Power Solutions

Power-One's 110,000 square foot facility located in Phoenix, AZ

The new Ultra 1.4 MW is the largest PV inverter available in the market.

Power-One
3201 East Harbour Drive
Phoenix, AZ 85034
USA
Phone: +1 877 261-1374
sales.usawest@power-one.com
www.power-one.com
Founded: 1973
Turnover: 1.0 billion USD (2011)
3,263 employees (2011)

Power-One is the world's second largest manufacturer of solar power inverters with facilities on three continents producing renewable energy products in Italy, the USA, Canada and China. With a long-standing history in the global power electronics industry, Power-One can provide a four-decade strong foundation for its technology innovation, quality and service within the renewable energy industry.

Offering a full range of photovoltaic and wind products, from small residential inverters to large utility-grade units, Power-One has a diverse range of solutions to meet the needs of every installation. The broad array of Aurora products offers industry-leading efficiency and reliability, providing customers with a technologically advanced product that produces higher yields than its competitors.

Power-One's Aurora solar inverters range from residential units, including micro, single-phase and three-phase inverters, to large commercial and utility grade scale applications of up to 1.4 MW in size. So far, Power-One has installed products totaling more than 6 GW of power globally.

Aurora products from Power-One compare favorably with the competition for the high innovation content and key features which are the stronghold of our offering. Our Maximum Power-Point Tracking (MPPT) technology allows you to accommodate sub-arrays with different orientations, or made up of different PV panels. This technology also allows the installation designer to overcome any incidents of partial shading using MPPT technology to create the optimum power curve for energy harvesting.

In addition to inverter manufacturing, Power-One also offers its Aurora Vision monitoring and control solutions. Power-One is headquartered in Camarillo, CA, and has global sales offices, manufacturing, and R&D operations in Asia, Europe, and the Americas.

Always Striving for Absolute Perfection

1 MW solar park in Villafranca (Italy) with PerfectEnergy modules

Through the very high quality of its solar cells and modules, PerfectEnergy demonstrates its pursuit of absolute perfection. The company's products not only meet various international standards, they go far beyond them: For this company, perfect energy does not just mean providing "green" energy, but also the optimum energy yield from photovoltaic installations. PerfectEnergy's product portfolio comprises both monocrystalline and polycrystalline modules, as well as complete system solutions.

PerfectEnergy produces most of the solar cells for its modules in-house. Specific quality tests are integrated into both solar cell and module production lines, such as resistance tests for wafers or electroluminescence tests for strings prior to lamination. The EVA gel content test, for example, establishes how well the individual laminate layers of the module are cross-linked, thereby providing an indication of the production quality.

PerfectEnergy modules attained excellent, extraordinarily consistent results in a test conducted by the Photovoltaik-Institut Berlin. Furthermore, all solar modules are manufactured in strict accordance with IEC 61215, IEC 61730, UL 1703 and JET standards.

Perfect Energy's ability to offer high-quality products at a reasonable price is based on effective, independent production methods and on appliances largely developed within the company. The high level of customer orientation and international involvement of the company result in the constant progression of independent research and development, executed by an in-house expert team with excellent connections to relevant scientific institutions in China and abroad. Technical support and customer service also contribute to lasting product quality and customer satisfaction. PerfectEnergy insures every individual module. The company has therefore taken out both a product quality guarantee and a product liability insurance policy with Alltrust Insurance Brokers & Consultants Co., Ltd., Shanghai. In addition we also have Zurich Insurance for our products on European markets.

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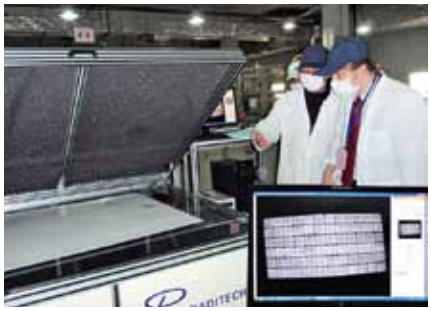
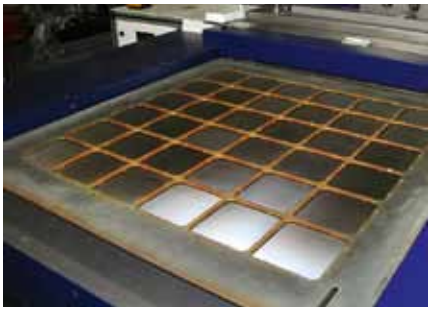
www.perfectenergy.com.cn



The electroluminescence check detects cell micro cracks, which are not visible to the naked eye.



Technical support checking a solar park in Spain (bottom)

The company

PerfectEnergy (Shanghai) Co., Ltd. develops and produces solar cells and modules. The company was founded in 2005 by Jack Li, who is also the president of the public holding company PerfectEnergy International, listed on the OTCBB under the symbol PFGY.

Each wafer is checked carefully before cell production commences.

PerfectEnergy GmbH, based in Sankt Augustin near Cologne, Germany, is responsible for the sale of modules, technical support, customer service and warehousing in Europe. This subsidiary of PerfectEnergy International was founded in September 2007 by Margaret Xiao-chun Haas, who is also the Vice General Manager of PerfectEnergy (Shanghai) Co., Ltd. PerfectEnergy has supplied modules for numerous PV power plants constructed by developers not only in Germany, but also in Italy, France, Switzerland, Belgium, Spain, Slovenia and other European countries.

From 2012, PerfectEnergy has started to finance and construct its own PV projects. The project pipeline for this year is 20 to 30 MW.

We have recently acquired in-house and mobile testing equipment for our modules. Setting up these professional EL and flash testing facilities serves, on the one hand, as a signal of our determination to exercise the most diligent care of PerfectEnergy's own solar projects, and on the other hand to offer an improved after sales service to our clients.

At the beginning of 2012 we also set up our own brand in Japan under the name SEIBI-Perfectenergy. Together with our Japanese partner we shall now seek to strongly promote our products in the Japanese market.

PerfectEnergy has about 300 employees and manufactures solar cells with a total output of 60 MW and modules with a total output of 100 MW each year. By the end of 2012, the total module output will stand at 150 MW. The output objective for this year: Our 5" mono cells will achieve 18.5% efficiency. Furthermore, we shall increase the power output of our 72-cell mono modules to 195–200 W, of our 96-cell mono modules to 260 W, of our 60-cell mono modules to 240–260 W and of our 60-cell poly modules to 235 W.

Product range

Solar modules:

With 5" mono cells:

- PEM-xxx-96M5 (96 monocrystalline cells, power output from 245 W to 265 W)
- PEM-xxx-72M5 (72 monocrystalline cells, power output from 180 W to 200 W)

With 6" mono cells:

- PEM-xxx-72M6 (72 monocrystalline cells, power output from 280 W to 300 W)
- PEM-xxx-60M6 (60 monocrystalline cells, power output from 240 W to 260 W)

With 6" poly cells:

- PEM-xxx-72P6 (72 polycrystalline cells, power output from 270 W to 290 W)
- PEM-xxx-60P6 (60 polycrystalline cells, power output from 225 W to 245 W)

PerfectEnergy provides a ten year product quality warranty, a ten year warranty for 90% of the minimum rated power and a 25 year warranty for 80% of the minimum rated power.

High-Efficiency Inverters and Accessories for PV Installations

REFU*sol* string inverters at 4.6 MW PV installation in Belgium

REFU*sol* central inverter at 70 MW PV plant in Germany

REFU*sol* training center in Metzingen

REFU*sol* is a leading manufacturer of solar inverters. With over 47 years of experience in power electronics, REFU*sol* is one of the top providers of solar inverters globally and one of the fastest growing companies in this field.

Our company

Our goal is to maximize the yield of our customers' photovoltaic installations through our award-winning and cost-effective inverters – starting from small roof installations to larger solar power plants. REFU*sol* is headquartered in Metzingen, Germany, and has international offices in Europe, Asia including China and India, and the USA, as well as sales and service partners in key strategic photovoltaic markets around the world.

Creative freedom and a passion for innovation are among our key corporate principles. REFU*sol* allows for creative space to drive superior engineering and our employees are passionate about our products and the solar industry in general.

Our products

As a central component in photovoltaic installations, solar inverters play a key role in energy conversion, ensuring profitability. Through our ongoing commitment to technical innovation, our inverters are leading the market when it comes to technology and efficiency, communication and monitoring as well as easy installation and scalability. Whether sold under the REFU*sol* brand or via an OEM, REFU*sol* products are ranked top in Photon efficiency factor tests.

Our high-quality product portfolio includes string, central and large inverters with a power range of 3.6 kW to 1.3 MW. Available globally, the range can be used in family homes as well as in large-scale solar parks and is suitable for operation in extreme geographical and climatically-challenging environments, in an economic and efficient way.

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www.refusol.com
Founded: 1965
160 employees

The Global Specialist in Energy Management

78 MW power plant with saferay GmbH (Germany)

Solution for large commercial and PV power plants

Schneider Electric provides complete solutions from panel DC output to grid connection, including monitoring, supervision as well as service and maintenance.

From its creation in 1836 as a producer of iron and steel, Schneider Electric has evolved to become a global leader in energy management. Along the way, we have contributed to the transformation of industries with an innovative, international and responsible mindset. Today, with operations in over 100 countries and more than 130,000 employees, the company's mission is to help people make the most of their energy.

Schneider Electric offers a PV Box, a prewired equipment package for large PV power plants and large commercial rooftop solar installations. The PV Box is a complete solution for electrical distribution, security, monitoring and control, available from one vendor. A PV Box includes solar inverters (ranging from 100 to 680 kW), DC combiner boxes, step-up transformers and a medium voltage switchgear housed in a prefabricated building to allow quick field wiring from both the solar arrays and the utility grid connection point. Other items can be added to the package including climate controls, security equipment, monitoring equipment and power metering, with operation and maintenance offerings also available.

Through its operation and maintenance services, Schneider Electric is able to guarantee the availability of its installation to the operator, leveraging both preventive maintenance to anticipate problems and monitoring equipment installed at critical locations in the system. The monitoring devices provide a variety of data on the array's operation – the status of the photovoltaic modules and inverters, module yield, fault reporting and alarms – and enable Schneider Electric to respond in real time to correct malfunctions and resume operations as fast as possible.

With this turnkey solution, customers can significantly reduce total electrical installation costs and project cycle time, offering customers a reliable and complete solution from a bankable company with over 100 years of experience designing electrical distribution and control systems.

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Fax: +33 141 297-100
renewableenergy@schneider-electric.com
www.schneider-electric.com
Founded: 1836
Turnover: 22.4 billion euros (2011)
> 130,000 employees

SCHOTT Solar: Convincing Quality for PV Power Plants

Rhein Main Printing Center in Rüsselsheim, Germany: 2,927 SCHOTT Solar crystalline modules cover 4,771 m² of roof surface.

Excellent, reliable quality – approved and certified through independent institutes

SCHOTT Solar AG is an international solar company that focuses on manufacturing and marketing premium quality solar modules, and on the project management of large photovoltaic installations.

SCHOTT Solar, with its headquarters in Mainz, Germany, has over 54 years of experience in the field of solar technology. Through its business unit "SCHOTT Solar Power Projects", the company supplies PV modules for projects and offers its expertise in planning and even full-scale realization of solar power plants.

Quality has always been its utmost priority. In its in-house climate tests, the products offered by SCHOTT Solar must be able to meet requirements that are often twice as high as the international IEC standard specifications.

To ensure that its solar systems offer high performance and attractive power yields for extended periods of time, SCHOTT Solar offers a 25-year linear performance warranty on its glass-film modules and even a 30-year warranty on its double glass modules.

The high quality standards in the areas of development and manufacturing have been confirmed by independent parties on numerous occasions. For instance, the German consumer magazine "Ökotest" (edition 4/2010) evaluated solar modules from German and foreign manufacturers in terms of their performance. Of the 15 solar modules tested, only the SCHOTT PERFORM® POLY 220 module and two other modules received the top score of "Excellent". The German Agricultural Society (DLG) also confirmed SCHOTT Solar's high standard of quality just last year. The solar modules from SCHOTT Solar passed the DLG's "Focus test on ammonia resistance" and are thus suitable for use in agricultural environments. In addition, the double glass module SCHOTT PROTECT® POLY 290 received a score of "Excellent (-)" in the "PV+Test" conducted by Solarpraxis AG. These results show that SCHOTT modules are highly reliable during sustained use.

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solar.sales@schottsolar.com
www.schottsolar.com
Founded: 1958
2,300 employees (worldwide)

SFS intec AG
FasteningSystems

RELIABLE SOLAR INSTALLATION

SOL-R for pitched roofs

SOL-F for flat roofs

The pace of demand for photovoltaic (PV) solutions in recent months has resulted in rushed installations, sometimes using low performance products and creating poor quality results.

To achieve PV solutions that withstand the test of time (and weather), a quality, well-thought-out system is required. As with any new form of technology, it is only as good as the foundation it is built on.

Sourcing a purpose-designed solution which aids the installation process will inevitably be favorable. The industry should look for fastening solutions which have been developed for a particular building envelope material or frame. SFS intec's SOL-R post is designed to fasten solar panels onto profiled metal and composite panel roofs. Fixed to the profiled roof with a high performance sealant underneath the large base plate, the product provides a stable foundation for the fixers to quickly install the bracket. The post is easily adjustable in both height and rake conditions, allowing optimum positioning of the solar panels.

There are many other elements which can also differ with each building, so installations need to be considered on a project by project basis. Wind loads, loading requirements, structural security, location and design of the building are all parameters which must be considered when a PV system is installed.

Unlike the SOL-R post, the SOL-F is specifically designed for use with flat roof installations. The system is installed into a pre-cored support location through the insulation layer. The flexible length of spacer profile enables it to be used with a wide range of insulation material thicknesses and also for inclined insulation.

Specifically in retrofit projects, it is essential that the building owner is aware of the warranties already in place. They must ensure that when specifying PV they are not compromising any warranties provided by the original roofing contractor. Working with an experienced and coordinated supply chain will ensure the owner's expectations of returns over the 25-year period.

The industry must continue to offer innovative solutions which help to make installation easier, quicker and more cost effective as well as reliable.

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www.sfsintec.biz
Founded: 1960
3,300 employees

SIEMENS

Siemens Photovoltaic Solutions for Today and Tomorrow

The solar park in Les Mées, France, 31 MWp, provides electricity for more than 12,000 households.

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Industry Sector, Industry Automation
Würzburger Straße 121
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Fax: +49 (0)911 750-2246
sinvert.automation@siemens.com
www.siemens.com/sinvert

Energy Sector, Solar & Hydro Division
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Fax: +49 180 524 24 71*
support.energy@siemens.com
www.siemens.com/pv

Founded: 1836
360,000 employees

*14 cents/min from German landlines, prices for cell phone networks may vary.

Siemens covers the entire PV value chain: from glass and silicon materials to module production, field installation, inverters, integrated automation systems and as a supplier of turnkey large-scale PV arrays.

We are shaping a green and sustainable environment for future generations

Siemens is a global powerhouse in electronics and electrical engineering, operating in the fields of industry, energy and healthcare as well as providing infrastructure solutions, primarily for cities and metropolitan areas. For over 160 years, Siemens has stood for technological excellence, innovation, quality, reliability and internationality. The company is the world's largest provider of environmental technologies. Around 40% of its total revenue stems from green products and solutions. At the end of September 2011, Siemens had around 360,000 employees worldwide, based on continuing operations.

Utility-scale photovoltaic power plants

Siemens is actively engaged in the fields of Engineering, Planning and Commissioning (EPC) utility-scale photovoltaic power plants. As a general contractor, Siemens provides its customers with large-scale rooftop and ground-mounted arrays. The focus here is on customized solutions and overall optimization of the photovoltaic plants, with the goal of achieving the lowest power generation costs with the greatest degree of safety, reliability and return.

For the turnkey installation of PV power plants, Siemens supplies in-house manufacturing components such as inverters, transformers and medium-voltage switchgears, and combines these with PV modules from bankable suppliers and products from local markets. In addition, Siemens also offers a unique layout planning system for utility-scale PV power plants in its portfolio: It combines specific plant requirements

The first ground based multi MW PV plant in Israel: Ketura

with Levelized Cost of Electricity (LCoE)-optimized concepts.

Applying a contract model in which the Performance Ratio (PR) is anchored, the efficiency and defined performance data of a solar plant can be guaranteed over the entire life-cycle of the plant.

Maintenance and feasible solutions for solid financing are services that round out the Siemens portfolio. A selection of different service packages is available for the operational phase. Particularly worth mentioning is the performance ratio guarantee, which minimizes financial risk for the plant operator and investors. In conclusion, Siemens offers technically optimized plant designs with only best in class products to guarantee the highest plant performance while safeguarding the customers' investments over the whole lifetime of the plant.

SINVERT – photovoltaic inverters from Siemens

With their high level of availability and optimized efficiency, SINVERT inverters provide a reliable basis for operating a photovoltaic plant efficiently throughout its entire life-cycle. SIEMENS PV inverters, with their peak efficiency of > 98%, are available for a broad market spectrum (commercial and power plants). The functions and yield of the entire photovoltaic plant can be monitored and visualized in a user-friendly fashion using SINVERT WebMonitor or SIMATIC WinCC industrial software. Complimentary SINVERT Select layout software is available for determining the optimum configuration for a PV plant.

SINVERT PVM inverters are available in the range from 10 to 20 kW for small to medium-sized plants in the "commercial" market segment. The three-phase inverter series is characterized by its compact design, its robust quality and its long service life.

The SINVERT inverter family PVM and PVS

Close to the airport: Thunder Bay is one of three large-scale PV power plants in Eastern Canada.

The plant in Fontebella, Italy, has a size of 5 MWp.

SiG Solar GmbH – The Future Company
We Turn Your Investments into Success Stories

Right: Straddling history and high-tech:
solar farm in Possidente, Italy (8 × 500 kWp)
From top to bottom:
- Aerial photo of one of Spain's largest PV installations, located in Almería, with Sun Earth solar panels by SiG Solar
- One of the 500 KWp systems making up the 4 MWp installation located in Possidente, Italy
- Solar farms by SiG Solar – in perfect harmony with the environment (Possidente, Italy)

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www.sigsolar.de
Founded: 2004
70 employees

SiG Solar offers a wide range of products and services surrounding sustainable energy efficiency. As the company's core focus lies on PV, SiG Solar also develops synergies in related products, such as e-mobility and storage technology.

SiG Solar is the exclusive distribution partner for Sun Earth solar panels in Germany. The production process used to create the Sun Earth solar panels is based on experience in the field of module manufacture dating back to 1966. Thanks to a fully integrated production process in conjunction with German quality assurance, SiG Solar offers customers a product that complies with the highest European quality standards. SiG Solar is an international enterprise specializing in the construction of high-quality, reliable, large-scale photovoltaic installations. With locations and references throughout many European countries and the USA, it is clear that the group is committed to its goals and dedicated to future growth. SiG Solar customers can rely on high quality, experience, and technical and sales expertise.

SiG Solar is always one step ahead and fully integrating photovoltaics with energy-efficient concepts. SiG Solar's goal for the future is to generate renewable energy and use it in a productive and efficient way. And in order to achieve this goal, SiG Solar cooperates with strong partners to develop effective system solutions that are tailor-made for customers' individual solar energy needs.

Photovoltaic expertise
- distribution of high-quality Sun Earth solar panels
- German standards for quality assurance, product optimization and warranty handling
- EPC contractor for turnkey PV installations for international investors
- engineering, design, planning and integration
- after-sales service: operations, maintenance and monitoring
- worldwide partner network

Energy-efficient system solutions
- innovative storage technologies
- energy-efficient home system solutions (storage and home automation)
- electric mobility: etropolis e-scooters
- SunTree: solar carports with or without charging stations
- LED solutions, DK LED by SiG Solar

Sinosol AG

TOWARDS THE SUN

15.0 MW solar power plant,
Almeria, Spain

7.4 MW solar power plant,
Nordendorf, Germany

1.0 MW solar power plant,
Le Lauzet, France

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www.sinosol.com
Founded: 2006

Sinosol is an international project developer and EPC turnkey solution provider of solar parks, as well as a supplier of photovoltaic (PV) systems, solutions and components.

With its extensive experience in engineering, procuring and realizing international PV projects, Sinosol has a solid track record consisting of approx. 100 MW to date. For example, Sinosol has realized 15 MW in Spain, more than 10 MW in various parks in Germany, a 1 MW thin-film solar park in France and recently 5 MW in Italy.

The company's business activities are divided into projects and wholesale business. The projects line provides institutional investors such as financial institutions, banks, insurance companies, family offices, and utility companies with a complete range of services, from project development to a turnkey solution, as well as the operation of solar farms.

Project and site development

Sinosol performs all tasks related to project and site development, the authorization framework, site qualification and the preparation of a sustainable financing model. We also negotiate the relevant purchase and lease agreements and obtain the required approvals from municipalities and energy suppliers.

Planning, procurement and turnkey construction

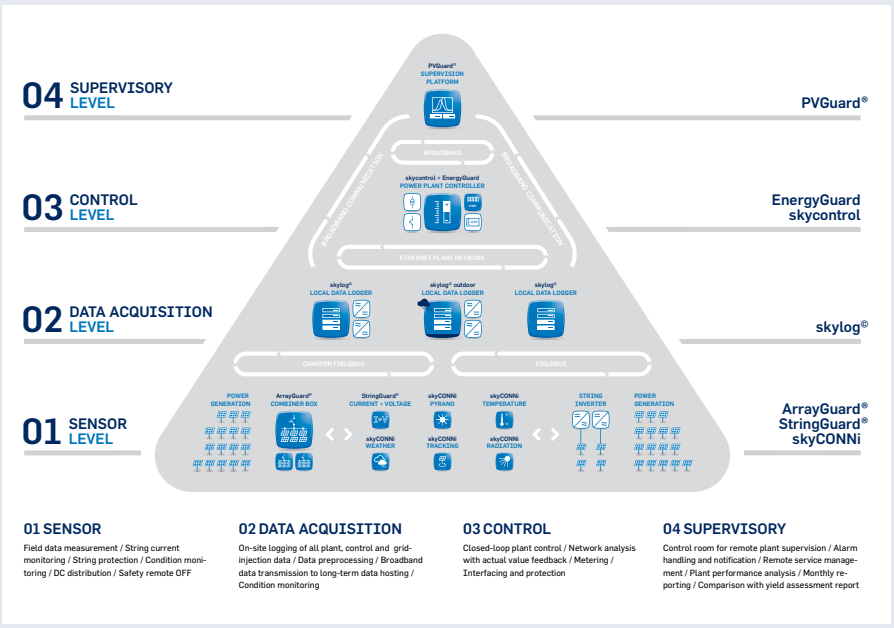
Sinosol assumes all responsibilities required for plant construction. When outsourcing services, Sinosol carefully selects suppliers and subcontractors who help to ensure the best project quality possible.

Operational management

Solar power systems have a service lifespan of several decades. Sinosol offers professional technical and commercial support throughout the entire service life and ensures that projects are successfully managed.

Sinosol's activities include selling PV system components and complete systems to resellers, such as photovoltaic wholesalers, project developers, procurement organizations and utility companies, which are tailored to customers' demands. We round off our sales support with training courses, technical, planning and design support, as well as all services related to logistics and product management.

Continuity since 1977 – 35 Years of Pioneering Spirit



skytron's solution for utility-scale photovoltaic installations (top right)
Easy, mobile access to your PV power plant – professional monitoring directly on your iPhone by skytron® energy (top left)
Industrial PCs – inverter-specific software installation on our skylog® data loggers (bottom)

Monitoring, control and supervision of photovoltaic power plants – secure your investment and optimize your profit with skytron's monitoring solutions

Pioneering spirit, continuity and long-standing experience, all combined with our vision for trendsetting power plant technology – this is our motivating force, and is driving the development of our integrated monitoring and control system for photovoltaic power plants.

With a total capacity of more than 2 GWp installed to date all over the world in utility-scale solar installations, skytron's monitoring solution meets the criteria for grid stability and security. It ensures dynamic adjustment of the feed-in power in response to the grid operator's demands.

From string current monitoring in the generator field to supervisory control room services allowing remote supervision of photovoltaic installations – skytron's monitoring solutions are independent of the inverter and energy meter technology used.

Our innovations are your benefit:

- integrated monitoring – independent of the inverter and energy meter technology used
- high-precision PV string current measurement
- sensorics for ambient condition measurement
- intelligent DC combiner boxes
- real-time high-resolution data logging
- multi-site multi-vendor SCADA
- closed-loop control of active and reactive power for grid stability
- life-cycle long-term plant data management and analysis
- control room facilities
- complete life-cycle O&M

Today, skytron® energy employs more than 65 people, some of whom have been with us since the company was founded. Headquartered in Berlin Adlershof, Germany's largest science and technology park, skytron® energy has been devoted to the sustainable use of solar energy since the 70s – so for 35 years now – always with one eye on the aspects of operating efficiency and profitability. By mid 2012, skytron® energy shall be operating three manufacturing facilities on three continents – Europe, Africa and Asia. It's not without reason that we pride ourselves on being "pioneers of energy".

skytron® energy GmbH
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info@skytron-energy.com
www.skytron-energy.com
Founded: 1977

SMA Solar Technology AG

SMA Solar Technology – Energy that Changes

Large-scale PV plants worldwide are equipped with SMA central inverters.

Sunny Central inverter production at SMA

SMA expertise around the globe

SMA Solar Technology AG
Sonnenallee 1
34266 Niestetal
Germany
Phone: +49 (0)561 9522-0
Fax: 49 (0)561 9522-100
info@SMA.de
www.SMA.de

Founded: 1981
Turnover: 1.7 billion euros
> 5,300 employees

Solar inverters for any module type and any power class: The global market and technology leader SMA offers worldwide service and top-class products for all types of PV installation, including comprehensive system solutions for PV power plants.

More than 30 years of experience and utility-scale projects in over 30 countries are evidence of SMA's outstanding PV-system expertise. SMA's expertise around the globe is impressively ensured by its 19 subsidiaries and 85 service-stations on four continents. Large-scale plants, such as the 85 MWp Montalto di Castro Solar Park in Italy, a 260 MWp project in California and several projects in the three-digit MWp-range, benefit from SMA's experience.

In the power plant solutions business area, SMA has developed an integrated approach to supporting customers and partners in the implementation of utility-scale PV plants. SMA Utility Grade combines advanced inverter solutions with a wide range of flexible system technologies and services for PV power station projects.

Similar to turnkey PV power stations equipped with Sunny Central HE inverters, the outdoor devices in the CP series are extremely efficient. With an efficiency of over 98%, the Sunny Central 800CP is the most powerful device in its class. Thanks to their weatherproof and lightweight enclosures, investing in concrete stations is no longer necessary. As numerous stress tests show, the Sunny Central devices in the CP series are highly durable even in extreme weather conditions.

The three-phase Sunny Tripower provides outstanding system technology for large-scale decentralized plant concepts. Benefitting from an efficiency of up to 99%, the user also profits from five technological innovations, which make the Tripower even easier and safer to use while also reducing system costs.

As the pioneer in grid management, SMA delivers tailor-made solutions for increasingly demanding power plant configurations worldwide while also ensuring the stability of the utility grids and maintaining compliance with the requirements of local grid operators.

Creating the Most Economical, Environmentally-Friendly Solar Energy Solutions on Earth

The Kunitomi Plant, the world's largest CIS manufacturing facility

1.2 MW installation in Coalinga, California

1 MW system in Niigata, Japan's 1st commercial solar power plant

Solar Frontier K.K. is the world's largest and, in 2011, was the fastest growing manufacturer of CIS thin-film photovoltaic (PV) modules. We are leading the commercialization of revolutionary CIS PV to help the world achieve a sustainable energy portfolio.

In 2011, we brought online the largest CIS manufacturing plant in the world, raising Solar Frontier's annual production capacity to gigawatt-scale across three factories in Miyazaki, Southern Japan. We are headquartered in Tokyo, have over 1,500 employees and staff, and operate regional offices in Germany, Saudi Arabia and the USA.

Combining world-record efficiencies, uncompromising engineering standards, and excellent bankability, we offer our customers more kilowatt-hours, reliability, and environmental peace of mind. To date, we have supplied over 500 MW of our CIS modules across a wide range of sectors and locations, ranging from residential rooftop installations in Japan to utility power plants in countries such as France, Germany, India, Thailand, Saudi Arabia and the USA.

Solar Frontier is a wholly-owned subsidiary of Showa Shell Sekiyu K.K. (TYO: 5002), which is listed on the Tokyo Stock Exchange. Showa Shell Sekiyu has over 100 years of experience operating in the energy sector and is based in Tokyo. As part of its medium-term strategy, solar energy is the company's second core business, along with petroleum products. Solar Frontier leverages over 30 years of leadership in solar R&D and over 100 years of energy expertise derived from our parent company, Showa Shell Sekiyu. Spurred on by the oil crises of the 1970s, we began developing solar technologies in collaboration with the Japanese government and academia, and early industry leaders such as Arco Solar. In 1993, we identified CIS as having the greatest potential of any PV technology. We ramped up our first plant in 2007, followed two years later by our second plant. By July 2011, we had achieved full commercial operation of the world's first gigawatt-scale CIS production facility – also Japan's largest PV production plant – just 21 months after commencing construction.

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Japan
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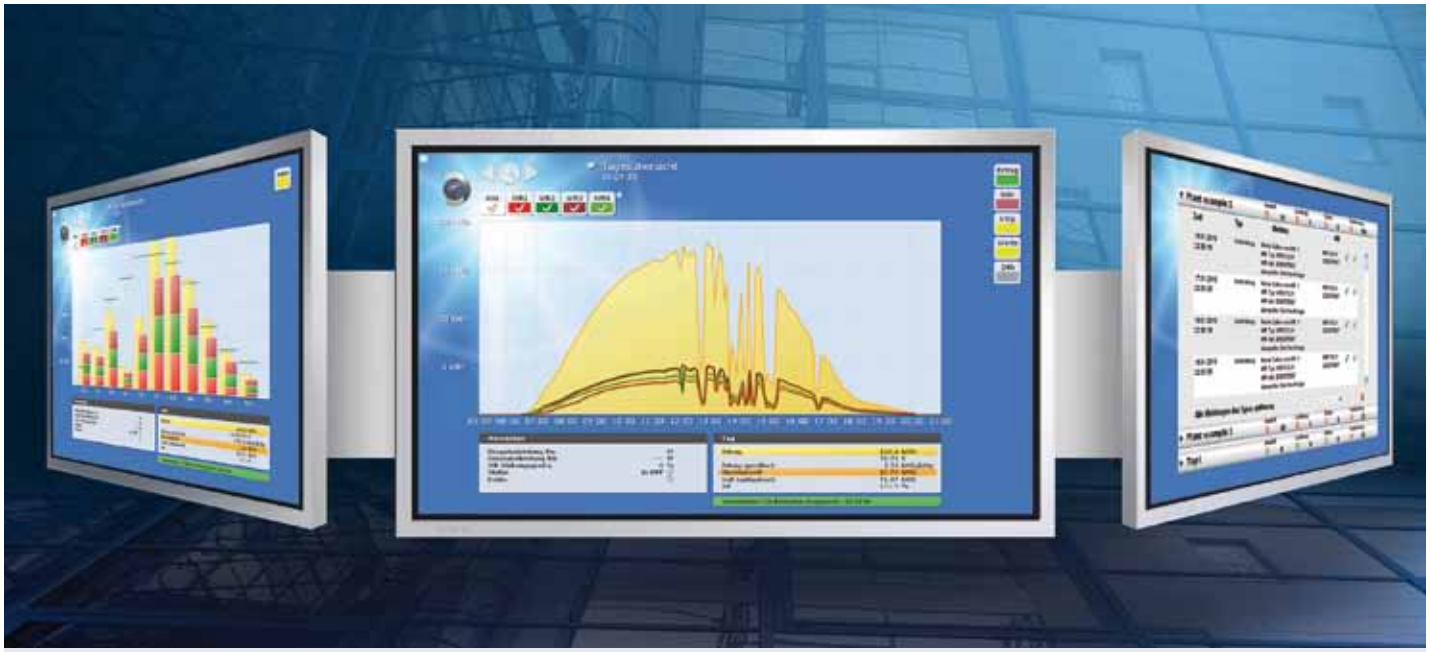
www.solar-frontier.com
Founded: 2010
>1,500 employees

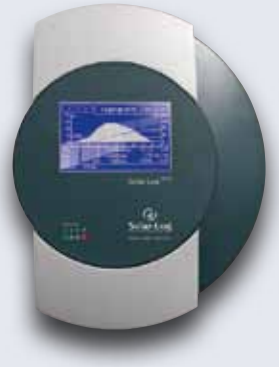
Solare Datensysteme GmbH

Solar-Log™
by Solare Datensysteme GmbH
MAXIMIZED SUNPOWER

Everything You Need to Monitor Your Photovoltaic Plant



For the best possible overview of your PV system – at any time



Solar-Log¹⁰⁰⁰

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Phone: +49 (0)7428 9418-200
Fax: +49 (0)7428 9418-280
info@solar-log.com
www.solar-log.com
Founded: 2005
60 employees

Solar-Log™ represents PV plant monitoring and management. The Solar-Log™ monitoring system, manufactured by Solare Datensysteme GmbH, has been on the market since 2005. As market leader we monitor more plants than any other monitoring organization.

The products we have developed at Solare Datensysteme GmbH are highly user-friendly, requiring zero software installation. Our products scale from small residential up through large commercial applications. Solar-Log™ is compatible with most major inverter manufacturers on the market. With our new "Easy Installation" firmware we have automated the inverter detection process as well as the Solar-Log™ WEB (if used) provisioning process.

In addition to monitoring and efficiency control, users have the capability to analyze their data either on site or via the internet. This is accomplished by means of attractive graphical data representations, as well as informative data tables. Control your PV system at any time, wherever you are in the world, using Solar-Log™ APP for iPhone and iPad.

Besides cable connectivity, Solar-Log™ also offers wireless connectivity using GPRS, WLAN and Bluetooth. Solar-Log™ even offers a solution for monitoring, controlling and optimizing one's own solar power consumption as well as powermanagement and cos ϕ control.

Solar-Log™ is just as suitable for plants with one inverter as it is for large plants with central inverters and complies fully with technical regulations. For the monitoring of individual strings in very large plants, we now also have a high-quality string connector box in our product portfolio.

Solar-Log™ WEB Commercial Edition web portal offers installers a comprehensive plant maintenance portal. The ability to carry out remote configuration and maintenance can save work from having to be performed on-site. Error messages are clearly displayed in an overview screen and can be processed using the integrated ticket system and error analysis tool.

Solare Datensysteme GmbH offers inverter and solar panel manufacturers the unique opportunity to collaborate on a well-engineered and specially adapted OEM solution without investing any development costs of their own.

Swiss Quality by Sputnik Engineering

Swiss quality with high efficiency: SolarMax inverters set standards in terms of quality, reliability, and maximum yields.

With its SolarMax brand, Sputnik Engineering AG has focused on solar energy since 1991 and has been a pioneer in the industry ever since. Founded in the Swiss town of Biel, the company develops, produces and sells grid-connected inverters for every solar system.

High-quality products made in Switzerland have enabled SolarMax to grow from a start-up into one of Europe's leading inverter manufacturers in an astonishingly short space of time. At present, the company has some 360 employees at its Swiss headquarters and at locations in Germany, Spain, Italy, France, China, Belgium, Great Britain, Greece, Bulgaria and the Czech Republic.

Thanks to technical know-how, broadly supported knowledge, and more than 20 years of experience in developing inverters SolarMax is able to produce high-quality products. SolarMax inverters are among the industry's best, offering high efficiency, an intelligent cooling concept, an attractive, easily-mounted casing and a user-friendly graphics display. SolarMax has the right inverter for every application – from photovoltaic systems on single-family homes whose kilowatt output is modest, to the solar power plants whose output is measured in megawatts. Furthermore, the product family comprises a series of communication and monitoring solutions, as well as software tools developed for specific assignments. All inverters are extremely robust and absolutely reliable – and at a convincing price/performance ratio.

Each individual SolarMax inverter manufactured in Biel is put to the acid test upon completion, with a full load test of several hours, amongst others. This way, we are able to guarantee that each device meets the requirements for Swiss quality work. Extendable service agreements ensure ideal planning security of up to 25 years. This way we offer our customers quality and safety at the same time.

Sputnik Engineering AG
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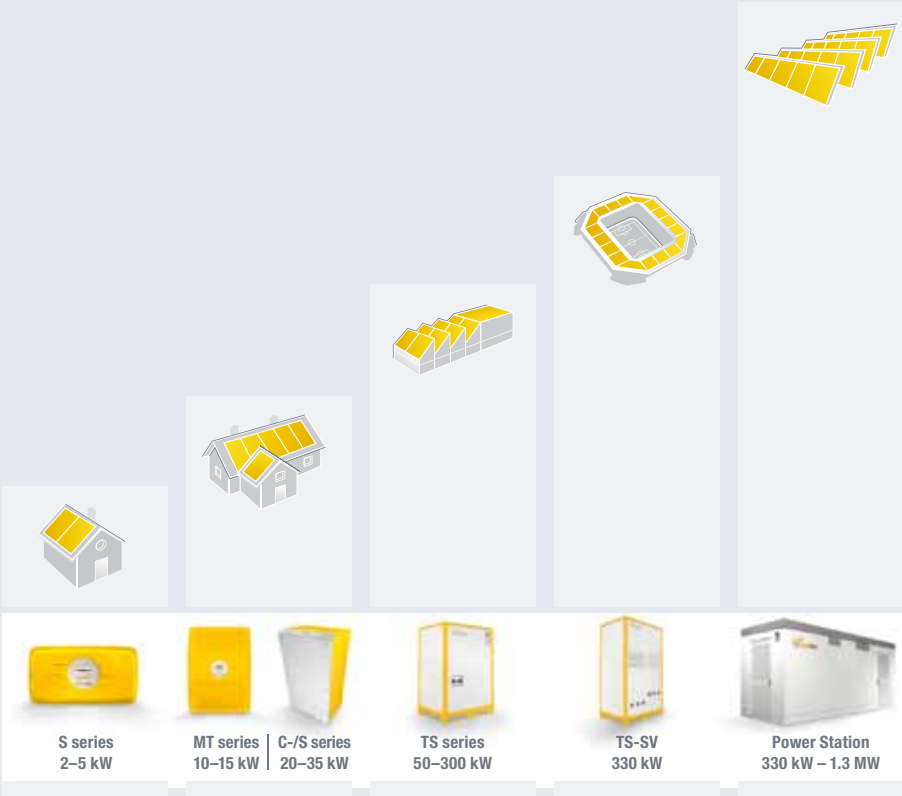
2502 Biel/Bienne
Switzerland
Phone: +41 32 346 56 00
Fax: +41 32 346 56 09
info@solarmax.com
www.solarmax.com
Founded: 1991
360 employees (2011)

Coping with enormous challenges: The highest grid-connected solar power station in Europe on the Jungfraujoch in Switzerland runs with SolarMax inverters.

Highly qualified technicians are on hand to advise SolarMax customers on the phone.

Service at its very best

SolarMax customers who call the technical help line obtain advice from highly qualified technicians. The service team finds and eliminates errors by remote diagnosis or by sending a technician to the site. Retailers, wholesalers, electricians and operators of solar plants benefit from courses and training sessions designed by SolarMax for their own products and provided either at the company's headquarters, at one of its branches, or directly at the customer's premises. The SolarMax experts are always available for their customers with advice and support. All requests are answered rapidly, frankly and directly, because SolarMax believes in solid customer service and long-term customer relations.



SolarMax offers system solutions for all requirements.

Environmentally-Friendly Solar Electricity for Over 20 Years

Blended into the landscape: solar power plant in the Czech Republic, 680 kWp

Also reliable in salty sea air: solar power plant in Greece, 100 kWp

SOLARWATT:
The highly automated production process at the Dresden plant allows the manufacture of high-quality products made in Germany.

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www.solarwatt.de
Founded: 1993
470 employees

With its expertise in manufacturing Germany-made premium products, Dresden-based SOLARWATT AG is one of the most innovative suppliers of photovoltaic systems and a leading producer of high-grade crystalline solar modules for an extensive range of applications. This German company also develops and markets intelligent energy management systems to provide efficient control and optimum utilization of solar electricity. A further business field encompasses the planning and building of turnkey PV systems and solar power plants.

Solar power plants: open surfaces for environmentally-sound solar electricity

As a project developer, SOLARWATT is able to look back on more than 20 years of experience in photovoltaics and has already successfully implemented a large number of projects throughout Europe. As a general contractor, the company constructs turnkey power plants for investors and energy suppliers, starting with planning and design, and continuing right through to initial operation. Once plants are successfully connected to the grid, SOLARWATT offers an expert maintenance service, thus ensuring that solar power plants reliably supply environmentally-friendly solar electricity for the long-term.

Award-winning – commitment to a sustainable future

SOLARWATT has a European-wide sales network, which it is expanding on a continuous basis. Independent studies certify that the company also achieves excellent customer satisfaction with regard to its products, solar module quality, customer guidance and service.* This German premium manufacturer has also received the *Top Brand PV* seal, which attests to the module manufacturer's brand management and brand awareness. "Excellent product quality and exceptional customer focus are the central point of our business strategy," affirms Detlef Neuhaus, Head of Sales and Marketing at SOLARWATT AG. "It enables us to create an impressive premium range of customized photovoltaic solutions for our customers and long-term partners."

Further information: www.solarwatt.de

* Source: a representative customer survey conducted by the market research institute EuPD Research

SolarWorld AG

We turn sunlight into power.

State-Of-The-Art Technology You Can Trust

Solar plant in Biederbach/Germany (left)
SunPark® in Cincinnati/USA (top right)
Roof-top installation in Orlando/USA (bottom right)

The SolarWorld AG Group is a leading provider of quality solar power technology. We have the entire value chain covered, from manufacturing crystalline solar modules to providing PV systems. Our core business is the manufacture of crystalline solar modules and providing PV system solutions, which are sold through our strong distribution network.

SolarWorld delivers real solutions

At SolarWorld, we make the most of available space to generate clean energy. Our range of turnkey solutions includes everything from sophisticated rooftop installations to utility scale, ground-mounted PV systems. SolarWorld's superior quality design ensures the highest energy yields and performance.

You can be sure to achieve the best possible return, no matter whether you invest in SolarWorld modules, balance of plant, turnkey solutions or our full EPC service. With our expertly installed high-performance modules, you will enjoy exceptional yields and returns.

We also provide customized mounting structures for all kinds of solar applications, using high-quality core materials such as aluminum and stainless steel to guarantee maximum stability and a long service life. Let us help you design your ideal solution.

Powering the future

By placing your trust in SolarWorld, you are forming a partnership with an experienced and well-respected company, thereby laying a solid foundation for your investment. We will draft a detailed site plan and shading analysis for your project to calculate your potential yield. Sunny prospects are guaranteed for operators and investors alike, thanks to our professional system design services, which are essential for determining a system's cost-effectiveness and operational reliability. And our sales representatives and certified specialist partners will ensure you enjoy one of the best customer support services that Germany has to offer. SolarWorld is also active across the globe, with locations in France, Spain, the USA, Africa and Asia. Because after all, high-performance solar technology always pays off, no matter where you are in the world.

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service@solarworld-global.com
www.solarworld.com

Founded: 1988
Approx. 3,300 employees (worldwide)

PV Inverters, Built for the Real World

Solectria's Megawatt Solar Stations (MSS) provide the highest quality inverters for direct to medium voltage solutions.

6 MW solar system in New Jersey using 12 SGI 500 utility-scale inverters

Our utility-scale inverter solutions power the largest installations in the USA.

Solectria Renewables, LLC
360 Merrimack Street, Bldg 9
Lawrence, MA 01843
USA
Phone: +1 978 683-9700
Fax: +1 978 683-9702
inverters@solren.com
www.solren.com
Founded: 2005
150 employees

Solectria Renewables, LLC is a leading US-based grid-tied PV inverter manufacturer. We offer residential, commercial and utility-scale inverters, as well as string combiners and web-based monitoring.

The story behind the company

Solectria Renewables' inverter technology is backed by over 20 years of experience

- 1989 – Solectria Corporation was founded as an electric vehicle company
- 2005 – Solectria Renewables emerged to solely focus on the development of grid-tied PV inverters

Our product line at a glance

- Megawatt Solar Stations
  contain 1–4 SGI inverters
- smart grid inverters
  from SGI 225 kW–500 kW
- commercial inverters
  from PVI 10 kW–95kW
- string inverters
  from PVI 1800 kW–PVI 7500 kW
- string combiners
  DC disconnect and other options
- web-based monitoring

Reliability and quality

Our inverters are reliable and have up to 98% efficiency. In an industry comparison of our utility-scale solutions, Solectria ranks higher than any other inverter manufacturer in electrical, mechanical and option categories and can be installed outdoors. Commercial and utility-scale inverters are manufactured in the USA. They are ARRA compliant, Ontario FIT compliant and are listed to UL 1741/ IEEE 1547.

Complete peace of mind

All inverters come with a standard 5- or 10-year warranty that can be extended out to 20 years. Our customer service department can be notified through our optional monitoring program if an inverter ever needs attention.

Sopray Energy Co., Ltd

Sopray – Helping You Create a Better Life

2.42 MW solar park in Bulgaria (top left)
1.3 MW solar park in Valencia, Spain (top right)
Each solar cell will be tested (bottom right).

Sopray Energy Co., Ltd, founded in 2007 in Taizhou, China, is a vertically integrated manufacturer of photovoltaic modules.

In 2010 Sopray built a new, fully integrated photovoltaic industry park on more than 600 acres in Shanghai, and successfully created a leading business which includes R&D, solar cell and module manufacture and the development of photovoltaic power systems, providing systematic solar solutions to customers all over the world.

Together with its production line in Taizhou, Sopray expects to reach an annual output of 3,000 tons of solar ingots, 500 MW of silicon wafers and 1,000 MW of solar cells and modules by 2015. Sopray's current annual manufacturing capacity is 600 MW of solar cells and 500 MW of modules.

Sopray's strict quality control ensures stable product quality, reduces light-induced degradation and guarantees the long service life of the products.
Sopray uses first-class testing equipment and adapts it to international quality control standards for testing everything from raw materials to finished products, for example minority carrier lifetime testers, high-magnification microscopes, laser ellipsometers, BERGER flash-testers, etc.

Sopray modules have convinced clients across the globe of their high quality due to their excellent mechanical, electrical and chemical characteristics as well as their exceptional weather resistance.
In addition to IEC 61215, IEC 61730, CE, UL, MCS and JET standards, Sopray also passed the salt mist corrosion testing on photovoltaic modules by TÜV Rheinland and obtained the corresponding IEC 61701 certification. Sopray sells its products to Germany, Italy, Spain, the USA, Greece, Australia and emerging markets such as Eastern Europe, South America and South Africa, as well as over 30 other countries and regions.

Local customer service and technical support

For prompt and efficient service, **Sopray Solar Europa** in Frankfurt runs the sales and customer service in Europe and assists clients with warehousing and professional technical support. Outside Europe, Sopray has sales networks in the USA, Hong Kong and Japan, among other countries.

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www.sopraysolar.com

Sopray Solar Europa GmbH
An der Welle 4
60322 Frankfurt am Main
Phone: +49 (0)69 75937955
Soprayeuropa@gmail.com
jjsopray@gmail.com

Founded: 2007
Turnover: 250 million euros
Approx. 1,500 employees

TÜVRheinland®
Precisely Right.

Your Partner for Quality Assurance, Due Diligence, Bankability Services, Yield Optimization and Certification of Photovoltaic Power Plants

TUVdotCOM service for qualified PV power plants (basis for the evaluation of bankability)

The range of services offered by TÜV Rheinland to investors, system manufacturers and operators includes site evaluation and system inspection services, as well as long-term monitoring services which aim to certify and confirm PV plant quality by means of a test mark. Its expert reports are required by banks, financial investors and insurance agencies as the basis for the evaluation of bankability, which is required for project funding and for the purpose of risk minimization.

TÜV Rheinland has over 25 years of experience to look back on, not only in the field of plant certification. As the global market leader for PV module certification, running seven laboratories in Europe, Asia, and the USA, TÜV Rheinland has the necessary expertise and capacity to test and certify PV modules and other components.

Every successful project relies on an optimized expert report on energy yield, based on a site evaluation. Taking into consideration long-term irradiation data, selected plant configurations and further specifications, yield forecasts are compiled using simulation programs and shadowing analysis.

TÜV Rheinland assists clients with tendering procedures and evaluates offers before the plant's planning and construction phases. Construction supervision measures enable the prevention of failures and defects at an early stage to improve safety and service lifetimes of the PV systems.

Acceptance testing of the plant examines conformity with the guaranteed electrical and mechanical characteristics. One important aspect is operator and system safety. The evaluation and assessment of PV system performance is realized through on-site monitoring combined with the laboratory testing of carefully selected, random samples of solar modules. TÜV Rheinland also has suitable concepts for system monitoring, performance checks and evaluation in order to facilitate complete and consistent yield documentation. All measures are carried out on the basis of a catalog of criteria and lead to the issuing of a certificate and the test mark TUVdotCom.

Over many years working in the PV power plant sector, TÜV Rheinland has performed acceptance tests on plants up to a size of 70 MWp and has gained a multitude of references.

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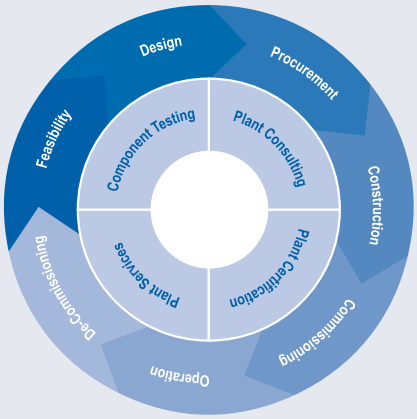
energie@de.tuv.com
www.tuv.com
Founded: 1999
160 employees

TÜV SÜD

TÜV SÜD. Ensuring Bankability – Optimizing PV Performance.
TÜV SÜD. Choose certainty. Add value.

We ensure bankability of projects and optimized performance.
TÜV SÜD offers fully customized and integrated solutions along the entire value chain.
The TÜV SÜD Certification Mark – synonymous with quality and safety – delivering confidence worldwide



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pv@tuev-sued.com
www.tuv-sud.com/pv
17,000 employees

TÜV SÜD was established in Germany more than 145 years ago with the aim of protecting people, the environment and property against the possible adverse effects of technology. Today, the company provides testing, certification, inspection, consulting and training services to a myriad of industries. Our world class expertise allows us to help our business partners to manage risk and deliver confidence to end consumers via a network of 17,000 employees located across 600 locations worldwide.

Clients can rely on TÜV SÜD's multi-disciplinary approach and complete solutions, which cover the whole value chain from the manufacturing of modules and components through the investment process to the operation phase and decommissioning. TÜV SÜD provides clients with in-depth knowledge and experience to help them manage risk, thereby assuring clients that their business operations will run at optimized performance and maximum efficiency, without compromising safety and quality.

TÜV SÜD provides a range of inspection and certification services for PV investors, importers and installers, who can rest assured that products with TÜV SÜD Certification Marks adhere to EU and US safety and performance requirements.

Our experienced inspectors monitor and examine the supply chain of components during pre-shipment and post-shipment inspections. They evaluate the bankability of both the products and the proposed facilities. Aspects of our inspection services may include initial site assessment, feasibility studies, energy yield evaluation, technical due diligence, construction and financial monitoring, monitoring of the yearly energy production and performance ratio evaluation, and diagnostics of malfunctions. Investors can depend on our expert opinion with regards to the reliability and feasibility of design and network compatibility. TÜV SÜD experts also advise clients on complex engineering solutions for integrating PV elements into buildings (BIPV). Additionally, TÜV SÜD is able to support clients with training and management system certification services.

Turnkey Solar Power Plants: Experience Provides Security

Cavarzere, Italy: capacity 2.7 MWp, built in 2011 (right)
Cavarzere: 11,664 polycrystalline modules installed on an area of 5.4 ha (top left)
Directors Division PV Power Plants: Frank Börsig and Patrick Metzger (bottom left)

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wuerth-solar@we-online.de
www.wuerth-solar.com

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Phone: +49 (0)761 12039-0
Fax: +49 (0)761 12039-6499
powerplants@we-online.de
www.wuerth-solar.com

PV Power Plants Division:
Founded: 2010
59 employees

Würth Solar PV Power Plants is an internationally active, full-service project contractor for photovoltaic power plants that benefits from over 25 years of experience, making it an excellent partner for PV investors.

The PV Power Plants Division of Würth Solar provides services for all aspects of PV power plant projects, from planning to handing over turnkey plants. Based on a differentiated consultation procedure, the project team will perform feasibility studies, organize construction of the installation and provide monitoring, maintenance and insurance for the PV plant as needed from its modular portfolio of services. Würth Solar PV Power Plants implements both free-standing projects and all common types of roof-mounted and facade installations.

The project experience gathered by Würth Solar PV Power Plants, in Germany and across the globe, ensures that large-scale PV installations are designed and implemented in accordance with the relevant national regulations in a manner that is precisely tailored to the requirements. In terms of financing, Würth Solar PV Power Plants can provide support in matters of regional remuneration legislation and will calculate the potential financial yield of the planned installation. In each venture, experienced project managers work together with local Würth Solar project teams. The high quality standards that characterize all phases of every project ensure both the reliable performance of the completed solar power plant and optimum yields, which have been repeatedly verified by measurements from independent institutes. Alongside its versatile mobile teams, Würth Solar PV Power Plants has established branches in Italy, Spain, France, Greece, Switzerland and the USA.

Roots of Würth Solar PV Power Plants

The PV Power Plants Division was established in 2010 as the result of a merger between the project divisions of Würth Solar and SolarMarkt AG. It brings together over 25 years of experience in developing and realizing PV projects with outputs of 0.5–20 MWp, within and outside Europe. In addition to project management, the company also has roots in developing PV components and in trading. To date, Würth Solar PV Power Plants has installed more than 100 MWp of PV capacity.

Publishers

SOLARPRAXIS
engineering | conferences | publishing

Engineering, Conferences and Publishing for Renewable Energies

Solarpraxis communicates expertise and practical knowledge to professionals.

The engineering department generates up-to-the-minute knowledge.

Solarpraxis' conferences are valued industry platforms.

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Founded: 1998
Turnover: 6,9 million euros
70 employees

The Berlin-based company has been providing clients with expertise and professional services in the fields of engineering, conference organization and publishing since 1998.

Engineering

Solarpraxis' engineering department generates up-to-the-minute knowledge and processes it for your customers using a targeted and project-orientated approach, operating in areas such as expert opinion reports, training, technical hotlines, technical documentation and planning for solar installations.

Conferences

The conferences of Solarpraxis AG are valued industry platforms, which offer decision-makers in the renewable energy industry opportunities for targeted networking and information exchange. They are well-established, close to the market and customer-oriented. Using a combination of specialist presentations and topical panel discussions, they present practical knowledge relating to market development, financing and policies. Industry representatives are given the opportunity to share ideas, to follow and discuss the latest developments, and to meet representatives from politics, the press and the financial world.

Publishing

Solarpraxis AG offers a wide range of trade magazines and industry guides dedicated to renewable energies, and addressing professionals in the manufacturing and installation sector.

The B2B magazines "photovoltaik" (German edition, with Alfons W. Gentner Verlag) and "pv magazine" (global and Chinese edition) publish monthly or quarterly technology-focused reporting that covers the latest trends and market developments in the field of photovoltaics.

In collaboration with various specialist organizations, Solarpraxis AG publishes multilingual industry guides for various sectors of the renewable energy industry. These provide companies with the opportunity to present their products and services. An editorial section sets out the essential facts and figures relating to each sector plus the latest technological and economic developments.

Sunbeam GmbH

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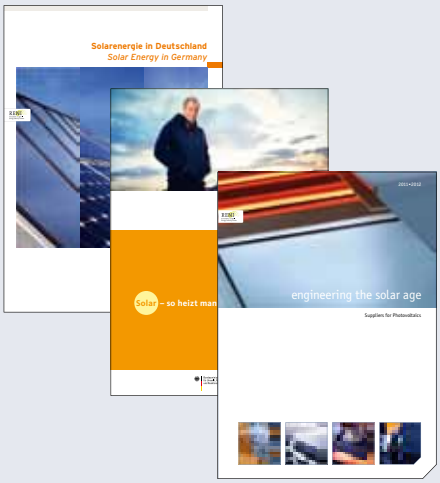
Communications for the European Renewable Energy Market



Sunbeam combines high-quality communication services with expertise in technologies and markets in the field of renewables.

As full-service partner we support you managing your cross-media communications.

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Founded: 1998
Turnover: 1.4 million euros
19 employees

Sunbeam offers technically oriented communication services perfectly tailored to the dynamic environment of the European renewable energy market.

Since 1998, Sunbeam has been providing in-depth market knowledge and excellent contacts with industry associations and the media. We offer our expertise in the following domain areas:

Communications

With over ten years of experience in renewable energy, Sunbeam has acquired expertise in all relevant technologies as well as an extensive media network in the field. The company has successfully conducted a variety of campaigns for governmental departments and offers a wide spectrum of services to corporate clients, ranging from PR concepts and consultancy to the complete management of all press contacts.

New media

Sunbeam is one of the leading German agencies for information-oriented, accessible websites. The agency has won a prestigious BIENE award and ranks top in relevant listings for the content management system TYPO3. Two team members are also the authors of renowned specialist books on the design and implementation of web presentations.

Design

Sunbeam values visual communications as a key success factor in the renewable energy market, and thus offers comprehensive expertise in presenting complex matters to technically oriented target groups. In our work for companies, associations and governmental departments we specialize in editorial design for periodical magazines, high quality brochures and extensive industry guides.

Added value

Sunbeam operates through all media channels connected to public relations, new media and design. Clients benefit from our experience both in the management of individual formats and the creation of integrated marketing solutions. Examples of this cross-media approach include our widely distributed press reports on solar, wind and bioenergy ("PresseTrend") and various services for print to web and/or social media publishing.

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Photovoltaics is becoming increasingly inexpensive. In contrast, the prices for electricity from conventional power plants are climbing. This is making the solar farm market segment progressively more lucrative for financially strong investors. Photovoltaics offers a profitable, long-term investment with comparatively low risk.

"PV Power Plants" is the first industry guide to focus exclusively on utility-scale solar power plants, and is aimed at system integrators, distributors, project developers, top planners and investors. Besides corporate portraits, it includes an overview of international market conditions and developments in technology, and depicts crucial issues related to planning and financing.

www.pv-power-plants.com

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