The Jännersdorf Solar Park in Brandenburg (Prignitz), which boasts a capacity of 40.5 MW, was completed in June 2012 and put into operation in accordance with the German Renewable Energy Sources Act (EEG).

Photo: Tom Baerwald/Parabel AG

Central inverters in a large-scale PV installation

Photo: Regine Baerker/shotshop.com
Dear Readers,

If a British company in the automotive industry builds a five Megawatt (MW) solar plant on its factory roofs in the North West of England, as happened recently, a large amount of solar power no longer flows into the grid. The plant capacity covers up to 40 percent of the company’s energy needs. This way, that 40 percent can be used at a stable price regardless of market prices for electricity because it is produced and consumed on site.

Another example of how energy-intensive companies are now turning to the on-site production of solar power in the megawatt range to, at least in part, meet their energy needs. However, what happens if the electricity is to be consumed on site and several megawatts of power are to be integrated into the public grid as usual? After all, the continued success of renewable energy increases the risk of overloading the power grid because sun and wind provide fluctuating energy that does not follow consumption.

Storage systems are the solution. They are both an opportunity and a necessity. On one hand, they allow for a time gap between power production and consumption (which of course is also good for direct consumption); on the other hand, the energy revolution can only be successful if renewable energy storage systems can ease the burden on the public power grid in the long term.

However, large-scale storage for PV plants is not yet competitive, with the exception of pumped storage. Specific geographical conditions are needed for pumped storage, which can therefore only be implemented in a limited number of places and, even then, this significantly impacts the environment – decentralization is a different matter.

Although the technological tug of war has only just begun and it remains to be seen if we will combine mechanical, electrochemical or electrical storage with large-scale PV plants in the future, storage systems will no doubt transform the centralized grid structure into a decentralized one. Together with an intelligent energy management system, they pave the way for large-scale grid integration of photovoltaic power. Technology that is used in various applications from load balancing to cloud mitigation will play an important role in the near future. The inverter will become a flexible interface which takes over associated system management tasks.

Experts are still engaged in a zealous debate when it comes to weighing up the costs and benefits of storage technologies. Most concepts for large-scale PV plants have not yet emerged from the experimental stage. Small, privately-owned PV systems will be the first to see storage take hold, in favor of increased direct consumption. A look at current projects shows that storage for large-scale plants is still a marginal topic and a major challenge. That said, the industry is already waiting in the wings – and photovoltaics will once again prove how it is driving the energy revolution forward thanks to its innovative force.

Best regards,

Karl-Heinz Remmers

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Dear Readers,

PV is no longer a niche technology. It is rapidly becoming an important contributor to Europe’s power system. As large-scale PV plants provide an ever-increasing share of the continent’s electricity, stakeholders and policymakers need to consider some new challenges, including how to integrate variable electricity production into the grid.

While there is no denying that the PV industry has been navigating difficult waters over the past year or two, it is also true that the technology is holding steady on its course for competitiveness against other sources of electricity. The world’s cumulative PV capacity surpassed an astounding 100 gigawatts (GW) in 2012 – a landmark few would have thought possible even five years ago. And in 2012, more than 30 GW of PV capacity were installed globally, nearly the same as in the record-setting year of 2011. In some regions (e.g. Germany, Italy) there is already today a high penetration of PV in the distribution grid. The associated challenges can be solved by providing grid services from the PV systems and sound adaptation of the future smart grid.

But as the saying goes: With great power comes great responsibility. The increasing share of PV electricity in Europe’s power system is raising a series of important issues – mainly stemming from the variable nature of PV electricity generation. However, as shown in the recent EPJLA report, “Connecting the Sun: Solar photovoltaics on the road to large-scale grid integration”, PV is already providing solutions to these challenges.

Without a doubt, large-scale PV plants remain an important driver of the technology’s evolution into a mature and mainstream energy source. But it’s clear the market is changing in important ways. Europe’s dominance of PV in all segments is giving way to a more balanced – and, ultimately, sustainable – market with different regions around the world driving different segments.

Going forward, the utility-scale segment is expected to decline or at best stagnate in Europe as it booms in the Americas and Asia including China and Japan. Under almost any scenario for the coming five years, the Asia-Pacific region should see the largest share of new utility-scale applications.

But the fact that the market for big PV power plants is changing does not diminish the importance of its role in meeting Europe’s ambitious energy and environmental goals. PV can, together with wind, help provide up to 45 percent or Europe’s electricity needs in 2050. With the right policies in place, even the utility-scale segment can grow in Europe over the medium to long term, especially in southern Europe.

People want solar power: Even the technology’s harshest critics in the conventional energy sectors will ultimately have to agree that under all scenarios envisioned in the coming decades, solar PV will be a major part of Europe’s (and the world’s) electricity mix – with electricity gaining an increasing share in the global future secondary energy.

Best regards,

Dr. Winfried Hoffmann
While ground-mounted photovoltaic systems have to date predominantly generated medium-scale outputs of between 200 and 1000 kilowatts (kW) and more than the previous year (2011: 2,620 MW), the power plant plays an important role in supplying the wider Berlin area with electricity.

Annual installations 
Cumulative installations

Evolution of PV capacity (annual and cumulative) in MW

Ground-mounted photovoltaic power plant in Templin (Germany):

Module prices are expected to stabilize during the course of 2013 as a result of existing overcapacities disappearing from the market. The price of other important components, such as inverters and substructures, is also falling, a development that is fueling the worldwide boom in large-scale solar power plants and small roof-mounted systems alike. On the other hand, the fuel costs of conventional power plants are increasing, causing power generation costs to rise with them. This is making the solar park market segment progressively more lucrative for financially strong investors – even in the face of tumbling feed-in tariffs.

Deciding factor economic viability

Project planning and management, installation and the operation of ever-larger PV power plants present new challenges to 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. The profitability of the installation plays a decisive role in terms of project financing. While the investor’s credit standing hardly comes into question at all, the project’s viability is not the only thing that counts, however: speed plays a big role, too. Power plants with large outputs of more than 100 MW and above can be planned and 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 order to cover the worldwide electricity demand of around 12,000 GW with photovoltaics and other renewable energy sources over the coming years, the annual amount of newly installed solar power plants must reach around 300 GW.

Speed matters

Size is not the only thing that counts, however – speed plays a big role, too. Power plants with large outputs of more than 100 MW and above can be planned and 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 order to cover the worldwide electricity demand of around 12,000 GW with photovoltaics and other renewable energy sources over the coming years, the annual amount of newly installed solar power plants must reach around 300 GW. However, the markets are still far from achieving this target. In Germany alone, solar generators with a capacity of around 200 gigawatt peak (GWp) are required to ensure that – when working in combination with wind energy, hydro-power and biomass – the power supply is fully covered by renewable sources.

The Lieberose Solar Park near Cottbus (Germany): Covering an area of 60,000 m², the current second largest solar park in the world boasts 30,000 thin-film modules and a capacity of 20 MW.
Generating solar power locally requires rethinking the existing centralized power grid so that it contains decentralized facilities. Grid connection, especially in terms of large-scale ground-mounted solar power plants, presents a particular challenge, since the dramatic expansion of photovoltaics is increasingly creating bottlenecks in the power grid. If solar power plants are to succeed in making substantial contributions to the power supply, they must also play a greater role in maintaining grid stability. Technological progress in power electronics has resulted in solar inverters being able to feed reactive power as well as real power into the grids, freeing up additional grid capacity and easing expenditure on new, expensive power lines. Solar inverters are able to stabilize the grid because when combined with batteries, they can substitute the inertia of the rotating masses in maintaining grid stability. Sections of the grid can be stabilized by means of inverters that are able to perform such a function from 2017.

Increasing attention is being paid to hybrid power plants, which generate both solar and wind power in close proximity to one another and are able to use the same grid feed-in point. 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 evenst 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. Taken together, solar parks and wind power plants only exceed the maximum grid capacity locally available to them during very short and rarely occurring periods of the year, meaning that very little, if anything at all, needs to be spent on grid expansion.

With the success of renewable energy increasing the risk of overloading the grids – due to sun and wind providing fluctuating energy that does not always follow patterns of consumption – storage systems can be used to relieve the pressure on the public power grid in the long term. It remains to be seen if mechanical, electrochemical or electrical energy storage will predominate in large-scale PV plants in the future. Coupled with an intelligent energy management system, storage systems will, in any case, ease the way for the large-scale integration of photovoltaic power into the grid. Inverters will serve as flexible interfaces, taking over associated system management tasks. Photovoltaic power plants also have been proven to be extraordinarily capable of withstanding natural disasters. As Superstorm Sandy hit the highly populated east coast of the USA, the area’s large-scale power plants lost their connection to the grid. However, while it took a considerable number of hours for the conventional large-scale power plants to be started up again, the solar parks on Long Island were immediately able to feed power into the grid once the storm had passed.

Rising demand

In the spring of 2012, the German government made drastic cuts to the feed-in tariff for large-scale power plants. From April 1, 2012, plants with outputs of between 1 and 10 MW received only 13 €uro cents per kWh. Meanwhile, the feed-in tariff (for newly installed plants) has continued to sink monthly, meaning that by the end of 2013 it will drop a great deal further. In contrast, 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 permanently 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” (capacity of a few kW) 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 in the MW range are described as “utility-scale” plants. They are subject to the regulations on power plant construction.

### Top 15 markets 2012 worldwide

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>2012 NEWLY CONNECTED CAPACITY (MW)</th>
<th>2012 CUMULATIVE INSTALLED CAPACITY (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Germany</td>
<td>7,014</td>
<td>32,411</td>
</tr>
<tr>
<td>2. China</td>
<td>5,000</td>
<td>8,100</td>
</tr>
<tr>
<td>3. Italy</td>
<td>3,438</td>
<td>16,305</td>
</tr>
<tr>
<td>4. USA</td>
<td>3,346</td>
<td>7,777</td>
</tr>
<tr>
<td>5. Japan</td>
<td>2,000</td>
<td>6,914</td>
</tr>
<tr>
<td>6. France</td>
<td>1,079</td>
<td>6,023</td>
</tr>
<tr>
<td>7. Australia</td>
<td>1,000</td>
<td>2,422</td>
</tr>
<tr>
<td>8. India</td>
<td>980</td>
<td>1,209</td>
</tr>
<tr>
<td>9. United Kingdom</td>
<td>912</td>
<td>1,829</td>
</tr>
<tr>
<td>10. Greece</td>
<td>912</td>
<td>1,559</td>
</tr>
<tr>
<td>11. Bulgaria</td>
<td>787</td>
<td>908</td>
</tr>
<tr>
<td>12. Belgium</td>
<td>399</td>
<td>2,650</td>
</tr>
<tr>
<td>13. Spain</td>
<td>276</td>
<td>5,166</td>
</tr>
<tr>
<td>14. Canada</td>
<td>258</td>
<td>780</td>
</tr>
<tr>
<td>15. Ukraine</td>
<td>182</td>
<td>319</td>
</tr>
</tbody>
</table>

### Global cumulative installed capacity share 2012 (MW)

- **Germany**: 32,411
- **Italy**: 16,301
- **China**: 8,100
- **Japan**: 6,914
- **Spain**: 5,166
- **France**: 4,000
- **Belgium**: 2,650
- **Australia**: 2,412
- **Czech Rep.**: 2,073
- **Rest of the World**: 12,544
The market’s most important driving forces are the falling system costs of photovoltaics and the increasing price of electricity generated using conventional technologies. While solar module prices could stabilize in 2013, system costs are more likely to change. EPIA estimates that the price of PV systems belonging to the utility-scale sector (≥ 2.5 MW) will fall by a quarter within the next ten years, from 1.22 euros per watt (W) in 2012 to 0.92 euros per W in 2022.

In 2012, 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 smaller roof-mounted installations, expansion in Asia, North America and other regions has almost exclusively stemmed from installations within the utility-scale sector.

According to figures from EPIA, 31.1 GW of new installations were added in 2012, with 17.2 GW in Europe. Europe’s share is declining. In 2011, 22.4 GW were installed on the continent (30.4 GW globally). Analysts at NPD Solarbuzz predict that emerging markets, such as China, North America and India, will also grow further in 2013. In 2012, they were responsible for around a third of new PV capacity installed worldwide.

Europe

In terms of global cumulative installed capacity, Europe still leads the way with 17.2 GW connected to the grid in 2012. This represents 55 percent of the world’s annual PV capacity. The European photovoltaics market is dominated by four countries: Italy, Germany, France and the United Kingdom. Together they accounted for 75 percent of the European market in 2012. The most important single market was Germany, which installed 76 GW of new capacity (75 GW in 2011).

A new set of rules governing feed-in tariffs have applied in Germany since April 1, 2012, lowering remuneration to 15.5 euro cents per kWh for ground-mounted solar installations with outputs of between 1 and 10 MW. Additionally, the feed-in tariff for new installations is falling further each month in line with the current rate at which new capacity is being installed, and plants with capacities greater than 10 MW no longer receive any remuneration whatsoever, with additional restrictions applying in the case of neighboring power plants, for example. It is therefore expected that in the future the construction of new solar power plants with MW-scale outputs in Germany shall exclusively follow the cost-effective investment model of directly marketing solar power currently in use in the USA.

It has been estimated that the German market shall reach a capacity of between 4 and 5 GW by the end of 2013. It remains uncertain as to what extent power plants in the MW range will contribute to the newly installed capacities over the years to come. In 2012, systems greater than 2.5 MW contributed around 40 percent of the annual installed capacity in Germany.

However, since PV systems with outputs of 10 MW and more are no longer supported by a feed-in tariff, this amount is likely to fall. In Italy, the fact that the money made available by the fifth Conto Energia was used up prematurely by the start of 2012 meant that the amount of new photovoltaic capacity installed in the country fell from 3.4 GW in 2011 to 2.4 GW in 2012. Here, political debates have prompted a drastic reduction in feed-in tariffs and in the middle of 2012, the government in Rome decided not to support any further ground-mounted solar parks.

In addition, all solar generators with outputs greater than 12 kW must be entered into a plant registry in the future. No restrictions are to be made on the installation of smaller systems. However, feed-in tariffs are being cut significantly: 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. The amount of new capacity installed is likely to amount to between 15 and 2 GW in 2013 and the years to follow.

According to figures from EPIA, France connected around 1.8 GW of solar power to the grid in 2012, more than 2011 with 1.1 GW. 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 and 2013 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.

The performance of the year in 2012 came from Great Britain, which installed 925 MW of new capacity (2011: 87 MW). 912 MW was newly constructed in Greece, owing to the fact that the country’s sunny
climate allows photovoltaics to act as an
to the price of PV components, have opened up
installed in the province of Cáceres by 2015,
will have a capacity of 100 MW which will be
Spain has completed stopped feed-in
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 up
this market segment, breathing new life
into the Spanish solar market (2012: 200 MW).
For example, a solar farm with an output of 250 MW, which is to be
installed in the island of Crete generates around 1.2 MW of clean
electricity each year.

The future course of development in
Poland is rather uncertain, as although the
government in Warsaw is working on a
law to promote renewable energy that
also intends to include a feed-in tariff for
solar power, this shall not be passed before the government’s 2013 summer
break. As a result of the weak grid,
connecting large-scale power plants is ex-
pected to prove particularly problematic.

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 US’s Purchase
Power agreements is paving the way
towards independence from government
subsidies. The first of Germany’s solar
power market sectors (in particular roof-
mounted systems) is expected to fall
below grid parity in 2013/2014. In Italy and
Spain, this milestone has already been
reached for ground-mounted photovoltaic
systems. However, large-scale photovoltaic
installations do not compete with the
electricity price paid by end customers
(private households and/or companies),
but rather with the market price of peak
load power.

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 700
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, In-
vestment Tax Credit (ITC) incentives of up
to 30 percent are anticipated.
However, these are set to fall to ten
percent by 2017. Some states launched
new incentive programs in 2012 to sup-
port the installation of small roof-mount-
ed installations, while the building of
large-scale solar power plants continues
to follow the regulations governing
power plant construction. The announce-
ment that the major American investor
Warren Buffett was purchasing two solar
power plants in California caused a stir in
the fall of 2012. The investment, which
amounted to around 2.5 billion US dollars
(1.8 billion euros), saw Buffett acquiring
the Antelope Valley Solar 1 and 2 power
plants in California. The two power
plants, which boast a cumulative capacity
of 573 MW, are expected to be connected to
the grid by the end of 2013.

The graphs illustrate the time
when grid parity is reached as a
function of the installation costs:
The placement of the federal
incentives is explained by their
levels of insolation and the (expected)
development of electricity prices
from 2010 to 2018.

Placement either on or to the right
of the graphs indicates when grid
parity will be reached, for example in
New Jersey. The installation costs of
US dollars per kW and an ITC of
ten percent will give grid parity in
2016– without SREC (Solar Renew-
able Energy Certificates or Credits).
SREC are awarded in some federal
states. They currently electricity pro-
ducers 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 reARRANT
their investment by selling SREC
on the market in addition to the
solar power they generate.
This creates investment incentives
that are similar to the CO₂ certificates
in the European Union.

Tax allowances, or ITC, represent
another approach. They allow
investors to claim part of the
investment for tax relief purposes
and offset it against their tax
liabilities. ITC 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 (when also the
region’s energy utility). The pric-
ing regime is usually fixed for a
period of 10 years and is based on
the supply contract, the PPA.

left: Spain: solar park in Viana With a capacity
of around 4 MW, the park is able to supply more
than 2,500 households with electricity.

Right: Thanks to the highest levels of insolation
throughout Greece, nine solar parks on the
island of Crete generate around 12 MW of clean
electricity each year.

Below Kenya, a city in the Central Anatolia
Region of Turkey, boasts the country’s first
grid-connected photovoltaic power plant. The system
generates around 300,000 kWh annually.
New solar parks are also being planned south of the border between the USA and Mexico with the aim of exporting solar power to the USA. Feed-in tariffs have either recently been launched or are due to be introduced in a few Caribbean countries. Puerto Rico, for example, intends to cover a third of its electricity demand with solar power by 2020.

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 by 20 percent. According to data from EPRI, around 268 MW of solar power were installed in Canada in 2012 (2011: 497 MW).

**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 approximately double the average level in the area between the North Sea and the Mediterranean Sea. The Saudi Arabian government has announced plans to cover a tenth of its energy requirements with solar energy by 2040 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 8 square kilometers. The first step is to construct a 10 MW photovoltaic power plant, which will be connected to the grid in 2019.

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 EPRI and Solarbuzz, the Chinese photovoltaic market grew by 5 GW in 2012, meaning that the solar power plant capacity in the Middle Kingdom more than doubled in one fell swoop. Since the beginning of 2012, Beijing will pay one renminbi per kWh solar power (approximately 11 euro cents). The Chinese aim to install around 5 GW of capacity every year until 2015. Large solar farms make up the majority of new photovoltaic installations in China. While merely a few demonstration projects were installed between 2009 and 2011, the Chinese market is now on the verge of enormous growth. The majority of utility-scale plants are being installed in Western China, Inner Mongolia and Tibet. Here, the solar power plants belong to the state and are regarded as infrastructure projects, which are constructed through calls for tender.

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 in 2012, but only 50 percent of it was connected to the grid in good time. Above all, there are not enough transformers for the 380 kilovolt (kV) transmission lines. In Tibet, the construction of a 220 kV line to connect additional solar power plants has been delayed.

India and Thailand

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. According to data from EPRI, the LCOE for solar power is between 14 and 16 euro cents, making it competitive in comparison to diesel power, particularly in light of the country enjoying around 300 days of sunshine every year. Especially in the western and southern parts of the sub-continent, insolation is very high and evenly spread. By the end of 2012, 1,206 MW of solar capacity had been installed, with around 1 GW newly installed capacity in 2012. The states of Gujarat, Rajasthan and Madhya Pradesh in particular put out large-scale power plants to tender.

The state of Jharkhand aims to install around 500 MW by 2017 and 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.
Japan, Malaysia and the Philippines

Following the nuclear reactor disaster in Fukushima, Japan has regained the world’s largest solar nations. In 2012 2 GW of new solar capacity were installed (2012: around 1.3 GW). 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. All of its 45 nuclear power stations are not connected to the grid anymore, production capacities of conventional systems there have reached their limit. In the Greater Tokyo Area, industrial companies must reduce their electricity demand by around 15 percent or are forced to generate the same amount using their own solar power.

New, lucrative feed-in tariffs have been in effect since July 2012 which are boosting the market. Small private plants, on the other hand, are no longer receiving any remuneration whatsoever because on-site consumption allows them to pay for themselves. Ten Japanese energy suppliers are planning to make considerable investments in utility-scale solar farms. Feed-in tariffs have 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. A feed-in tariff for solar power was introduced in Malaysia as early as at the end of 2011. Installations with outputs of more than 10 MW can expect to receive around 20 euro cents per kW. 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 kW 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 ongoing.

Meanwhile, Thailand aims to increase its solar capacity by approximately 500 MW by 2020 in order to achieve its target of covering 20 percent of its electricity requirements with solar power. This market is driven by PPA. The state puts power plants out to tender, fixing the purchase price of solar power at 19 euro cents per kWh for ten years, but in 2012, the price fell to 15.2 euro cents. By mid-2013, solar power plants with a total capacity of around 3.4 GW had been proposed in Thailand, but the grid is the major hindrance to progress here as well. The amount of newly installed capacity amounted to around 210 MW in 2012.

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 megawatt hour (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. According to figures from EPIA, capacity installed in 2012 alone amounted to 1 GW, a slight growth compared to 2011 (875 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 America have hardly got off the ground. In 2011 and 2012, Kenya and South Africa became the first African countries to install large plants. During the course of 2012, initial plans were drawn up to construct several solar power plants each with capacities greater than 70 MW. Thanks to its relatively well-developed infrastructure, stable financial system and advanced grid, South Africa has been awarded the accolade of being the sunny continent’s market leader. Here, the World Bank plays a considerable role in funding the power plants.

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 Chile and Brazil in particular. The sunny, dry plateaus of the Andes are particularly ideal for solar power plants. The first pilot power plant with an output of 1.4 MW, which supplies a nearby copper mine, was installed in northern Chile in 2012. In addition to providing millions of people in South America and Africa with power for the first time, photovoltaic power plants on these continents also make it possible to provide precious drinking water at a low cost, support communication networks and store vital medicine and food in air-conditioned storage areas.

State of play: May 2013

Having completed the first phase in just ten months, the power plant in La Huaya (Chile) aims to increase its 1.4 MW output to 90 MW by 2019.
Technology

Striving for increased efficiency

Crystalline modules (below) and thin-film modules (right): Owing to the relatively high efficiency of crystalline modules, a smaller installation area is needed per unit of output compared with thin-film modules.

Until just a few years ago, PV plants were chiefly built from components that were often only available in limited quantities and PV modules were lacking in particular. 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 kWh of solar electricity, which competes with that of other technologies. During the first stage of the market launch, the solar energy price per kWh must be lower than the feed-in tariff in order to ensure that the PV power plant is profitable. During the second stage of market penetration, it is sufficient for the price to be less than that of conventional power generated by coal-fired or nuclear power plants. 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 MW 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 14 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 “cast-mono” wafers achieve similarly high efficiencies to monocrystalline solar cells thanks to the particularly cheap polycrystalline silicon wafers employed.

Innovative processes, such as the string-ribbon process, may reduce manufacturing costs further. A thin ribbon of silicon is pulled from a melting crucible between two wires. This technique facilitates the production of ultra-thin wafers just 15 micrometers (μm) thick and eliminates the heavy material losses that ensue from sawing conventional silicon wafers, which are 180 μm thick. Tandem cells that combine crystalline wafers with amorphous silicon coatings achieve extremely high efficiencies with the wafers being exceptionally thin. Novel cells with selective emitters and rear-side contacts are only between 100 and 120 μm thick. Bifacial cells that are also able to absorb sunlight on the rear sides of modules and thereby boast yields of between 25 and 30 percent higher than comparable standard modules have also been on the market since 2012.

As thin-film modules are significantly less efficient than crystalline silicon modules, 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. The efficiency of research modules with fitted with cadmium telluride cells has now increased to more than 18 percent, while that of cells made from copper-indium gallium diselenide have risen to more than 17 percent. If these efficiency values are also attained in commercial modules, the fact that thin-film solar modules require a larger surface area will no longer have such a bearing.

Since it is now possible to manufacture thin-film solar modules in large numbers, the costs of doing so have plummeted. In terms of price per unit of output, thin-film modules now cost the same as crystalline silicon modules. However, the manufacturing costs (and therefore the prices) of solar modules with crystalline silicon solar cells have recently fallen at a greater rate than those of thin-film solar modules, resulting in the current market share of thin-film technologies declining somewhat.

As a general rule, large-scale PV plants equipped with thin-film modules can produce power just as cheaply as those constructed using crystalline modules. The lower manufacturing costs may 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 significantly more suitable for the hot climate of the 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 expensive 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 and 2012 saw the market share of thin-film technology recede, 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 construc-

| CELL MATERIAL                  | MODULE EFFICIENCY | SURFACE AREA NEED FOR 1-W-P | 1-W-AREA
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Monocrystalline silicon</td>
<td>14–20%</td>
<td>5–8 m²</td>
<td>1-W-AREA</td>
</tr>
<tr>
<td>Polycrystalline silicon</td>
<td>11–15%</td>
<td>7–9 m²</td>
<td>1-W-AREA</td>
</tr>
<tr>
<td>Amorphous silicon</td>
<td>8–10%</td>
<td>10–12 m²</td>
<td>1-W-AREA</td>
</tr>
<tr>
<td>Thin-film – copper-indium/gallium sulfide/diodeled (CIGS/SC)</td>
<td>10–12%</td>
<td>8–10 m²</td>
<td>1-W-AREA</td>
</tr>
<tr>
<td>Thin-film – cadmium telluride (CdTe)</td>
<td>9–11%</td>
<td>9–11 m²</td>
<td>1-W-AREA</td>
</tr>
<tr>
<td>Amorphous silicon</td>
<td>5–8%</td>
<td>13–20 m²</td>
<td>1-W-AREA</td>
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*Research, experimental stage / ** Space travel, concentrator system

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

The temperature coefficient indicates the percentage by which a module’s output decreases as its temperature increases. With crystalline silicon modules, output falls by around 0.5 percent for every degree 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’ temperature rises by 40 kelvin (K) to 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. The PVT-Test (www.pvt-test.de) introduced by Solarpraxis AG and the German Technical Inspection Association (TÜV Rheinland), on the other hand, buys samples covertly so that manufacturers are not able to preselect which items are tested. Increasing importance is being attached to testing for potential induced degradation (PID), electrochemical stress and module inspection and thermography, as these analyses reveal weak points in production and allow flaws to be detected faster.

In addition to these types of 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 electrochemistry 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 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 certifications 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 system technology. This is why large project developers are changing their strategy to offer only standardized power plant units comprising just one specific module type and one particular plant design (substructure and string connection). 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 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 (direct current, DC) 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 medium-voltage grid, which can have a voltage of between 20 and 500 kV, depending on the national grid standard in a given country.

Not all inverters are suitable for every type of module (depending on MPP voltage window, whether or not a transformer is present and whether or not the DC circuit is grounded). It should there-
String inverter: The electricity is fed into the grid by several, independent inverters.

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 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 voltage, which 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 ideally be given to the system with the lowest localized cost of electricity, allowing for the plant to be operated in the most profitable way possible.

Module Level Power Management
Of late, module level power management (MLPM) solutions have increasingly gained precedence. Known as power optimizers, they are called upon 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.

An enhanced version of the power optimizer was recently launched onto the market as module maximizer. This device not only tracks the MPPT it also records the output data of a module at any given moment and sends this to the central monitoring system. The device is designed to optimize 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 of technical and auxiliary problems which can result from complex DC cabling in large inverter systems.

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 directive on medium voltage grid feed, which came into force in Germany, 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 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 of power plants. This power manifests itself as a high level of reactive power. In the future, large inverters fitted with batteries will take charge of grid management in the initial critical milliseconds of instability. These solar inverters are able to stabilize the grid as they can substitute the inertia of the rotating masses found in large-scale fossil fuel power plants by using energy reserves from storage devices. This also results in energy utilities’ conventional regulating power plants, which are also known as must-run units, becoming redundant.

Permanently monitoring of plant operation is 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 in 2011, and even in medium- and high-voltage grids, was introduced soon afterwards. Inverter manufacturers must provide certificates to demonstrate that their devices meet the new guidelines, and increasing conductivity has resulted in an even greater number of PV plants feeding their power into the medium- and high-voltage grids.
plant certificates must be issued follow-
ing the installation of solar parks to con-
firm that their interaction with the power grid is appropriate and has been simulated.

Since July 2011, large-scale solar plants in Germany must be issued with a certifi-
cate proving their compliance with the technical specifications of feed-in man-
agement before they can be connected to the grid. The certification process is con-
ducted by independent test insti-
tutes. In mid-2012, these test institutes were not numerous enough to process the backlog of applications. Therefore, transitional provisions were implement-
ed until the end of 2012.

Foundation and anchoring
Solar parks should reliably generate electricity for at least 20 years. They are generally built on open land, such as
former military sites, landfill sites, former mining fields or hitherto untapped
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 installa-
tions are vulnerable to wind-induced vibrations, though frameless modules
exhibit different elastic properties to their framed counterparts. The simplest
and least expensive types of foundation are ones that use piles driven into the
earth. Alternatively, piles are also avail-
able that are screwed into the ground
(screw pile foundations). Concrete foun-
dations made from either ready-mixed or
in-situ concrete provide a further alterna-
tive for applications such as tracking
systems or those where the piles cannot
be driven into the ground.

The modules are supported by systems
made of wood, aluminum or steel. Wood-
en 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. Alumi-
num is also an extremely light material.
Systems made of this are easy to install
and hardly corrode, but the price of alumi-
num fluctuates greatly. Furthermore, owing to the thermal properties of alumi-
num, heat and frost cause greater stresses
in the structure. While steel substructures are more cost-effective, steel is not resis-
tant to corrosion and is therefore unsuit-
able for some locations.

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 installa-
tion, as the construction area is more
easily accessible than, say, a slanted roof.
A big disadvantage of free-standing
modules, 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 consid-
eration, as it will need to keep the equip-
ment 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 with one or two axes. Neverthe-
less, 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 expen-
diture is becoming less and less worth-
while given falling module prices and
higher maintenance costs.

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 foun-
dations; the ground must also be suffi-
ciently 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 dis-
tance from each other.

Cabling
Losses due to cabling are often underes-
timated. If the plant is badly planned,
total energy losses in copper cables can
add up – anything over one percent is
unsatisfactory. 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
dust 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
conducting material increases electrical
resistance and multipplies losses as a
result. What is more, sunlight (UV light
in particular) can degrade the cable
insulation material.

Lighting and overvoltage
Large ground-mounted PV plants always
need their own protection system
against lightning and overvoltage. Over-
voltage can be caused by indirect light-
ning strikes and the associated electro-
magnetic induction in cable loops.
According to TÜV Rheinland, in Germany
almost 50 percent of all damage to PV
plants is caused by overvoltage. Protec-
tion 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 discon-
nected from the grid in the event of
fault voltages or fires.

Storage systems for solar power
Storage systems for PV power plants are
just beginning to be competitive and it
remains to be seen if mechanical, electro-
chemical or electrical energy storage will
predominate in large-scale PV plants in
the future.

While in 2012, lead-acid and lithium-ion
batteries were only initially supplied for
small-scale systems to optimize on-site
consumption in private households, the
first large-scale storage systems with a
storage capacity of 500 kWh came onto
the market in the second half of the year.
In cases where the solar output must be
regulated by grid operators, these sys-
tems allow the solar yield of a 1 MW
power plant to be buffered for 30 min-
utes. 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. The methane, which is generated
from surpluses produced by the solar
power plant, is known as wind gas or
solar fuel. Once grid capacity becomes
available again, methane can be convert-
ed into electricity in traditional gas tur-
bines and fed into the grid. It is also used
to generate peak load power.

Operation and maintenance
In addition to costs of the technology
itself, the cost of operation and mainte-
nance is another important factor to
consider. These costs do not figure in
construction of the installation, but can
add up quite considerably over the ser-
vice life of a solar power plant. For each
kWh of solar power generated, between
eight and ten euro cents fall to the costs
incurred during the 20- to 25-year opera-
tion 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. Expen-
siture 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, inves-
tors can expect to pay around 10,000 to
14,000 euros for operation and mainte-
nance on top of the costs for the techni-
cal system.
Financing

Until 2009, manufacturing and sales of technical components were the focus of solar businesses. 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 kWh. This not only includes the system costs, but also every bit of expenditure on realizing the solar project, the operating costs and financing.

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 in terms of investment costs, while monocrystalline silicon parks with tracking systems are at the upper end. New module technologies (thin-film silicon, CIGS 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.

Opportunities for financing

Financing stands or falls with the actual annual solar power yield fed into the grid. Usually, 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 (between 2010 and 2011) and Italy (2007) often 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 southern 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 the production capacities of modules and inverters across the globe, there are practically no further production-related 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.

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 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 2012 by EPRA, 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 module prices, insolation at the site and plant lifetime. According to EPRA, the costs of grid expansion by solar generators must also be quantified in the future. The same of course applies to fossil fuel and nuclear power plants which, to date, have only taken into account power generation costs. Among other reasons, the fact that using photovoltaics no longer involves any fuel costs means that the costs of distributing power and operating the power grid are increasingly reflected in the calculation of electricity prices. Equally important are the cost-lowering effects of solar technology brought about by intelligent inverters, battery storage systems and on-site consumption.

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 contracts), encumbrances, pledging of the operator’s account or pledging of shares in the business. In the past, project financing was sometimes too tight,
Due diligence reports to be requested. It is not 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 negotiation.

Assessment may, for instance, follow these four steps:

Legal due diligence
Legal experts check the legal basis of a project from purchase or rental of property to fees 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
This step examines 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 deprecations and is carried out by independent consultants.

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, closed circuit television) and the costs of maintenance and land management (for example mowing and pruning).

Financial due diligence
This 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 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.

Market forces in the energy sector
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 guaranteed feed-in tariffs will soon be dead, and the dawn will rise on that of market-based remuneration, even if they belong to different owners. In the future, the outputs of all ground-mounted photovoltaic systems within a two-kilometer radius will be added together. If they are found to have a cumulative capacity of over 10 MW, these sub-generators will no longer receive remuneration, even if they belong to different owners. This rule is set to apply for an interim period of two years. In addition, the concept of commissioning a solar plant under the Renewable Energy Sources Act (EEG) established to guarantee the feed-in tariff paid in a particular month, has been reformulated, now stating that it is no longer possible to put modules of a photovoltaic system not equipped with an inverter into operation. However, the connection to the grid will continue to have no impact on the feed-in tariff a system receives.

New feed-in tariff in Germany
In 2012, the German parliament voted in favor of drastically lowering the tariffs again. There are four power classes now: small rooftop systems with outputs up to 10 kW, larger roof-mounted installations with outputs between 10 and 40 kW, plants with outputs up to 1 MW and systems installed on roofs or on the ground between 1 and 10 MW.

The remuneration for solar power fed into the grid is set to fall each month in accordance with market development. While small plants with capacities of up to 10 kW and MW-scale power plants are remunerated in full, only 90 percent of the solar yield generated by power plants with the two medium-scale power output classes is set to be remunerated from January 1. Meanwhile, installations with capacities greater than 10 MW will no longer receive any statutorily regulated remuneration whatsoever but may continue to be constructed. The adjustments to the feed-in tariffs are being made by the German Federal Network Agency, whose website (www.bundesnetzagentur.de) lists the current rates of remuneration.

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Project Planning

Ensuring feasibility

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.

Performance ratio
The ratio of actually generated power to the theoretical yield in a certain location is described by the performance ratio (PR). It serves as a measure of plant efficiency for evaluating different plants in different locations. Top priority is being given to optimizing a plant’s PR when operating in profitable conditions. Excellent PR values amount to between 80 and 85 percent (for crystalline silicon solar modules) or between 82 and 85 percent (for thin-film solar modules).

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 PR will earn an additional 396,000 US dollars annually.

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 PR of 75 percent, would produce 863 MWh of electricity each year. Increasing the PR by ten percentage points to 82.5 percent by optimizing the system components would represent a total of 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.

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?

How to start a project – Some important questions

During operation, comprehensive monitoring and short reaction times in the event of failures result in a short payback period.

Below: The inverters’ design has a considerable influence on the plant’s profitability.

Right: Monitoring devices are another way of monitoring and analysing the various inverters within a plant.

The greater the level at which photovoltaic capacity is expanded, the more important it is for grid feed-in to be controlled precisely, especially in terms of large-scale solar parks.
Early involvement of utilities
Rough technical planning is followed by submitting the feed-in application to the local utility. This is 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 an early stage 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 (approx. 100 kW). A solar park with a capacity of 25 MW requires around 250 containers which can only be moved using designated lifting equipment (cranes, forklift trucks, etc.). Just-in-time delivery is vital to avoid costs for idle periods. The handling of modules – especially frameless modules – in particular calls for extreme care so as to avoid breakage or damage.

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 MW 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.
“PV’s ability to provide grid support is underrated”

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

Large photovoltaic systems with more than one up to several tens of MW of power have gained growing market shares in the photovoltaics industry. What role do they play in restructuring the European energy sector?

It’s clear that the latest changes in national regulatory frameworks do not favour the development of large ground-mounted systems. In the short term, we should not expect dramatic development of this segment in the established markets. But with the continuous effort of the industry to decrease the cost of PV technology (and, as a consequence, its generation cost), large plants remain an important option for the decarbonisation of the industry. Large solar parks are able to stabilize the grid. How important is it for the rapid change in the system of electricity supply?

Well, these services are certainly necessary if we want to move from a fossil or nuclear-based, heavily centralized system to a clean, safe decentralized one. As PV increasingly becomes a player in the grid system, it will have to provide more services to the grid. We are already working in close collaboration with DSOs and TSOs on the role of PV in the future power mix and also during the transition. With the support of our members, the European Photovoltaic Industry Association (EPVIA) is working on EU-financed projects like PV GRID or RServis, which will help the transition. PV’s existing ability to provide significant grid support capabilities – including active power reduction, fault ride-through, and voltage support – is vastly underrated.

With increasing level of active power in the grid from solar parks or wind farms it might be more important to feed in reactive power. Which role can solar parks play in order to reduce the costs for new high-voltage or medium-voltage cables?

PV systems of all sizes can provide grid support services. The main advantages of large plants are the lower cost to provide the service and the ease of implementing communication. PV can participate in system operation either at the distribution or the transmission level. But it requires a cost-effective communication infrastructure, new system operation strategies that take advantage of PV’s capabilities, a better interaction between DSOs and a better understanding of what PV can provide. The effective use of PV capabilities can effectively reduce the need to extend the existing grid infrastructure.

Superstorm Sandy made it clear: The solar fields are the first generators returning to the grid after a blackout or shut-down of the grid in case of hazard or disaster. Do they diminish the risk of blackouts at all?

As EPVIA showed in its “Connecting the Sun” report, large-scale PV integration in the European grid is technologically feasible with a high level of security of supply, even under the most extreme weather and load conditions. With the right measures and investments in place, system reliability can be ensured. The concept of back start or restoration plans – restarting the system after a black out – is really complex. Currently PV is not integrated in such plans and is requested to disconnect during events. In a future with a lot of PV and with the development of the right measures, PV could serve as an emergency generation technology during critical events and help to restore the grids.

The most powerful voice of photovoltaics in Europe

EPVIA – 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. EPVIA’s mission is to give its global membership a distinct and effective voice in the European market, especially in the EU.
Overview

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

Companies (in alphabetical order)

| Page | Company | Solar cells | Inverters | Module manufacturing | Storage systems | Mounting systems | Tracking systems | Mounting solutions | IT solutions | Logistics | Certifier | Consultant |
|------|---------|-------------|----------|----------------------|----------------|-----------------|-----------------|------------------|-------------|-----------|-----------|------------|-----------|
| 44   | 3E       | ●           | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 45   | ABB      | ●           | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 46   | Activ Solar | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 47   | Advanced Energy | ●       | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 48   | AEG Power Solutions GmbH | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 49   | Alternative Antriebe & Erneuerbare Energien | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 50   | AXITEC GmbH | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 52   | BELECTRIC Solarkraftwerke GmbH | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 53   | Bonfiglioli Riduttori S.p.A. | ●           | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 54   | Dow Corning Corporation | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 55   | F&S solar concept GmbH | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 56   | Fronius Deutschland GmbH | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 57   | GP JOULE GmbH | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 58   | Ingeteam Power Technology, S.A. | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 60   | Mounting Systems Group | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 59   | Nuevosol Energy | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 62   | Platinum® GmbH | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 63   | Power-One | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 64   | PROFIL DU FUTUR | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 65   | Schneider Electric | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 66   | skytron® energy GmbH | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 67   | SMA Solar Technology AG | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 68   | SolarMax | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 69   | SolarWorld AG | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 70   | Solectria Renewables | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
| 71   | TÜV SÜD | ●         | ●         | ●                    | ●              | ●               | ●               | ●                | ●           | ●         | ●         | ●          |
3E is an independent technical advisor specialized in renewable energy and energy performance optimization. We provide expert consultancy services and software products throughout the full project life-cycle.

Since 1999, 3E has focused on serving investors, project developers and product developers with technical expertise to reduce risk and optimize performance throughout the full life-cycle of PV parks. Operating from Brussels (HQ), Toulouse, Milan, Istanbul, Beijing and Cape Town, the company has a project track record of more than 15 years in over 30 countries, and is a trusted partner for the major lenders and equity providers in the global renewable energy market.

In photovoltaics, 3E provides expert consultancy services, including resource modeling, development guidance, system engineering, technology assessments, due diligence and risk mitigation strategy, in addition to system monitoring and reporting tools. We have worked on ground-mounted and rooftop systems from 10 kWp to multi-megawatt projects, including utility-scale projects of up to 75 MWp. We have helped our clients to reduce risk and optimize the performance of their projects in Belgium, France, Italy, Greece, Croatia, South Africa and several other countries. We have also carried out factory audits and assessments on over 45 PV module manufacturers in China, Europe, India and Japan.

SynaptiQ, 3E’s monitoring and multi-stakeholder reporting software platform, is designed for performance optimization of multi-brand and multi-technology solar portfolios. SynaptiQ is a flexible and intelligent software tool, compatible with a very wide range of hardware devices (inverters, loggers, SCADA, etc.). The platform is already connected to over 1,000,000 components in utility-scale PV parks in ten countries.

Our consultancy and software services are enhanced and strengthened by an in-house research and innovation lab, specialized in modeling and data analysis. Bridging the gap between R&D and the market, 3E combines this in-house innovation, partnerships with leading R&D centers and a thorough understanding of practical industry needs to continuously offer high-performance, cost-effective services and products.

ABB Bankable ABB Central Inverters for Large-Scale PV Power Plants

Bankability is of extreme importance when choosing a solar inverter supplier, especially for large-scale PV plants. ABB central inverters meet all bankability requirements, making them a choice that you can confidently trust.

During the last ten years, ABB has delivered over 100 GW of power converters on the same platform that is used for ABB central inverters, which, after only a few years on the market, have now nearly reached 1 GW of installed capacity.

ABB’s successful central inverter series, rated from 100 to 1,000 kW, is designed for multi-megawatt photovoltaic (PV) power plants. The inverters give a high overall efficiency coupled with a compact and easy-to-maintain design. The 1,000 kW central inverter has a maximum efficiency of 98.8% and a European Efficiency rating of 98.6%. This, together with a very low auxiliary power consumption of only 60 W, results in the outstanding overall efficiency of our inverters. In addition, the wide temperature range and altitude rating, as well as a modular DC input layout, provide much greater flexibility for system integrators.

Power density is almost 20% higher than earlier central inverters, allowing savings to be made in installation space and transportation costs. Also, thanks to the inverters’ certificates and advanced, flexible grid-support functions, ABB central inverters meet all applicable network connection requirements.

ABB also supplies a megawatt station which is a turnkey solution for large-scale solar power generation. The megawatt station houses all electrical equipment needed to rapidly connect a PV power plant to a medium voltage (MV) electricity grid. All components are from ABB’s proven technology portfolio, providing high efficiency and reliability in a compact, easy-to-maintain unit.

In the end, your choice of inverter comes down to what makes you most confident about meeting your return on investment (ROI) goals. ABB central inverters do just that, with bankable credentials that you can trust.
Vienna-based Activ Solar is a solar industry pioneer focusing on emerging solar markets, where it has built some of the world’s largest photovoltaic installations.

Activ Solar’s main business areas include the development, financing and completion of large-scale photovoltaic installations in emerging solar markets, as well as the production of polysilicon at a wholly-owned semiconductor plant in Ukraine.

**Activ Solar**

**A Global Company Focused on the Development and Manufacture of Solar-Based Technology**

Vienna-based Activ Solar is a solar industry pioneer focusing on emerging solar markets, where it has built some of the world’s largest photovoltaic installations.

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**Project development**
- significant track record of solar developments and technical know-how to select and carry out projects with the highest expected returns
- own equity to co-invest, enabling project risks to be shared
- pipeline of processes typically performed with local partners to make projects shovel ready

**Financial solutions**
- background in finance & investments with strong track record in energy M&A and project finance
- strong track record in securing project finance from commercial banks and ECA’s, and in obtaining vendor finance
- broad network of international and local investors to facilitate exits, if needed

**Asset management**
- team with extensive experience in maximizing value and returns of operational portfolios
- management and maintenance of parks
- current assets under management of 400+ MW

**EPC**
- engineering team with proven track record of designing optimal large-scale utility PV parks
- excellent relationships with major bankable suppliers and “buying power” thanks to large procurement volumes (approximately 400+ MW over two years)
- construction management capacity worldwide

**Facts & figures**
- established in Vienna, Austria, in 2008
- over 1,700 professionals worldwide
- over 400 MW of utility-scale projects developed, financed and put into operation to date
- long-standing relationships with multiple tier one suppliers
- ranked globally as a top five developer of large-scale solar PV projects
- developed, financed and constructed some of the world’s largest solar PV power stations

**82.65 MWp Chotinbrod solar power station (Crimea, Ukraine), one of the largest solar parks in Eastern Europe (left)**

**105.56 MWp Pervomaisk solar power station (Crimea, Ukraine), one of the largest solar parks in the world (above)**

**Advanced Energy**

**ENERGY DELIVERED™**

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 and commercial solar project stakeholders to offer system owners a lower Levelized Cost of Energy (LCOE) and confidence their PV system will deliver on long-term production goals. With more than 30 years of leadership delivering innovative energy solutions, combined with a legendary reputation for customer service and a strong balance sheet, AE Solar Energy is a trusted partner for solar project developers, EPC companies, 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 in between. We provide application engineering support and warranties for up to 20 years, partnering with customers for the entire project life-cycle.
AEG Power Solutions GmbH

HIGH-VALUE SOLAR POWER
GENERATING PRODUCTS AND SERVICES

Building on its proven track record in supplying utilities and grid operators with reliable, fully-compliant solutions, the Protect PV/500, PV/500, PV/650, and PV/800 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 Protect PV 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&CC system. These single-source solutions ensure smooth PV power plant operation, in close cooperation with grid operators.

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, from our subsidiary skytron energy, called PVGuard, 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 and South America, AEG Power Solutions is on hand for collaboration with all potential partners, including EPC’s, consultants, operators and investors.

AEG Power Solutions – Competence Center Warstein-Belecke

Central Inverter Protect PV.800

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Fax: +49 (0)2902 763-1201
solar@aegps.com
www.aegps.com
Founded: 1946
Turnover: 368 million euros (2012, worldwide)
> 1,600 employees (2012, worldwide)

Eastern Europe, > 300 MW
AEG PS provided complete electrical systems for several PV power plants.

Alternative Antriebe & Erneuerbare Energien

Quality Control Safeguards Sustainable Yields

The engineering office Alternative Antriebe & Erneuerbare Energien has a wide range of clients, including system buyers (investors) and sellers (system constructors and operators), as well as money-lending institutions (banks).

The company’s founder, graduate engineer (Diplom-Ingenieur) Christian Dürschner, looks back on many years of experience as a project engineer and independent expert in photovoltaic systems. He founded the consultancy firm Alternative Antriebe, which focuses on solar cars, electric cars and hybrid vehicles, as early as in 1995, before expanding it into Alternative Antriebe & Erneuerbare Energien, an engineering office specializing in photovoltaics, in 2000. Certified as having expertise in photovoltaic systems by the German Technical Inspection Association (TÜV), the office mainly draws up objective and impartial reports for small, medium and large-scale PV plants.

Benefit from our long-standing experience in PV!

Our range of services from A to Z:
• analysis of yield reductions
• comparison of actual and nominal yields
• creation and evaluation of yield forecasts and yield reports
• damage reports and damage evaluations
• expert opinions for court cases
• I-V curve measurements of modules and strings
• inspections using electroluminescence and/or thermal imaging cameras
• profitability calculations
• quality assurance of construction processes
• support with EEG commissioning
• support with technical acceptance
• technical due diligence
• valuation of existing plants
• and much more...

Alternative Antriebe & Erneuerbare Energien
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Reduction in yield resulting from shading caused by plant growth (top left and right)
Reduction in yield resulting from shading caused by the system itself (left middle)
Burnt off plug connector and damaged DC cables (left bottom)

Benefit from our long-standing experience in PV!
AXITEC GmbH

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

With 300 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
• twelve-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 all international standards, e.g. IEC, UL, MCS and CEC. Additionally, all solar modules are certified according to IEC 61730 (Salt Mist Corrosion Test) and IEC 67516 (Ammonia Corrosion Test). As a result, all AXITEC solar modules can be mounted next to the sea and on agricultural roofs, including those of pigsties.

Global branch offices

AXITEC has branch offices in Italy, the USA and Brazil. Additionally, AXITEC solar modules are available worldwide from renowned distributors, whose objective is to appeal to customers and demonstrate the products’ technology.

References and installations

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

Bonfiglioli – Partner in Large Projects. Worldwide.

Bonfiglioli manufactures and designs power conversion systems from 3 MW turnkey solutions down to 30 kW compact devices, for medium-to-large commercial and utility-scale installations.

Thanks to the global nature of its distribution network and a wide range of high efficiency solutions, prestigious international engineering, procurement and construction contractors (EPCs) and independent power producers (IPPs) trust Bonfiglioli to supply the inverters needed for large-scale photovoltaic installations in Europe, Asia and North America. In 2008, Bonfiglioli supplied its solutions to the world’s largest photovoltaic field at the time (15 MW), which is located in Spain. In 2010, Bonfiglioli supplied the inverters for one of Europe’s largest PV fields (90 MW) in Italy and in 2012, a 60 MW PV field equipped with Bonfiglioli inverters came on line in Bulgaria. Its long history and consolidated international presence make the company a reliable and bankable investor, and have allowed the Bonfiglioli Group to contribute to the start-up of major installations in emerging markets.

Bonfiglioli’s RPS Stations, which are available in a vast range of power ratings from 280 to 3,000 kW, provide turnkey solutions for the complete photovoltaic field management of all large-scale ground installations. RPS Stations are produced and tested directly at the plant to ensure the highest standards of quality and efficiency alongside reduced costs. As a result, customers can take delivery of a fully equipped, ready-to-connect system in impressively short times.

The RPS TL modular inverters at the heart of every Bonfiglioli RPS Station guarantee the highest system yields and excellent international grid code compatibility, thanks to the modular engineering and German technology that distinguish all Bonfiglioli inverters.

An in-depth understanding of markets and market dynamics, 17 commercial subsidiaries, four photovoltaic production centers on three continents and a wide range of high-tech inverters make Bonfiglioli a long-standing and riskless industry player for photovoltaic field developments anywhere in the world.
Powerful, efficient and grid friendly: With the 3.0 MegaWattBlock, BELECTRIC is setting new standards in solar power production.

On a par with the functionality of large conventional power plants, BELECTRIC’s grid stabilizing power plant technology makes it possible to intelligently integrate renewable energy sources into existing power grids. This means that grid expansion caused by renewable energy can be kept to a bare minimum.

We design energy
BELECTRIC is one of the world’s leading companies in the development and construction of ground-mounted solar power plants and roof-mounted photovoltaic systems. As an international corporation, BELECTRIC has permanent offices in more than 20 countries, meaning it is able to reach almost every part of the globe. In 2012, BELECTRIC achieved a historic milestone by becoming the first systems integrator 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 solar power plants to photovoltaic rooftop installations and solar-optimized e-mobility charging boxes. 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. In 2012, the company looked back at a success story involving 100 patented innovations in the field of photovoltaics, and since being founded has implemented over 2,700 photovoltaic rooftop installations and more than 200 solar power plants worldwide.

BELECTRIC realizes photovoltaic solutions with a degree of almost 100% vertical integration along the value chain. This relates especially to the area of complex solar power plants and ranges from systems engineering and the manufacture of balance of system (BOS) components, through to O&M service packages. BELECTRIC consistently promotes photovoltaic modules with modern thin-film technology and has established long-term joint ventures with leading manufacturers in this field. By covering and optimizing virtually all areas of the solar business, BELECTRIC achieves the lowest levelized cost of energy (LCOE) in the photovoltaics business.

3.0 MegaWattBlock: reliable technology full of innovation
With a design that focuses on standardization, optimization and grid integration, we build solutions that perfectly match our customers’ demands and the world’s energy needs. All of these are combined in the 3.0 MegaWattBlock.

BELECTRIC has a successful history of product evolution with its 2.0/2.5 MegaWattBlock and is taking the same approach with the new 3.0 MegaWattBlock. The high power generating unit has been developed to construct top performance utility-scale solar power plants. The standardized modular design was formed with a simple goal in mind: to create a solar power plant that delivers power at the lowest possible cost. Designed with the aims of saving resources, fast construction and reliable operation, the new unit is synonymous with an optimum cost-benefit ratio.

Proving its technological leadership once again, BELECTRIC operates the 3.0 MegaWattBlock at a voltage of 1,500 V. The system uses the full power bandwidth defined by the EU’s Low Voltage Directive, enabling efficient grid integration and significant cost reduction at the same time.

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

With the 3.0 MegaWattBlock, BELECTRIC provides an essential component for sustainably stabilizing power grids. The solution comprises an intelligent control unit that can be used to smoothly integrate the new product range into worldwide power grids and combine them with conventional power plants. This new technology contributes significantly to improving grid stability for operators and consumers, as well as allowing photovoltaics as a decisive part of the energy mix and making the costly extension of the power grid redundant.

BELECTRIC – The Better Electric
Dow Corning Corporation

Reliable Silicon Solutions for Solar PV

Unleash the solar power of silicon

As the PV industry assumes an increasingly important role in meeting the world’s energy needs, Dow Corning Corporation is committed to helping the industry grow and succeed.

Dow Corning Corporation provides silicon-based solutions across the PV value chain, including feedstocks and a wide range of other material options, improving the performance and durability of finished solar modules.

A growing portfolio of solutions

As a leading materials supplier to the PV industry, our goal is to help our customers grow through innovation and material solutions across the entire solar value chain. Our portfolio of solutions includes:

- Silicon feedstock
- Conductive adhesives, coatings and cell applications
- Silicone encapsulants
- Junction box adhesives and potting agents
- Silicone sealants and adhesives for module finishing
- Structural sealants for module installation

Investing in the success of the PV industry

Our long-term commitment to sustainability and to providing solutions to the PV industry is demonstrated by major investments in Solar Solutions Application Centers around the world. Dow Corning’s state-of-the-art PV module and solar cell application centers enable close collaboration with industry leaders and testing and application development to be carried out on site. Driven by innovation and fueled by 70 years of talent, expertise and capabilities, Dow Corning delivers silicones, silicon-based technology and high-performance products that help create more reliable solar systems to increase the number of kilowatt hours of output and profitability.

You can learn more about Dow Corning Solar Solutions and view our virtual trade show at dowcorning.com/solar or e-mail solar.solutions@dowcorning.com.

F&S solar concept GmbH

Complete Solar Solutions – Made in Germany

Having already installed more than 1,500 solar power plants, F&S is one of the most important plant engineers across Europe.

Institutional investors, family-run offices as well as utility and public utility companies rank among our clients.

F&S solar specializes in the planning, development and subsequent construction of solar parks worldwide. Top priority is given to ensuring that all of the company’s power plants fulfill high-quality requirements, with everything right down to the smallest detail being regulated by certification. Extensive final acceptance inspections ensure that each system is in full working order, meets technical regulations and operates fault-free.

In addition to exceptional technical expertise, the company also offers legally compliant plant operation models. In a further department, F&S solar’s engineers and technicians develop bespoke, finely-tuned solutions for rooftop installations. The roof covering is examined and the amount of shading evaluated during an on-site meeting.

F&S solar concept GmbH

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info@fs-sun.de
www.fs-sun.com
Founded: 2007
Turnover: 75 million euros (2011)
50 employees + 250 service technicians

Following this, customized plans for the entire system are drawn up in close collaboration with the plant operator. The range of services is rounded off by comprehensive plant monitoring, a 24-hour emergency service and a sustainable maintenance system. On request, F&S solar can also act as technical plant managers for institutional investors.

At F&S solar, quality “Made in Germany” remains a guarantee for a secure investment.
Fronius Deutschland GmbH

Inverter room at the PV power plant in Eberswalde (Austria), 11 MW, 6 Fronius Agilo 100.0

Decentralized inverter concept for east-west orientation, 2.1 MW, 48 Fronius IG Plus 150

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. Its headquarters are based in Neuhof, located in the heart of Germany. There, all three Fronius divisions, Solar Electronics, Battery Charging Systems and Welding Technology, are consolidated under one roof.

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-poweredinverters for mains-connected 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.

From open-field PV power plants with a challenging topographic structure to complex rooftop systems – Fronius provides individual systems which reduce the cost of ownership. Low maintenance, minimized downtime and a longer lifespan of the implemented solar electronics are the result. This guarantees stability of yield and an attractive return on investment from the project.

Fronius inverters are perfectly suited to solar systems in the upper megawatt range, as they ensure economical operation with maximum yield.

GP JOULE GmbH

Energy quartet in Pompogne: four areas with a total of 40 MW

Series-ready hydrogen storage system from H-TEC

GP JOULE specializes in megawatt-class power plants. Solar is the main focus area, although the company also successfully implements wind and biomass projects.

Ove Petersen, CEO, defines the vision behind GP JOULE: “Our strength doesn’t only lie in plant construction. We also specialize in solutions for the future: We are certain that 100% renewable energy is a realistic goal and can show you how to achieve it in just a few years.”

The company is headquartered in North Germany. In addition to sites in the south of the country, GP JOULE is also represented in France, Italy, the USA and Canada, and is active in projects all over the world.

Good prospects: ecology meets economy

Better today than tomorrow: energy solutions

GP JOULE is constantly striving for progress, and not just in its future concepts division. Its series-ready storage solution using hydrogen technology was presented in 2012 in cooperation with the subsidiary H-TEC: the PEM-electrolyser provides a key to the future of renewable energy.

GP JOULE GmbH

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Founded: 2009
100 employees

Inverter room at the PV power plant in Eberswalde (Austria), 11 MW, 6 Fronius Agilo 100.0

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Ingeteam is a global corporation specialized in six different sectors (energy, industry, marine, traction, basic technologies and services) that are all customer-oriented and based on power and control electronics, electrical machines and application engineering. Thanks to its division-based structure and sustainable growth policy, Ingeteam enjoys a privileged, competitive position and has already overcome technology, and regulatory and integration roadblocks to offer holistic electrical equipment solutions in many solar installations operating throughout the world.

Ingeteam's latest innovations include the new Ingecon® Sun Power Max 1 MW central inverter for large-scale PV installations, which reaches an output power of 1,019 kW and a maximum efficiency of 98.8%. In order to meet households’ new energy needs, Ingeteam has also just presented the Ingeteam Smart House concept, a global energy management solution for residential and industrial use that allows for increased on-site consumption. Moreover, Ingeteam has launched the new Ingecon® Sun iPlay (2.5 to 10 kW) and Ingecon® Sun iPlay (10 to 40 kW) inverter families with improved features that include higher efficiency levels. Finally, the Ingecon® Sun Training platform offers a wide range of on-site training courses and live webinars aimed at professionals in the PV sector.

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Mount Your Investments on Intelligent Structures

Nuevosol Energy is a leading provider of optimized mounting solutions with over 150 MW of installations to date. Through optimal solutions, it has fostered grid parity in emerging solar industries like India.

Definitive solutions addressing infinite possibilities
Nuevosol’s portfolio includes mounting solutions encompassing all segments. Our philosophy of mounting structures rests in the triumvirate of customization, standardization and innovation.

Optimized mounting at competitive pricing
Nuevosol’s mounting solutions are a result of multifaceted optimization to create globally competitive solutions.

Intelligent structures with impeccable quality
A highly integrated design process with contributions from the R&D, manufacturing and installation teams results in intelligent structures, which can withstand wind loads of more than 180 km/h and resist harsh environments for 25 years.

Ground-mounted solutions
Nuevosol ULTIMA: For mega power plants available with adjustable tilt and contour adapting models.

Lowering costs – fostering grid parity
We believe in finding an optimal solution to achieve grid parity, with leaner designs and lower costs for commissioning.

Global compliance
Our design team is experienced in producing globally compliant structures following country specific codes and standards.

Why choose Nuevosol?
- 150 MW of installations in diverse settings such as deserts, coastal areas, extremely humid regions, areas prone to corrosion and undulating ground
- Ten-year warranty
- Designs simulated and tested using sophisticated tools and prototyping
- Designed for ease of assembly on site to achieve a pace of 2 MW per day
Mounting Systems Group

Mounting structures as the base of every PV power plant

With 20 years of market expertise, ISO-certified Mounting Systems GmbH is one of the world’s leading developers and manufacturers of photovoltaic substructures.

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. An additional representative office has been available to customers in Milton Keynes, Great Britain, since March 2012. Further international subsidiaries are planned.

The comprehensive product portfolio includes several fastening systems and components for photovoltaic and solar thermal installations. The international company provides innovative and customized solutions for large commercial open terrain projects and solutions for residential and commercial on-roof, in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roof and 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flat-roof systems, alongside in-roof and flat-roof systems, alongside in-roo
The PLATINUM® brand offers outstanding inverter technology at the highest level of performance. The patented DIVE® technology, SiC components and RAC-MPP®, which quickly finds the optimum working point, make PLATINUM® inverters one of the best of their kind with a peak efficiency of more than 98%. Thanks to the innovative DUAL-X® technology, the latest model—the PLATINUM® R3—achieves a peak efficiency of 98.2%, and is particularly low maintenance due to its pure convection cooling. PLATINUM® offers string inverters in the power range of 2–22 kW to ensure it can provide the right solution for every system size. These inverters are manufactured in Wangen im Allgäu, Germany, to the highest industrial quality. The failure rate is particularly low due to intensive, six-stage quality testing, which ensures the robustness and reliability of PLATINUM® inverters. The result: totally robust and reliable system components. The ten-year ex-works warranty and the option to extend it to 20 years for the majority of all products comes as standard with all PLATINUM® products.

In addition to inverters, the PLATINUM® product portfolio also comprises intelligent monitoring devices to monitor the power output of photovoltaic systems. PLATINUM® offers the WebMaster Home to optimize private consumption: It controls and visualizes any number of consumers, thereby allowing for intelligent energy management. PLATINUM® also supplements its system of high-quality solar technology with the PLATINUM® battery, which stores solar energy reliably and makes it available around the clock. PLATINUM® thus helps its users to achieve greater self-sufficiency in private power supplies and relieves the burden on national grids. The PLATINUM® battery is available in sizes ranging from Basic to XXL with a battery capacity of 4.6 kWh to 41 kWh and is compatible with all PLATINUM® photovoltaic systems or can be integrated into existing systems. PLATINUM® places emphasis on customer service as well as product quality. The company therefore runs regular training events for dealers, sales staff and installation engineers in its headquarters in Wangen im Allgäu.

Power-One is the second largest designer and manufacturer of photovoltaic inverters worldwide. The company offers a diverse range of inverters to meet the needs of every installation—from residential applications to large-scale solar parks.

With 50 years of experience in the global power electronics industry, Power-One benefits from a unique level of expertise in terms of innovation, quality and service. Over the past four years, the company has continuously expanded its global footprint, setting up manufacturing, sales, service, and design facilities in Asia, Europe and North America. Power-One’s aim is to continuously improve its market penetration and performance throughout the world. While the demand for utility-scale solar parks is shifting to the emerging PV markets, Power-One is prepared to meet both the requirements of developed and emerging counties with its central inverter solutions. Its AURORA ULTRA central inverter family is an output of up to 1.5 MVA is one of the best solutions in its class, offering an innovative circuit topology, a passive liquid cooling system and a robust IP65 enclosure. Due to its modular design concept with an output of 690 V AC, the central inverter ensures easy installation and maintenance as well as maximum energy harvesting with an efficiency of up to 98.7%.

In order to also meet the future demands of large utilities, Power-One is constantly striving to improve its central inverters. The company is, for example, currently developing a novel voltage source inverter topology with additional grid services, which helps to increase the hosting capacity and stability of the grid. Moreover, Power-One is also looking into evolving markets, such as energy storage, and is using its long-standing experience to develop new best-in-class devices, helping to ensure our future energy supply. Power-One also boasts one of the broadest portfolios in the inverter market for large-scale decentralized plants, offering three-phase string inverters ranging from 6 kW to 27.6 kW that guarantee high energy yields.
PROFIL DU FUTUR

Steel Structures & Foundations for PV Power Plants around the Globe

PV Power Plants around the Globe

Ground-mounted structure for a 3.2 MWp plant in (La Réunion) under installation (top)
Structure for a 5.6 MWp plant in a cyclonic region

Ground-mounted structure for a 3.2 MWp plant in Spain (bottom)

Magnelis®: The first metallic coating offering warranties against corrosion even on cut edges: 25-years warranty for solar applications

PROFIL DU FUTUR: competitive and guaranteed structures for all soils and climatic conditions
Magnelis®: the first metallic coating offering corrosion protection even on cut edges in harsh environments: 25-years warranty for solar applications

PROFIL DU FUTUR, a company belonging to the ArcelorMittal Group, is an expert in structural design and profiling for the construction market. Taking its industrial range of profiles as a basis (Multibeam, PSB, CE or U shaped), PROFIL DU FUTUR designs and manufactures structures for ground-mounted PV plants.

Foundation solutions are adapted to all soil types and use rammed or anchored poles depending on the ground’s characteristics.

Each project is engineered on the basis of:
• single-pole or dual-pole structures
• climatic & geological conditions
• Eurocodes’ static & dynamic calculations

PROFIL DU FUTUR offers short lead times thanks to an integrated supply chain and a dedicated engineering office.

PROFIL DU FUTUR works with approved installation partners.

Magnelis®
Magnelis® is an innovative zinc-aluminium-magnesium coating that offers protection in the harshest environments for solar racking and foundation systems.
• Superior against corrosion in comparison with other metallic coatings: Available in thicknesses of up to 6.0 mm, Magnelis® offers ultimate corrosion resistance in aggressive environments that is far superior to that of other metallic coatings thanks to the addition of 5% magnesium.
• Superior edge protection: Magnesium & aluminium elements combined in the coating layer create a thin protective film that protects cut edges from corrosion.
• Excellent workability: Folding, drawing or punching.

ArcelorMittal: your partner around the world
From products to tailor-made solutions, the ArcelorMittal Group is a global partner for all PV projects, thanks to its Flat Carbon Europe and Distribution & Solutions divisions, its International Construction Project teams & agencies network.

Schneider Electric

The Global Specialist in Energy Management

Schneider Electric provides complete solutions from PV panel output to grid connection, including monitoring and control, as well as operation and maintenance services.

With 401 years of experience in power conversion design and manufacturing, Schneider Electric is a Fortune 500 company that has been in business for more than 175 years. We’ve been manufacturing solar inverters since 1999, ranking us among the longest suppliers of such solutions on the market. Our presence in over 100 countries enables us to offer best-in-class balance-of-system solutions that meet local standards and benefit from local service capabilities, practically anywhere in the world.

Our solutions include:
• PV Box, a pre-wired, factory-integrated power conversion substation that includes the new Conext Core XC three-phase grid tie inverters, DC combiner boxes, a LV/NV step-up transformer and a medium-voltage switchgear.
• Conext Control, an intelligent and evolutive monitoring and control solution from string to grid.
• Array Box, a string combiner box installed between the PV modules and the inverter.
• Customized grid-tie substations enabling an efficient connection to the electric grid.

Schneider Electric products are present at every step of the power conversion chain, helping customers get the most efficient solar harvest from their installations thanks to qualified and reliable integrated solutions.

For more information about Schneider Electric and renewable energy solutions, please visit www.schneider-electric.com/solar

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Founded: 1836
Approx. 260,000 employees (Group)

Approx. 260,000 employees

Turnover: 24 billion euros (2012)
140,000 employees
How long does it take to find a coin on a football pitch? Even on a surface area of several football pitches, you should lose neither time nor money. With skytron® energy – Protected investments. Secured yields. Maximized profits.

How can our energy generation be shaped in a sustainable and profitable way? Providing the answers to this question has been the constant focus of all our operations for 36 years, ever since graduates from the Technical University of Berlin founded the Wuseltonik collective at the end of the 1970s and developed their initial visions for the systematic and cost-efficient use of renewable energy.

The pioneering spirit of those days is very much alive at the present-day headquarters of skytron® energy in the Berlin-Adlershof Science and Technology Park. Then as now, we consider working closely with scientific research as well as focusing on practical solutions to be essential in this fast-growing industry.

Our long-term experience ensures reliable plant monitoring at PV power plants throughout the world. Our power plant control technology and control room software now permanently watch over more than 3.7 GWp of installed PV output. We customize each installation to match the configuration of every individual plant—from precise string-current measurements right through to the control room presentation, thus allowing for effective supervision of your remote assets. Moreover, skytron® energy provides a complete O&M solution.

Our system is compatible with all standard inverters on the market, allowing it to be readily adapted to fit your facilities—and to expand with them. In this way your investment costs are protected and the cost-effectiveness of your plant is maintained.

The visions of the early days have been transformed into cutting-edge components for PV power plants in the MW sector, which are exactly what the market is looking for. Ensuring your success is at the heart of what we do.

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The SMA Group is the world market leader in solar inverters and an energy management group that provides innovative key technologies for future power supply systems.

More than 30 years of experience and PV power plant projects in the megawatt range in more than 50 countries show our outstanding PV system expertise. SMA employs more than 5,000 people and maintains 90 service stations worldwide. 1,000 dedicated PV experts in R&D work daily on the optimization and development of new products and technologies.

PV power plants are optimally equipped with powerful outdoor devices from the Sunny Central CP XT inverter series. With an efficiency of 98%, the Sunny Central 900CP XT is the most efficient representative of this family. The SMA Transform- er Compact Stations, including PV optimized transformers conforming to the international IEC standard, are ready for global application. As a turnkey medium-voltage solution, the SMA Transformer Compact Station can be used for all global voltage levels and enables flexible project planning and fast project kickoffs.

As a pioneer in grid integration, SMA offers tailor-made solutions worldwide that fulfill the rising demands of PV power plants. With their outstanding functions, SMA inverters play a central role in guaranteeing grid stability and actively managing PV power plants.

In addition to highest efficiency and low on-site consumption, SMA central inverters are designed for extreme environmental conditions. Only inverters with excellent technical properties, which operate in a smooth and uninterrupted manner over a long period of time, will guarantee the long-term success of PV projects in the sunbelt and climatically challenging regions of the world.

Large-scale PV power plants continue to present attractive long-term investment opportunities to investors, power plant operators and banks. To realize stable cash-flows of such projects, SMA central inverters as the core components of every PV power plant, secure maximum energy output and financial yields.
SolarMax

Swiss quality by Sputnik Engineering

SolarMax inverters ensure high yields in PV power plants worldwide.

With its SolarMax brand, the Swiss company Sputnik Engineering AG has been using solar power for more than 20 years. SolarMax is making a valuable contribution to protecting the environment and generating renewable energy, thanks to highly efficient Swiss quality inverters. Regardless of whether the PV plant is realized with central or string inverters, the high performance and reliability of SolarMax products ensures high yields year after year.

Today the company ranks as one of the leaders in the international market for grid-connected solar inverters and has made a crucial contribution to the success of solar energy utilization. And because SolarMax thinks and acts in terms of sustainability, it is already seeking tomorrow’s solutions today.

SolarMax has much expertise when it comes to large projects and has already overseen a large number of multi-MW projects around the world. SolarMax inverter and data communication products continue to meet increasingly more demanding grid requirements and make a huge contribution to grid stability. Inverters significantly influence each PV plant’s Levelized Costs of Energy (LCOE) in many ways. With this in mind, SolarMax develops high-efficiency inverter solutions with outstanding uptimes and long maintenance cycles. The flexible products and services meet investors’ specific requirements and fulfill challenging performance ratio requirements.

With long-standing experience, the company is a competent and reliable partner for utility-scale projects all over the world. Clients will be supported with assistance and advice during planning and commissioning as well as throughout the plant’s entire life cycle.

SolarWorld AG

state-of-the-art technology you can trust

The SolarWorld AG Group is a leading provider of quality solar power technology. We cover the entire value chain, from manufacturing crystalline solar modules to providing PV systems. Our core business is the manufacturing of crystalline solar modules and providing PV system solutions, which are sold through our strong distribution network. Through our 100% subsidiary Solarparc AG we can deliver utility-scale turnkey PV parks including project finance and full-service O&M.

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 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. Our sales representatives and certified specialist partners will ensure you enjoy one of the best customer supports 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.
Solectria Renewables

PV Inverters – Built for the Real World

Our utility-scale inverters power utility-scale installations in North America.

Solectria Renewables’ SGI 500X

Solectria Renewables is a leading USA-based grid-tied PV inverter manufacturer. Our versatile, high-efficiency products provide solutions from 1 kW systems to multi-megawatt solar farms. Our products are backed by over 20 years of power electronics and inverter experience, and are supported by world-class warranties. All of our commercial and utility-scale inverters are manufactured in the USA, are ARRA and Ontario FIT Content compliant, and are manufactured in the USA, are ARRA.

Industry leading technology
Solectria inverters offer best-in-class efficiencies to maximize production and ROI. Our inverters are customizable and offer a variety of options, such as integrated DC breakers, that result in flexible and cost-effective system designs.

Reliable performance
Solectria inverters are built to last for the lifetime of your power plant, providing high performance in any climate. Our unique inverter architecture minimizes hardware complexity and points of failure, resulting in high levels of uptime and simplifying field service and O&M.

World-class service and support
All Solectria inverters come with a standard five- or ten-year warranty that can be extended to 20 years, optional PM plans and 99% uptime guarantees are available. Our customer service department is available 24/7/365 and is staffed by a highly technical, qualified team.

Product line at a glance:
- MSS 1–2 MW Megawatt Solar Stations, utility-scale directly to medium-voltage solution, including 1–4 SGI inverters
- SGI 500XT: SMARTGRID 500 kW utility-scale, external transformer inverter, 98% CEC efficiency
- SGI 225–500: SMARTGRID inverters, 225–500 kW, 97% CEC efficiency
- PVI 10–100kW: commercial inverters, 10–100 kW, configuration options
- PVI 1800–7500: single-phase residential inverters, 1.8–7.5 kW
- String combiners: optional DC disconnectors, surge arresters, positive grounding and stainless steel or fiberglass enclosures
- SolerView web-based monitoring, inverter direct, revenue grade, sub-array, agency reporting, XML feed, weather and cellular options

Solectria Renewables
Solectria Renewables

TÜV SÜD

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

TÜV SÜD offers fully customized and integrated solutions along the entire value chain. We ensure bankability of projects and optimized performance.

The TÜV SÜD Certification Mark – synonymous with quality and safety – delivering confidence worldwide.

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 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 19,000 employees across 600 locations worldwide.

Clients can rely on TÜV SÜD’s multidisciplinary approach and complete solutions, which cover the whole value chain from the manufacturing of modules and components through the investment process to operation and decommissioning. TÜV SÜD provides in-depth knowledge and experience to help clients manage risk, assuring that their business operations will run at optimized performance and maximum efficiency.

TÜV SÜD provides a range of assessment, inspection and certification services for PV investors, developers, EPC contractors, operators, manufacturers and importers. Our Certification Marks or expert reports adhere to local and global 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 assessment and 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.

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Solarpraxis AG is one of the leading knowledge service providers in the renewable energy sector. Since 1998 the Berlin-based company has been providing clients with expertise and professional service in the fields of engineering, conference organization and publishing.

Engineering
The engineering division generates up-to-date knowledge, which is then prepared for and presented to manufacturers, wholesalers, planners and trade professionals in a targeted, project-specific manner. Whether in the area of photovoltaics, solar thermal technology, heat pumps or pellets, clients receive expert and reliable support for reporting, large-scale solar projects, technical documentation, training, expert hotlines and customer service.

Conferences
The conference division focuses on organizing high-quality industry events for decision-makers both in Germany and abroad. These events are substantiated, relevant to the market and customer-oriented. Using specialist lectures and topical panel discussions, the division provides practical knowledge on market performance, finance and politics. The events are organized in Europe, Asia, North America and in the Middle East.

Publishing
The third and final component of the company’s service portfolio is its publishing department, which boasts two international brands, “pv magazine” and RENI | Renewables Insight. Since its initial publication in 2008, “pv magazine” has evolved into the top international photovoltaics magazine for decision-makers. With a global, Chinese and German edition, “pv magazine” is expanding its position as a knowledge provider. The media portfolio includes print magazines, e-papers, websites and daily newsletters.

The multilingual industry reports under RENI | Renewables Insight respond to the demand for high-quality industry and technology guides. In collaboration with professional associations, information on technology and markets is provided and companies are given an opportunity to communicate expert knowledge about their products and services.

Sunbeam Communications

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 fifteen 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 BIEGE 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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Legal Information

Important Notice, Picture Credits
Bankability of PV Projects

- Environmental impact studies (eg. glint and glare reports)
- Grid connection consulting
- Yield assessment reports
- Quality assurance reports

Our independent third party reports are accepted by all major European banks.

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www.solarpraxis.com/engineering

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EU PVSEC 2013
28th European Photovoltaic Solar Energy Conference and Exhibition

The most inspiring Platform for the global PV Solar Sector

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Paris, France

Conference 30 Sep – 04 Oct 2013
Exhibition 01 Oct – 03 Oct 2013

www.photovoltaic-conference.com
www.photovoltaic-exhibition.com

JUNE 19–21 2013
www.intersolar.de

The World’s Largest Exhibition for the Solar Industry
Messe München, Germany

Intersolar Europe gives you an insider advantage on cutting-edge information about the dynamic markets of the solar industry
- Connect with 1,500 international exhibitors
- Learn everything about the latest innovations
- Keep up with future trends for continued business success
- Get inspired!

Top information for your visit in Munich, Germany
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