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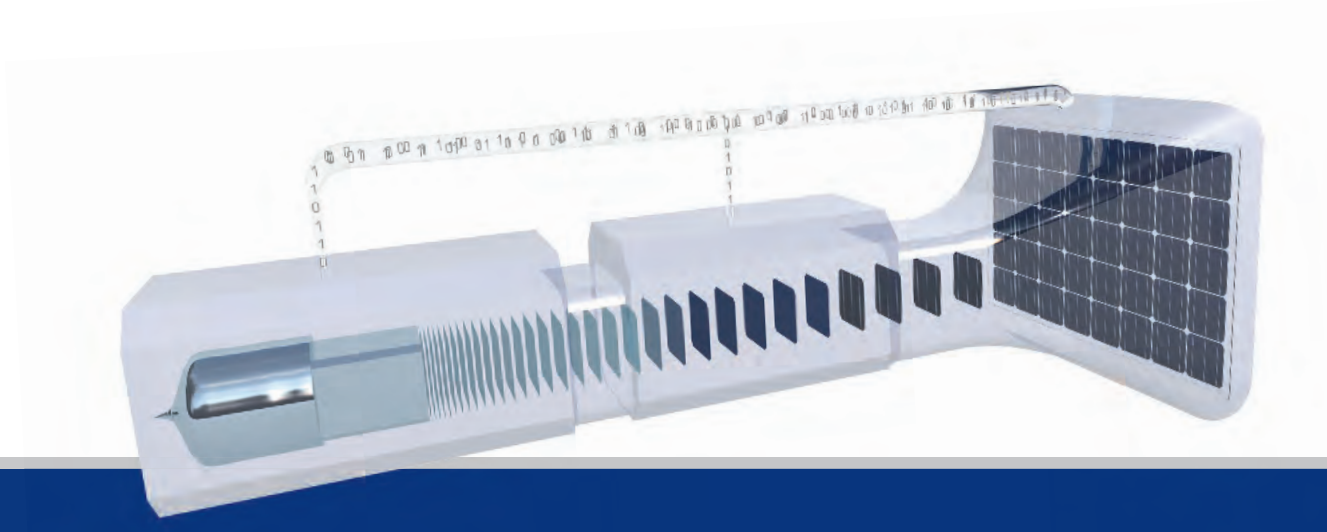

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editor's view

By david ridsdale, editor-in-chief

Technological differentiation

Photovoltaic technology was able to develop as quickly as it did by utilising the existing infrastructure of microelectronics manufacturing. While thin film technologies have also benefitted from the prior knowledge of their suppliers, it has been polycrystalline based PV that has most benefited from sharing similar materials and tool requirements with semiconductors.

Semiconductor technology trod a well-worn path towards manufacturing improvement via Moore's Law of expected returns. PV does not have the same sort of carrot driving technology forward and has so far relied on market growth to provide impetus to improve technology. The pressure for technological advances has increased following consolidation and stronger competition for market share.

PV may not have the same impetus as microelectronics but the market dynamics are similar in terms of consolidation following an oversupply as the industry matures. With manufacturers seeking technological differentiation from competitors there has been an increased pressure downstream for suppliers to reduce costs while improving performance. This is nothing new in any industry but the speed at which it is occurring was not planned or expected. There is no reason to imagine that market dynamics of semiconductors will not follow the same fast track in solar.

Semiconductor market consolidation led to a similar situation we now have in solar. Manufacturers have buying strength and place pressure on material and tool suppliers downstream to maintain margins. This is problematic for small enterprises whose only focus is solar. An example of this is the inverter sector complaining of diminishing returns in a growing market. Using the semiconductor example we are seeing the downstream impact of consolidation for a busy market sector.

The only lesson companies can take is to improve their technology offerings while holding down margins. The inverter

manufacturers have been highlighting advances and they have there own battle for market share. Like in the semiconductor industry, the manufacturers are reaping the benefit of such aggressive competition downstream.

Companies would be wise to look to the semiconductor example and note how the dynamics changed as consolidation took its toll along the value chain. The PV industry is moving faster than semiconductors and until a disruptive technology appears is likely to follow the same fiscal road. This means manufacturers may not have long to take advantage of this buyers market.

The semiconductor industry provides an excellent example of how this will play out. You only have to look at lithography giant ASML, a medium sized player a decade ago, who now have enough strength to make IC manufacturers pay up front for their future technology. As the old maxim goes, be nice to everyone in the elevator ride up to success, as you never know who will be heading up with you.

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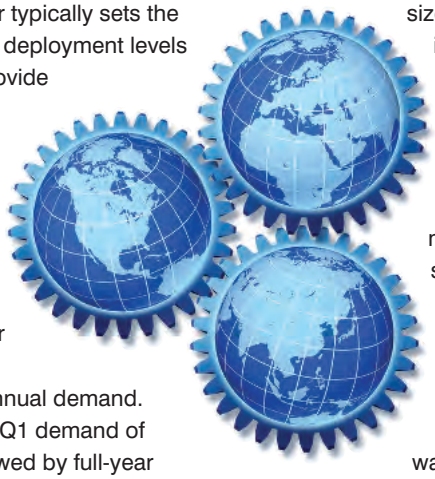
Record-breaking demand for global PV in Q1 2014

New solar photovoltaic (PV) demand added during the first quarter of 2014 exceeded 9 gigawatts (GW), which was 35 percent more than the previous first-quarter record, set last year. In fact, every quarter in 2014 is forecast to reach new highs, with trailing 12-month demand at the end of Q1 2015 forecast to exceed 50GW for the first time, according to findings in the latest NPD Solarbuzz Quarterly report.

The record level of demand achieved in the first quarter was driven by strong growth in Japan and the United Kingdom. These two countries combined accounted for more than one-third of global solar PV demand in Q1 2014 and set new quarterly records for PV deployed.

"The record demand added by the PV industry is the fifth straight year that a quarterly record has been set at the start of the year," said Michael Barker, senior analyst at NPD Solarbuzz. "While demand during the first quarter typically sets the low point for the year, deployment levels during this quarter provide an excellent means of benchmarking demand for the rest of the coming year."



Solar PV demand during the first quarter typically accounts for up to 20 percent of annual demand. In 2013, for example, Q1 demand of nearly 7GW was followed by full-year demand above 37GW. "Purely on a pro-rata basis, the first quarter of 2014 provides strong confidence that 2014 solar PV demand will indeed reach, and possibly even surpass, NPD Solarbuzz's 2014 full-year forecast of 49GW," Barker noted.

With Q1 2014 now closed, the trailing 12-month demand suggests that the true size of the industry today is almost 40 GW. By the end of Q1 2015, the PV industry will likely break through the pivotal 50GW barrier, bringing the industry much closer to rational supply and demand levels.

"During the past few years, the solar PV industry has been waiting for end-market demand to catch up with the excess manufacturing capacity added between 2010 and 2012," added Finlay Colville, vice-president of NPD Solarbuzz. "This wait is now coming to an end. As annual demand approaches the 50GW level, suppliers will finally be able to shift their focus from short-term tactical survival to long-term strategic planning."

Asian sales can't make up Chinese losses in Europe

THE CHINA CHAMBER OF COMMERCE for the Import and Export of Machinery and Electronic Products (CCCME) has released solar market figures for 2013.

Asia, led by Japan, has become the largest market for China's solar power products, as exports to Europe plummet amid ongoing trade disputes, an industry official said.

Sales of solar cells, modules and related products to Europe fell about 62 percent last year to $3.7 billion. In contrast, sales to Asian customers soared 124 percent to $5.5 billion, according to the solar division of the CCCME.

Sun Guangbin, secretary-general of the chamber, told the Intersolar China Conference that sales to Europe contracted starting in 2012, after the European Union launched an anti-dumping probe into Chinese solar products. Chinese producers have been forced to scour new emerging markets for buyers. But it hasn't been easy to find enough of them to replace sales lost in Europe. In 2013, China's total solar exports dropped 17.9 percent to $12.3 billion. Japan become the largest customer, accounting for nearly 25 percent of the total, while exports to Germany fell 75 percent to $507million.

Analysts said that as Japan continues to mothball most of its nuclear power plants, the country has accelerated its development of renewable energy sources, especially in the solar power sector. There are 5 gigawatts of projects in the pipeline for installation in the first half of the year.

"Demand from Japan will remain robust in the coming years, as the country faces a potential future without nuclear power and prices for liquefied natural gas remain high in Asia, creating demand for solar power products," said Sun.

"At the same time, we're also looking at other emerging markets with very high potential such as South Africa and India."

Although exports fell last year, China's total solar market showed continuing signs of life. Yingli Green Energy Holding Co Ltd said fourth-quarter revenue increased 28 percent to 3 billion yuan in the fourth quarter.

Li Junfeng, head of the China Renewable Energy Industry Association stated, "China's solar panel industry has just started to revive. We don't want to see a new round of anti-dumping investigations or any trade disputes but I'm concerned at solar companies rushing into Japan's market, driving down prices and causing a breakdown of their own sector."

Quality more important than price in maturing market

THE MOST CRITICAL FACTORS for buyers when selecting a photovoltaic (PV) module are reliability and quality, which were found to be more important than low prices, according to a recent survey of solar module purchases conducted by IHS Technology.

In the survey, respondents were asked to rank various PV module aspects by importance, ranging from efficiency to weight and size. The chief factor by a significant margin was module reliability, with 99 percent of respondents deeming the characteristic as either "very important" or "important."

In comparison, "high quality" was named the second most important aspect and "low price" was revealed as the third. While quality was seen as the top aspect across three major regions analyzed in the research, other attributes were regarded as weightier in some regions than others. In particular, low pricing was more significant to respondents in the United States than in Germany and the United Kingdom, where "high efficiency" was placed at a higher premium.

The survey was conducted among photovoltaic system installers; integrators; engineering, procurement and construction (EPC) entities; and distributors of PV components, who all buy modules from the makers.

"While price is still a highly important factor when selecting PV modules, purchasers believe that performance-related factors are of greater value, particularly in European markets," said Stefan de Haan, principal solar analyst at IHS. "This is a reflection of the growing awareness and focus on the total CoO of a PV plant in Europe. As incentive levels and internal rates of return (IRR) for all types of PV systems become lower and lower, the cost of every kilowatt-hour becomes increasingly important. In other markets, such as the U.S., incentives more commonly take the form of grants and tax breaks—meaning that there is a slightly stronger focus on upfront cost."

In determining the preferred brands and buying preferences of customers, the survey also uncovered that less than 10 percent of companies use a single module supplier for their entire business, with EPCs and integrators less likely to use one brand compared to smaller installers. As few as 20 percent of respondents would consider using just one brand in the future, doing so in order to obtain better pricing as well as easier system design and logistics.

The majority of customers, however, reported they would never consider using a single brand for an entire business.

"PV module purchasers demonstrate a clear preference for maintaining business relationships with more than one module supplier, as this allows them to ensure they are receiving competitive pricing and provides them with access to as wide a range of products as possible," de Haan noted. "Importantly, many also express a reluctance to rely on a single company for their total module supply, reflecting clear concerns about the survival of module suppliers and suppliers' capability to provide sufficient and flexible stockpiles."

Despite the professed preference of solar module buyers for using more than one brand, over half of customers reported having a favorite. Survey respondents were asked to list their overall preferred brands, as well their chosen names in terms of quality and price attractiveness. Three Chinese suppliers appeared among the top five overall brands, and the five top brands in terms of competitive prices were also all Chinese.

IEA report shows solar energy contribution

AFTER TWO YEARS of market and industry consolidation, the PV market grew again in the 2013. In total, about 36.9GW of PV capacity were installed in the IEA PVPS countries and the other major markets during 2013 (2012: 29.4GW; 2011: 29.2GW; 2010: 16.7GW). This raised the total installed capacity in IEA PVPS countries to 123.2GW with another estimated 10.8GW of capacity installed in other major countries.

After several years of rapid growth and a stabilization in 2012, the PV market grew in 2013 to at least 36.9GW. The Asia Pacific region represented around 59% of the global PV market in 2013, a premiere in more than a decade. While Europe still represented 59% of this global market in 2012, its market share fell to 28%, a consequence of a reduced market in Europe and a growing global PV market. The PV market in the Americas went above 5GW for the first time. The Middle East and Africa remain regions in development for the PV market. However, the most important growth was observed in China which has progressed quickly and was the very first market in 2013 with 11.3GW of PV systems connected to the grid. The second largest market in 2013 was Japan with 6.9GW, ahead of the USA, with 4.75GW and finally the first European market was Germany at 3.3GW.

The annual PV contribution to electricity demand has passed the 1% mark in 15 countries, with Italy at the top with at least 7.8 % and the overall European PV contribution amounting to around 3% of Europe's electricity demand. Australia, Japan and Israel have also passed the 1% mark but larger consumers of electricity such as China or the USA will require more PV capacity to reach this threshold.

Latin America leads manufacturing capacity expansion for photovoltaics industry

WITH CAPITAL EXPENDITURES for the photovoltaic (PV) industry set to bounce back in 2014, a new round of solar spending will commence that will reach $3.8 billion by year-end, according to IHS Technology.

PV capital spending has been rising notably over the past two quarters, en route to a third straight increase with the trend clearly continuing into the first quarter this year. Global PV capital spending is expected to rise by 45 percent in 2014 from $2.7 billion in 2013.

“Since August of last year, IHS has observed strong signs that a new capital spending cycle would start in 2014,” said Jon Campos, solar analyst at IHS. “Key factors such as market sentiment, PV demand and equipment-supplier bookings have continued to progress as a result of a healthy level of optimism.”

Most Tier 1 PV manufacturers are utilizing, expanding and planning to increase manufacturing capacity, Campos said, with an extra emphasis on expanding their presence in emerging markets. Capital expenditures are expected to climb considerably in 2014 and 2015, with Latin America leading the way.

Latin America this year will lead all regions in manufacturing capacity growth for solar panels with an expansion rate of 35 percent, slightly down from 42 percent in 2013, when it was also the global leader. Latin America is ahead of the Middle East-Africa market with 33 percent, as well as third-placed North America with 13 percent.

Next year, solar manufacturing capacity in Latin America will boast even higher growth at an outsized 147 percent, with the region continuing to lead in 2016 and 2017.

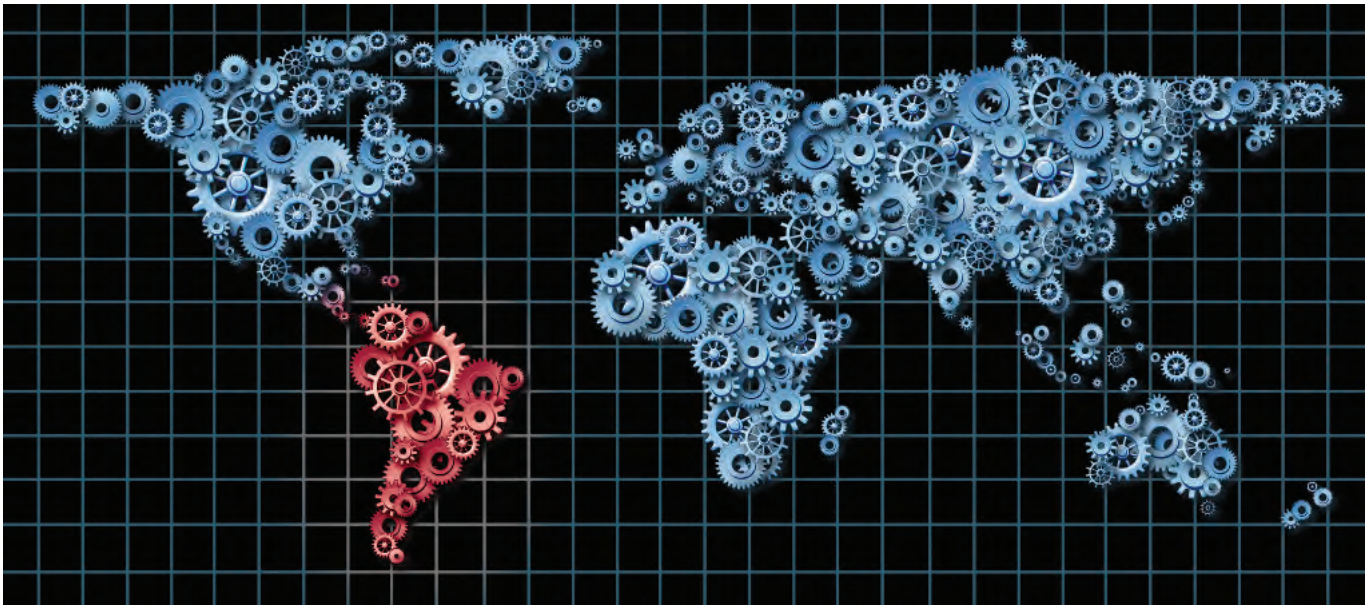
Earlier this year, Chinese manufacturer Hanergy released a statement unveiling plans to build a $500 million thin-film PV factory at an undisclosed location in the Ivory Coast of Africa. Fellow Chinese maker JA Solar has also executed a joint venture with Powerway PV, another Chinese-based PV player, for a 150-megawatt (MW) plant that is scheduled to begin commercial production in South Africa.

Meanwhile, Nigeria’s first module manufacturing plant has been completed and is now operational. The plant, in Sokoto, has been built by German firm JVG Thoma and will produce the company’s Desert range of modules, which have been designed to operate in extreme conditions. First announced last summer, the plant was part financed by the World Bank and will have a 10MW nameplate capacity. Comparable-sized manufacturing lines have also come online in Algeria in the last quarter.

In Latin America, Brazilian PV company Solar-Par Participações aims to build a vertically integrated solar module production facility in Teófilo Otoni, in the SE Brazilian state of Espírito Santo.

The factory, which would produce ingots to modules using an unspecified technology, requires an investment of $103 million, and will have an annual capacity of 95MW. The company plans to immediately submit its project proposal to environmental authorities, and it hopes to begin production at the facility in early 2015. Solar-Par intends to eventually establish a research and development center at the facility as well, which will necessitate an additional investment of $5 million.

In its latest quarterly report, IHS states that order activity for major equipment suppliers has been trending upward for the past two quarters and is forecast to continue doing so for another two quarters until at least the second quarter of 2014.



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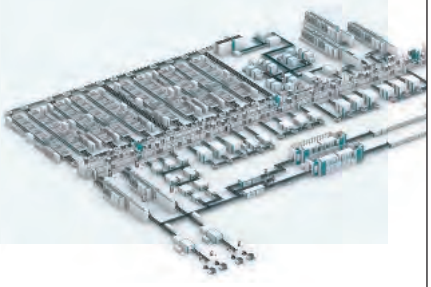

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IHS reports on changing inverter market

IN A SIGN of their growing acceptance, string inverters are increasingly being considered in megawatt-scale PV systems, with over 40 percent of inverter buyers regarding them as suitable for use in systems larger than 1MW, according to a new report from IHS Technology.

In an IHS survey, more than 300 solar installers, distributors and engineering, procurement and construction (EPC) companies were asked about their preferences and opinions on PV inverters, in order to help suppliers better understand the needs and requirements of their customers.

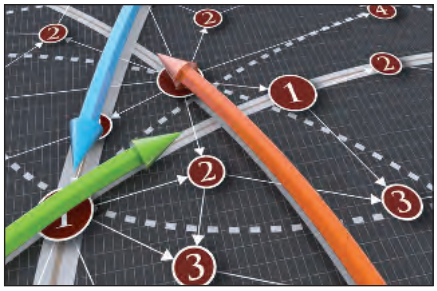
Of the more than 200 purchasers of PV string inverters that completed the survey, 80 percent indicated they might use string inverters in systems larger than 100kW. All told, nearly half reported they would consider using the inverters in systems larger than 1MW.

This marks an increase from the previous year's survey when only 17 percent considered using string inverters in systems larger than 1MW.

"The survey confirmed that the acceptance of string inverters in large systems has accelerated over the last year, mirroring the IHS forecast that these products will gain share in several key PV markets," said Cormac Gilligan, senior PV market analyst at IHS. "The most common reasons given for solar purchasers preferring string inverters increasingly over central inverters in large systems were better system design flexibility, minimizing losses in the case of failure and lower lifetime system costs."

IHS predicts that low power three-phase inverter shipments will increase by 14 percent a year on average for the next four years, with annual shipments of nearly 20 gigawatts (GW) in 2017.

The report also found that Chinese-made inverters are gaining increased acceptance in places such as the United States, Germany and the United Kingdom.



Chinese inverter suppliers appear to be overcoming the perception that their products are not of adequate quality.

When buyers were asked the question, "Do you think Chinese inverters offer sufficient levels of quality?" half answered yes. This shows that the level of acceptance for Chinese inverters has increased for a second consecutive year.

The biggest increase was recorded in United Kingdom, where nearly 60 percent of inverter buyers consider Chinese inverters to be acceptable quality, compared to 40 percent in the U.S.

"The last two years have seen the United Kingdom transform quickly from a booming new market with a highly attractive feed-in tariff (FiT), to a steady-growth, low-cost region with lean subsidies," Gilligan noted. "As a result of high price pressure in the U.K., the country has become a strong focus for Chinese suppliers, which have been able to gain a foothold in Britain."

More entities are buying microinverters in 2013, according to the survey, with 42 percent now utilizing such products. The US continued to show the highest levels of microinverter usage, while larger gains came from the European markets.

"Following several years of intense marketing and training for installers, microinverters have now progressed from being a 'niche' product, to gaining wide acceptance in the PV market," said Gilligan. "Major suppliers, such as SMA and Power-One, have also released microinverters—helping them to gain acceptance and traction in key markets."

Grid parity in parts of Europe

THE RESULTS of the third issue of the study "PV Grid Parity Monitor", carried out by the consulting firm ECLAREON show that photovoltaic grid parity is an economic reality in the commercial segment in Germany, Italy, and Spain. The Grid Parity Monitor (GPM) analyzes competitiveness of the PV technology with retail electricity prices in one sunny city of 7 different countries: Brazil, Chile, France, Germany, Italy, Mexico, and Spain. According to the study, in the last semester of 2013, the cost of PV generation decreased in all of these cities.

In spite of this improvement most LatAm country's high installation prices prevent PV being competitive against grid electricity. The majority of these countries have been facing retail electricity price decreases. In contrast, European countries such as Germany, Italy, and Spain have reached grid parity, with France as the only exception, as high irradiation levels and relatively low installation prices are offset by low electricity rates in the country.

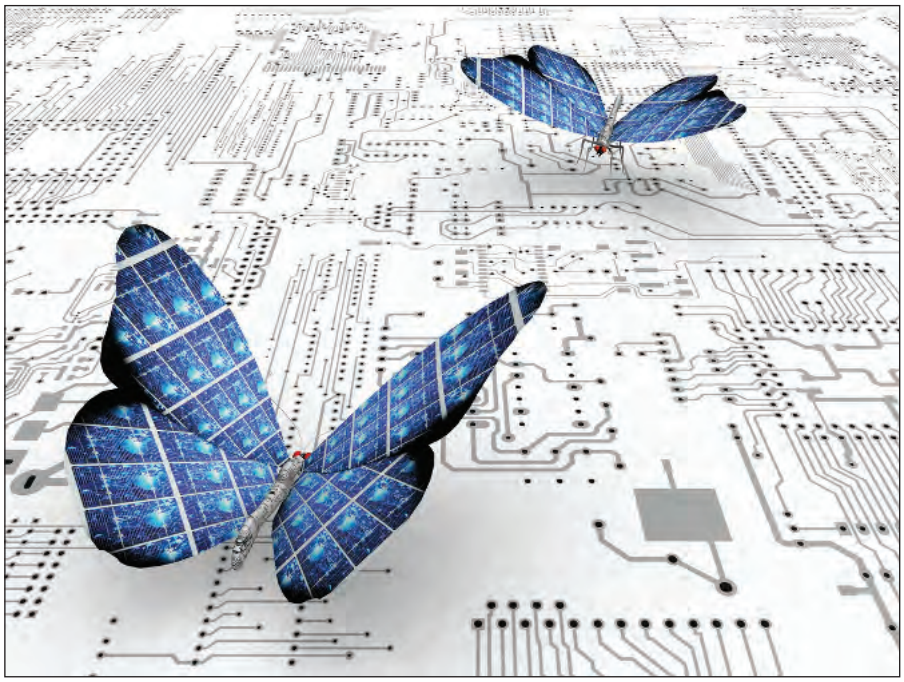
"In countries such as Brazil and Mexico, self-consumption is being encouraged by an effective regulatory mechanism, which allows prosumers to feed their excess generation into the grid for later consumption", states David Pérez, partner of ECLAREON in charge of the study.

The study remarks that grid parity by itself is no guarantee of market creation. PV self consumption will be fostered if grid parity is combined with governmental support.

According to Pérez, "in countries such as Italy and Germany, both at grid parity and with proper regulation, PV systems for self-consumption represent a viable, cost-effective, and sustainable power generation alternative".

HCPV driving towards cost comparable status

CONSISTENT IMPROVEMENTS in technology and gradually lower costs will drive high-concentration photovoltaic (HCPV) systems to superior efficiencies, making HCPV an increasingly viable rival to conventional solar-generating solutions, according to the latest analysis from IHS Technology.



The cell efficiency of HCPV systems, currently at 40 to 42 percent, will exceed 45 percent by 2017. Such cells, used with concentrating optics, will then lead to commercial-system efficiencies approaching 40 percent, compared to the less than 35 percent conversion rates typical at present, as shown in the attached figure.

"Efficiency is the most important requirement in CPV technology in order to generate competitive energy costs," said Karl Melkonyan, photovoltaic analyst at IHS. "And with the solar industry continuing to be firmly engaged in a quest for ongoing improvements through the development of new technologies, the efficiency of HCPV cells will advance over the years."

The anticipated improvements in HCPV systems are based on cell efficiencies having reached 44.7 percent in laboratory conditions, indicating that further advances are possible.

Even so, the gains in efficiency will have to be balanced against the additional manufacturing costs expected to be incurred when implementing the improvements, Melkonyan noted. These findings can be found in the report, "CPV on the Edge of Breakthrough," from the solar research service at IHS.

Driven by falling system prices, HCPV is gradually becoming attractive in several regions of the world. IHS forecasts that the United States and Central America will install the largest number of HCPV systems between 2012 and 2017, serving as the world's biggest regional market. Installations for the region reached 54.1 megawatts in 2012. Most HCPV suppliers are, in fact, based in the United States, and their forays into the domestic U.S. market will provide notice to rival conventional PV suppliers. Mexico is also forecast to become a large part of this regional market, with plans in place for a 450-megawatt installation.

Meanwhile, enormous growth will occur in South America, where the HCPV market is projected to surge by 560 percent from the time installations start in 2013 until the end of the forecast period in 2017. The primary driver of South American expansion is Chile, which has the world's highest solar irradiation levels important for solar-power generation.

But the greatest increase in the HPCV market will take place in the Middle East and Africa region. HCPV installations for the region—excluding South Africa, which is tracked separately because of its more advanced PV market—will grow to 155 megawatts in 2017, up from just 1.8 megawatts in 2012. Morocco and Saudi Arabia will be the main drivers.

China could also emerge as an important player soon as suppliers from the country grow in number, with parts of southwest China shaping up to become prime HCPV locations.

Unable to keep pace with the dramatic cost and price reductions that conventional PV saw, many CPV pioneers faced financial difficulties in the course of the PV price collapse that took place in 2011 and 2012. Numerous formerly leading companies—among them SolFocus and GreenVolts from California, as well as Opel Solar from Connecticut—ceased operations or became insolvent.

The industry has regained stability since 2013, however, and advances in new technologies continue to reduce costs. Just the same, only a few survivors are left from that tumultuous period, and those that remain are the ones with large cash balances and the most cost-efficient technologies. .

Among the major players, the two biggest CPV manufacturers—Suncore Photovoltaics from China and Soitec Solar from France—will each be expecting HCPV installations of about 50 megawatts by the end of the year.

Suncore and Soitec—along with top five suppliers Solaria and SunPower from California, and Magpower SA from Portugal—account for more than 80 percent of the CPV market at present. Two other manufacturers—Heliotrop from France and North Carolina-based Semprius—could also join the ranks of the top 10 this year.

First Solar sets CdTe record again

FIRST SOLAR has announced it has set a world record for cadmium-telluride (CdTe) photovoltaic (PV) module conversion efficiency, achieving a record 17.0 percent total area module efficiency in tests performed by the U.S. Department of Energy's National Renewable Energy Laboratory (NREL). The new record is an increase over the prior record of 16.1 percent efficiency, which the company set in April 2013. This announcement comes weeks after First Solar announced it achieved a world record in CdTe research cell efficiency of 20.4 percent.

The record-setting module was created at First Solar's Research and Development Center in Perrysburg, Ohio, using production-scale processes and materials, and included several recent technology enhancements that are incrementally being implemented on the company's commercial production lines.

Notably, the First Solar research module also has a confirmed "aperture area" conversion efficiency of 17.5 percent. Many manufacturers often quote this aperture area efficiency when claiming record performance, particularly for small mini-modules custom-built in R&D labs. First Solar's record is all the more significant because it is full production size.

"This achievement demonstrates our ability to rapidly and reliably transfer research results to full-size modules. We can take CdTe innovation from the lab to production faster and more reliably than other technologies due to our robust, adaptable manufacturing processes and the accommodating nature of CdTe material technology," said Raffi Garabedian, First Solar's Chief Technology Officer. "Our R&D efforts are delivering technology that will quickly be scaled to real-world application as part of our integrated power plant systems, which are engineered to deliver the best performance, reliability and value for our customers."

Garabedian said the efficiency milestone is also a signal that First Solar's CdTe modules are becoming a more attractive option for application in constrained space projects and commercial/industrial installations. "With the highest demonstrated thin-film module performance, we are positioned to pursue new deployment opportunities around the world," he said.

Based on the company's sustained high velocity in technology development, Garabedian said First Solar has accelerated its production module conversion efficiency roadmap, raising its lead-line production nameplate efficiency target for YE2015 to 15.6 to 15.8 percent. First Solar also extended its module conversion efficiency roadmap to 2017, with targets for year-end lead-line production nameplate efficiency of 17.7 to 18.4 percent in 2016 and 18.1 to 18.9 percent in 2017.

Solar Frontier sets thin-film record with 20.9% CIS cell

SOLAR FRONTIER, in joint research with the New Energy and Industrial Technology Development Organization (NEDO), has achieved 20.9% conversion efficiency on a 0.5cm^2 CIS cell. This is a world record conversion efficiency for thin-film photovoltaic technologies, beating Solar Frontier's previous world record of 19.7% conversion efficiency for CIS thin-film cells that do not contain cadmium, on top of the previous-best 20.8% cell efficiency record set for all thin-film PV technologies. The result has been independently verified by the Fraunhofer Institute, Europe's largest application-oriented research organization.

"Solar Frontier's new 20.9% efficiency record resulted from a CIS cell cut from a 30cm by 30cm substrate produced using a sputtering-selenization formation method - the same method we use in our factories. The significance is twofold: it ensures we can transfer our latest achievement into mass production faster, and it proves the long-term conversion efficiency potential of Solar Frontier's proprietary CIS technology," said Satoru Kuriyagawa, Chief Technology Officer of Solar Frontier.

Conversion efficiency is a popular measurement used to compare the performance of solar modules. Actual performance after installation, however, depends on how differing PV technologies react to their surrounding environment and climate. Solar Frontier's CIS modules are proven to generate more electricity (kWh/kWp) in real operating conditions than crystalline silicon modules.

Together with high automation and precision manufacturing in Japan, CIS modules provide long-term competitive and reliable returns on investments for customers.

Solar Frontier's latest efficiency record was achieved at the Atsugi Research Center (ARC) in Kanagawa, Japan. As part of the ARC's customer-centric approach, it focuses on boosting the conversion efficiency of its CIS modules, developing its proprietary mass production machinery, and reducing overall system costs for end users. The ARC has been at the forefront of advancing CIS technology, setting numerous world records since it was established in 2009.

RENA seeks self adminstration in dealing with insolvency

RENA GmbH plans to continue its on going restructuring as part of its insolvency proceedings under self-administration. The management submitted the relevant application to the responsible district court in Villingen-Schwenningen. This step became necessary because the financing solution discussed among the financing partners in recent days unexpectedly fell through due to joint liability issues related to debts of the subsidiary SH+E, which has been insolvent since 19 February. The application filed today only applies to RENA GmbH. The other domestic and foreign subsidiaries of the RENA Group will continue operating as usual. The financing partners and important principal creditors support this step.

"Our core business at RENA has developed positively over recent months. The fact that SH+E filed for insolvency on 19 February also means we have prevented a further outflow of capital. On this basis, we were confident of completing our restructuring with the support of our financing partners. The financing solution ultimately fell through as we could not rule out joint liability for debts of SH+E," explains RENA founder and shareholder Jürgen Gutekunst. "For the onward restructuring process we are counting on the support of our customers, suppliers and creditors. At the same time, we intend to maintain responsibility for continuing our fundamentally sound business, as we are convinced that this is how we can generate the maximum value for all stakeholders. A self-administration insolvency is a restructuring tool that allows us to do both these things,"

A self-administration insolvency enables RENA GmbH to independently restructure the company under the supervision of a court-appointed custodian and on the basis of a future concept agreed with the creditors. The administrator will ensure that the legal regulations are adhered to and will also secure creditors´ interests. During this phase the company is largely protected against enforcements of judgements and coercive measures

by the creditors, and it remains fully operational.

Business at RENA GmbH and the other RENA Group companies is therefore continuing as usual. Furthermore, in recent weeks the level of orders received in RENA´s core business of machine building has picked up. So far in 2014 RENA has gained new contracts with a volume of around EUR 22m. Orders in hand currently amount to over EUR 100m. There are further signs of an upswing in the solar market and for applications in medical technology, circuit board and semiconductor production.

After consulting with the creditors, the owners of RENA GmbH have appointed the restructuring expert Thomas Oberle from the law firm Wellensiek to the management with immediate effect.

A lawyer and a specialist in maintaining companies during insolvency, he will support the RENA GmbH with its restructuring. In particular he will be responsible for the self-administration and will significantly manage the development of the future concept, acting as a mediator between the creditors and the company.

During the ongoing reorganisation Mr. Eckhard Rau stepped down from his position as CFO with immediate effect, to accompany the insolvency proceedings at Hager + Elsässer GmbH exclusively and to concentrate on its future and M&A process.

Decline seen in European inverter market

SMA's full year financial results have reinforced IHS' previous predictions of a major decline in the European PV inverter market. IHS estimates that PV installations in Europe declined by 37% in 2013. This slump in demand ignited a severely competitive price war which led to European PV inverter market revenues declining by a huge 46% to $2.1 billion.

Europe accounted for 33% of the global inverter revenues in 2013, compared to nearly 60% in 2012.

Although SMA weathered this storm better than many of its smaller European competitors, some of which have exited the market during the last 12-18 months, its share of the global PV inverter market fell to approximately 17% in 2013. SMA's market share had previously stood close to 40% in 2009, but has now declined for five consecutive years. Its lead over the second largest supplier (Power-One/ ABB) has narrowed by 4 percentage points compared to 2012.

In order to remain a top supplier, it is critical for SMA that it delivers on its promises of cost reduction and expansion into China, Japan and other emerging markets that will offer growth opportunities in the future.

Many of its plans in this area are tied to its recent M&A activity. However, Zeversolar remains a loss-making asset, and although its newly formed relationship with Danfoss will enable savings through greater component purchasing power, further cost reductions through technological improvements are unlikely to be significantly improved by the merge.

IHS expects China and Japan to account for 44% of PV installations in 2014 and 35% of inverter revenues. SMA currently has a very minor position in both of these markets.

SMA to acquire Danfoss inverter business

SMA Solar Technology and Danfoss A/S have announced plans to enter into a close strategic partnership. The two system technology specialists will take advantage of economies of scale and joint development initiatives. Danfoss will acquire 20% of SMA's outstanding shares and in return plans to sell its complete solar inverter business to SMA.

"The strategic alliance with Danfoss strengthens SMA's leading position in the global photovoltaic market. We are faced with a highly competitive market environment and increased price pressure. In this context, SMA will benefit from Danfoss' years of experience in automated drives.

This market has been characterized by fierce competition for a long time. Accordingly, the strategy of the Danfoss group targets continuous cost improvements through global sourcing and cost down initiatives. By establishing a close cooperation there is significant potential to improve the cost position in both companies," says SMA CEO Pierre-Pascal Urbon.

With the acquisition of Danfoss' solar inverter business, SMA will increase the attractiveness of its product portfolio. After the completion of the transaction SMA will launch new products for the fast growing market segments of medium-sized photovoltaic plants in Europe, China and the USA.

"With the strong cooperation between Danfoss, as a leading specialist in the field of drives, and SMA, with a unique positioning in the solar inverter market, both companies will create one of the world's largest converter alliances with a global presence.

A shareholding of 20% in SMA is a bold statement and proves our continued dedication and confidence in the solar business. We are committed to drive innovation and competitiveness by integrating Danfoss know how from the drives technology to the photovoltaic inverter business. Danfoss will certainly benefit from economies of scale and the high growth rates of the solar industry," explains Niels B. Christiansen, President and CEO of Danfoss.

Danfoss will receive 6.94 million of SMA shares at a price of €43.57 per share from the SMA founders, their trusts and families. The cash consideration corresponds to a premium of 50% to the volume-weighted average share price over the last 60 days. The transaction volume amounts to €302,38 million. After completion of the transaction the freely tradable free float of the SMA share will be at 25.05%. The SMA founders, their trusts and families will hold 54.95% of the SMA shares after the transaction is completed. Danfoss will not buy or sell shares for a lock-up period of at least 2 years. The share purchase is subject to regulatory approval. Closing of the acquisition of shares and the cooperation contract is expected within Q3 2014.

SunEdison manufactures over 1GW of PV modules

SUNEDISON has announced that they have shipped over 1GW (gigawatt) of Silvantis Solar PV modules, making them one of the top 5 solar module manufacturers in the world. Growth was driven by strong demand for high performance solar modules from SunEdison's utility and commercial business groups and external customers.

"This is an exciting time for SunEdison because we have created a business model that leverages our innovations in silicon and module technology while minimizing capital requirements," Gokul Krishnan, Module Business Unit General Manager, Solar Modules, SunEdison, said. "With our advanced silicon and crystal technology we were able to design highly efficient and reliable solar modules. To limit capital outlay we partnered with experienced contract manufacturers who assemble our modules to specification, under rigorous quality control. Hitting the 1GW milestone in less than 3 years is a tremendous achievement."

Production of solar modules is a key element in the vertical integration of SunEdison's energy business. SunEdison produces the silicon, specifies the technology and production of solar modules, develops business across all key global market segments, and provides ongoing monitoring of completed solar power plants.

"The dedication and excellence of our team, our advanced technology, and the tremendous support of our partners has enabled us to achieve our production goals faster than planned" said Dave Ranhoff, president, Solar Materials, SunEdison. "Our focus on delivering the most advanced, lowest cost solar modules, in the most capex efficient way, is unwavering."

SunPower sells over 70 Megawatts in Inner Mongolia

SUNPOWER CORPORATION has announced the sale of more than 70MW of cell packages to the Huaxia Concentrated Photovoltaic Power, joint venture (JV) in Inner Mongolia, China.

These packages will be used for the first phase of two SunPower C7 Tracker (C7) projects, which includes a 20-MW project in Saihan and a 100-MW project in Wuchuan. Both are located in Hohhot, Inner Mongolia and completion is expected in 2015.

"The announcement is a first step in our aggressive efforts to break into the Chinese market," said Tom Werner, SunPower president and CEO. "Working together with our strong local partners, we believe that we can deploy significant volumes of our SunPower C7 Tracker power plants to help serve China's growing need for clean power."

The definitive agreement for the Huaxia Concentrated Photovoltaic Power JV was initially signed in December of 2012, and officially approved and registered in November of 2013.

The JV includes SunPower, Tianjin Zhonghuan Semiconductor Co., Ltd., Inner Mongolia Power (Group) Co., Ltd. and Hohhot Jinqiao City Development Company, Ltd. Its focus is to manufacture and deploy SunPower's proprietary C7 concentrator technology in the Chinese market.

To date, a 300-MW C7 receiver manufacturing facility has been set up in Jinqiao Development Zone, Hohhot, Inner Mongolia, and a 50-MW production line is now in operation.

The C7 combines single-axis tracking technology with rows of parabolic mirrors that reflect light onto SunPower's high efficiency, third-generation Maxeon solar cells with efficiencies of up to 24.5 percent.

These mirrors will reduce the number of cells required to generate electricity, lowering the levelized cost of energy when compared to competing technologies. For example, a 400-MW C7 power plant requires less than 70 MW of SunPower cells.

Through significant localization of C7 manufacturing and supply chain, and deployment of the C7 for large-scale power plant projects, it is expected that this venture will facilitate the development of a low cost, high volume supply chain and accelerate the cost reduction roadmap of this product.

LDK reassures creditors as NYSE threatens delisting

LDK SOLAR, in provisional liquidation and its Joint Provisional Liquidators, Tammy Fu and Eleanor Fisher, both of Zolfo Cooper (Cayman) ("the JPLs") in response to the announcement by the NYSE of its decision to suspend trading in LDK's American Depositary Shares and to commence delisting proceedings, wish to reiterate their commitment to continuing to work with LDK Solar's offshore creditors to achieve the restructuring of LDK Solar's offshore liabilities.

The JPLs are evaluating all of their options with respect to the NYSE's announcement, and are greatly encouraged by the significant progress made since their appointment.
As announced by the Company, restructuring support agreements have been signed by holders of approximately 60% in aggregate principal amount of the Company's 10% Senior Notes due 2014 (the "Senior Notes RSA") and by holders of approximately 79% of the convertible preferred shares issued by an affiliate of the Company and involving claims against the Company.

The Company has obtained a signed commitment letter from Heng Rui Xin Energy, an existing shareholder of the Company, to provide interim financing up to an aggregate principal amount of US$14 million.

The execution of both the Senior Notes RSA and the Preferred Obligations RSA together with the commitment to the Interim Financing represent a significant and positive step for the Company in its efforts to restructure its offshore obligations, and the JPLs intend to seek the sanction of the Cayman court for LDK Solar to enter into the Senior Notes RSA, the Preferred Obligations RSA and the Interim Financing at a hearing scheduled for April 2, 2014.

Largest Latin American PV plant in operation

EVERSTREAM ENERGY CAPITAL MANAGEMENT has announced that a group of investors, led by EverStream and Claro y Asociados and including SunEdison, has recently closed on the 50.7 MWp solar power plant (known as "San Andres") located in the Atacama Region of Chile, near the city of Copiapo.

SunEdison developed the San Andres project and will retain a partial equity position. It is the largest merchant solar power plant in Latin America and one of the largest such plants in the world.

In November, 2013, the project received $100.4 million in non-recourse debt financing from the Overseas Private Investment Corporation (OPIC), the U.S. Government's development finance institution, and International Finance Corporation (IFC), a member of the World Bank Group. In addition to the debt financing provided by OPIC and IFC, the project received a Chilean peso denominated VAT facility from Rabobank equivalent to US $25.6 million.

San Andres is distributing energy directly into the Central Interconnected System (SIC) and selling the energy on a merchant basis, with prices determined by the spot market instead of a long term off-take contract. The peak coincidence of solar irradiance and spot electricity prices makes solar PV a competitive alternative to traditional energy sources.

"Closing financing on the San Andres project is another important milestone as we continue to build our solar power project portfolio," said PJ Lee, Managing Partner of EverStream Energy Capital Management. "As one of the largest solar merchant power plants, this project will bring advanced solar generation technologies and advanced operation and management practices to Chile."

"Our Private Equity team is excited to announce the closing of this project," said Javier Contreras, Managing Director of Claro. "This transaction leveraged Claro's unique combination of industrial and project finance expertise to deliver

renewable energy exposure for the sophisticated group of investors involved. We are happy to have had the opportunity to partner with EverStream and SunEdison on this landmark solar project, and look forward to working together in the future."

"As one of Latin America's first merchant solar plants, The San Andres merchant PV plant demonstrates that solar PV is already a competitive energy source in countries like Chile," said Jose Perez, SunEdison Vice President and Head of Europe and Latin America. "We are very pleased to maintain a long term ownership stake in this project alongside our investment partners, including EverStream and Claro."

China Singyes results reveals changing dynamics

CHINA SINGYES SOLAR has announced its audited annual results for the year ending December 31, 2013. The Group continued its focus on consolidating and developing solar energy related businesses, including solar EPC and sale of new energy and new material goods, with the total revenue increasing 34% to RMB4,151 million; and net profit surging by 49.3% to RMB491 million.

During the year, the revenue of solar EPC business increased 76.2% to RMB1,889 million; while the gross profit margin was 29.5%. The Group completed a total of 340MW solar EPC project in FY2013.

In January 2014, the Group signed a MoU with Gansu Wuwei municipal government to develop approximately 1.1GW of solar power station in Wuwei City over the next 5 years. The Group will take part in developing the EPC as well as sourcing suitable investors and helping them to get relevant permits.

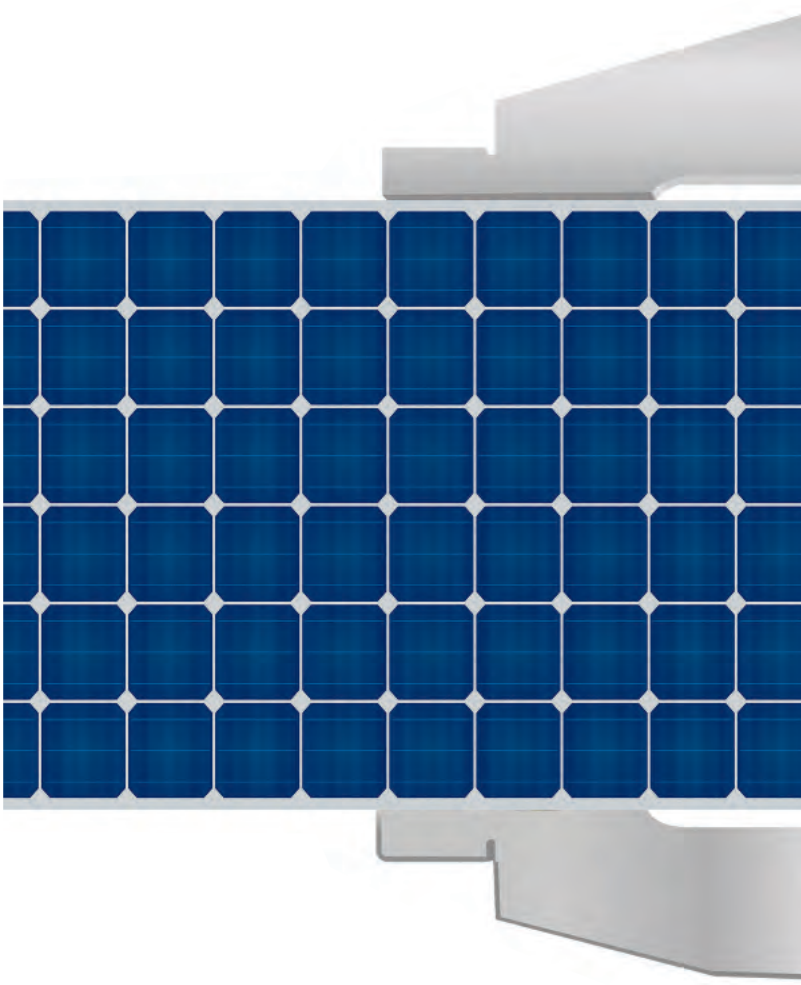
As of the end of last year, the Group has completed approximately 195MW of self-developed solar projects, while approximately 115MW projects were under the Golden Sun Program. The Group also sold approximately 15MW of solar projects in Guangdong to a third party. The net gain on selling these 15MW projects was RMB19.62 million. In recent years, the Group has launched a number of new energy and new material goods, including solar photovoltaic materials, air-source heat pump, solar heat collectors and solar heating system as well as Indium Tin Oxide (ITO) film and ITO embedded glass.

The revenue and gross profit margin of sale of new materials have increased due to improvement in technology. Solar EPC project's order on hand As announced in mid-January 2014, the Group had approximately 320MW of solar EPC projects on hand, which is close to the total solar EPC delivery in 2013. Conventional curtain wall business In view of the Group's shifted focus towards the solar business, the revenue contribution from the curtain wall engineering projects and sales of curtain wall materials to the total revenue has dropped to 38%.

Mr. Liu Hongwei, Chairman of China Singyes, said, "Following the Group's expansion into the solar application market in China in 2007, we have recorded a significant growth in the solar EPC business over the past few years, because of the strong support provided by government policies. We believe the Mainland China will soon become the largest solar user in the world."

The value of **performance measurement** in PV

A consolidating market pushes companies to differentiate their product's attributes and an area that directly relates to financial outcomes is power performance measurement. Meyer Burger's competence centre for measurement technologies, Pasan SA, discusses why measurement uncertainty is so important in realising the best return on PV cells and modules.



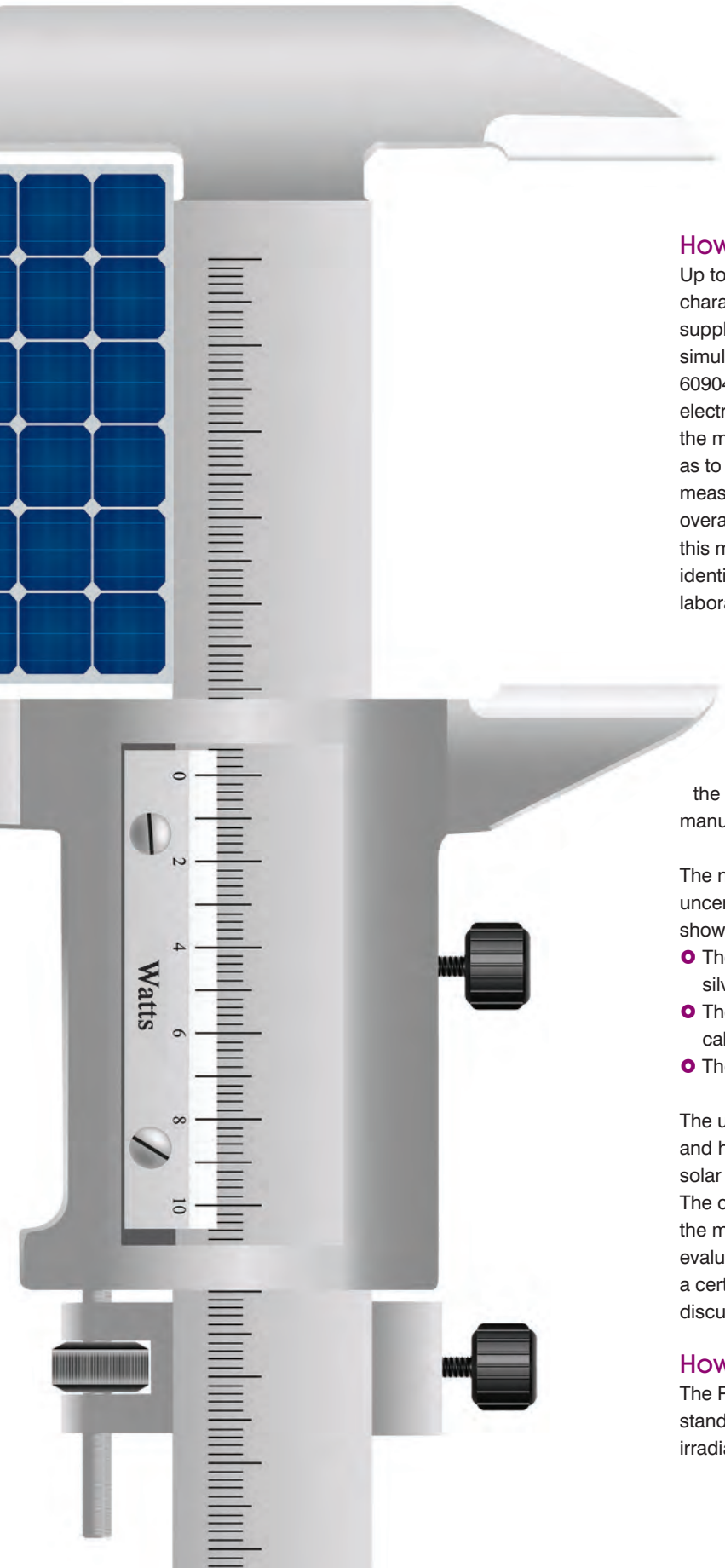
THE POWER RATING of photovoltaic devices, whether cells or modules of standard or high efficiency technologies, is commonly related to their electrical parameters, namely the maximum power (Pmax), the short-circuit current (Isc) and the open-circuit voltage (Voc). The measurement of these parameters is carried out using a solar simulator and the result enables the sales price of the PV devices to be fixed, based on the Pmax in $/W.

This power rating has to be "right" for both the buyer and seller of the cells and modules. For a measurement system, "right" means that the uncertainty of the measurement is low, i.e. the measurement is accurate and precise. The cell or module manufacturers provide the nominal power or efficiency being supplied usually together with a tolerance range expressed in ± W values for power. The tolerance appearing on the manufacturer's documentation must be consistent with the uncertainty of the power measurement. An unreliable measurement, if nominal power is over estimated, is a cause that will breach the trust between the manufacturer and the customer. Besides the detrimental impact on the brand, the module manufacturer will bear legal costs if the claim goes to court. An unknown uncertainty poses a risk not to achieve the promised performance.

The manufacturer may choose to cover the uncertainty range for the customer and bear the cost of doing so. As an example, when a module's Pmax is measured to be 200±10W, manufacturers can choose to report its performance to be 190W. This lost power (10 W) is the cost of uncertainty that the manufacturer incurs. On the flip side, if the manufacturer does not take it into account, the cost of uncertainty will be borne by the buyer.

So every percentage point of uncertainty counts. For instance, to cover an increase of the measurement uncertainty of 1% for a production output of 200 MW at 0.5 $/W could cost the module manufacturer up to 1 million $ a year. Note that this 1% value difference is the estimated difference between an $A^+A^+A^+$ and an AAA class solar simulator. So a larger measurement uncertainty will lead to higher costs.

The same is true for the power measurement at cell level. Significant R&D efforts are being made to gain an absolute



0.1% of efficiency. This gain will vanish through poor measurement accuracy. Furthermore, poor cell sorting will increase the cell to module losses and lower the harvested energy (kWh).

How to assess uncertainty?

Up to now the overall measurement uncertainty was not a characteristic that was generally given or discussed by the supplier of a solar simulator. Usually, only the class of a solar simulator is given (according to the international standard IEC 60904-9), the accuracy of the measurement channels of the electronic load (IEC 60904-1) and sometimes the repeatability of the measurement in different conditions. So the question arises as to how to use these given values to determine the power measurement uncertainty in production. In the end it is only the overall measurement uncertainty matters. In order to assess this measurement uncertainty, the uncertainty sources must be identified and quantified. These have been well established for a laboratory environment.

However their identification in a production environment has been an open question till recently. Meyer Burger's centre for measurement excellence, Pasan SA, in partnership with ESTI, the PV Lab of the European Community and TÜV Rheinland studied this topic and listed the main measurement uncertainty sources in a PV module manufacturing environment.

The numerous parameters which contribute to the overall uncertainty in production can be grouped into 3 main sources shown in Figure 1:

- The uncertainty of the reference cell or module (golden or silver sample)
- The QA process of the manufacturer (operators' skills, calibration procedures, environment, temperature, etc.)
- The uncertainty of the solar simulator.

The uncertainty of the reference module is given by test institute and has to be taken as a given. The uncertainty related to the solar simulator itself is under the direct control of the provider. The customer process errors also have an important impact on the measurement reliability. It is very difficult to quantitatively evaluate these impacts but solar simulator manufacturers can to a certain degrees assist in minimizing them. These points will be discussed in this article.

How to choose your solar simulator?

The PV performance measurement is defined by the IEC standards at STC (Standard Testing Conditions given for an irradiance of 1'000 W/m^2, a temperature of 25° C and the AM1.5

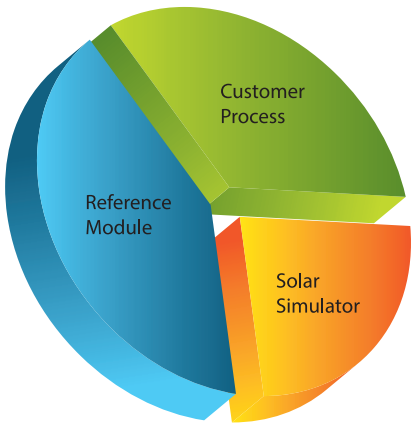


Figure 1. The three main causes of PV measurement uncertainty

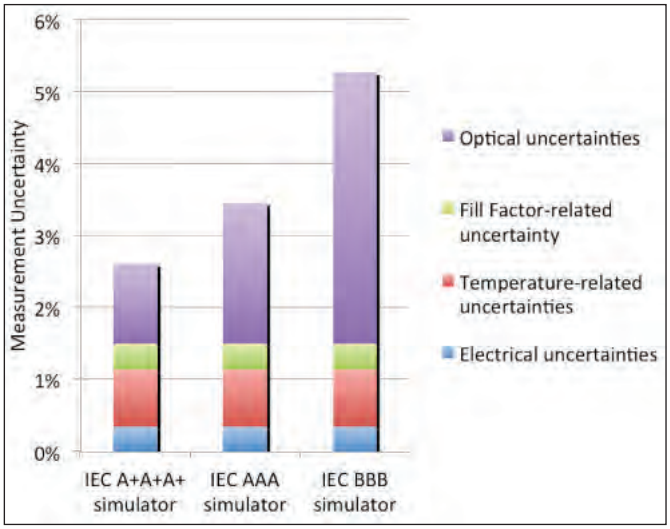


Figure 2. Breakdown of the uncertainties associated with the simulator

solar reference spectrum). The main parameters that influence the solar simulator's contribution to the measurement uncertainty are:

- The spectral match: how close is the spectral content of the simulated light to the refer-ence solar spectrum (AM 1.5)
- The uniformity on the entire illuminated area
- The stability of the light irradiance during the illumination

Based on the first three parameters which determine the quality of the light source, the IEC standard ranks the solar simulators into classes: the best being AAA and the worst being CCC. Over the past few years technological progress has led to the development of improved simulators and the TÜV Rheinland has defined a higher class $A^+A^+A^+$, with twice better performance than AAA (Table 1).

For a given simulator these values are provided by the supplier. Some certification bodies, such as TÜV Rehinland, check and certify that the real performance of the solar simulator complies with the one given by the supplier as is the case for Pasan.

The question which then arises is how the choice of the simulator will impact the uncertainty of measurement. In addition to the parameters defined by the standard, there are other influences which must be taken into account when evaluating this point:

IEC 60904-9 /-1	Pasan $A^+A^+A^+$	AAA	BBB
Spectral match	< ±12.5 %	±25 %	±40 %
Non-uniformity	< 1.0 %	2 %	5 %
Instability	< 1.0 %	2 %	5 %

Table 1

Uncertainty on Pmax	Pasan $A^+A^+A^+$	AAA	BBB
	3.1 %	4.1 %	8.6 %

Table 2

the spectral and also the irradiance uniformities over space and time during the flash, the PV technology to be measured (the IEC standard mostly focuses on standard crystalline cells), the spectral contribution of energy out of the 400-1'100 nm range, the dynamic and thermal behavior of the electronic load and the electrical contacting system, particularly for cell testers.

The impact of the solar simulator and the reference panels on the measurement uncertainty are given in Table 2. To better understand how these values have been obtained, a breakdown of the various contributions have been illustrated in Figure 2. The main source of the contribution to the uncertainty of the simulator is optical quality of the simulator. An $A^+A^+A^+$ simulator yields a measurement with 1% better uncertainty than an A class simulator. The latter has, as mentioned above, a cost of uncertainty of up to $1 million for a 200 MW production.

Given the significant leverage of these parameters on the measurement uncertainty, and thus directly on the output rating, only certified high class simulators such as a Pasan $A^+A^+A^+$ should be considered. In this regard Pasan is the only TÜV Rheinland certified $A^+A^+A^+$ simulator.

In order to obtain the lowest measurement uncertainty, the solar simulator supplier needs to master how to perform a good measurement and work with the cell/module manufacturer to implement best metrological practices.

How to reduce the process and operators' impact?

As previously mentioned, the contribution of the measurement procedures and the impact of the operator's errors on the uncertainty are very difficult to estimate. In order to minimize their impact, Meyer Burger Group member Pasan has developed a concept called "Measurement Process (MeP)". The MeP principle is schematized in the Figure 3. Its concept can be

compared as an analogy to a game console such as ProLIGHT where the main software environment is used to drive the simulator. For each specific measurement, for example the IV characterization, shunt resistance measurement in the dark or the DragonBack measurement (dynamic method for measuring high efficiency technologies with a single 10ms pulse), a MeP is used and "plugged" in the main environment. Each MeP contains four components: "Autosettings", to automatically define the measurement parameters, "Calibration", "Production", to apply the parameters during measurement and to perform the data analyses particular to the MeP and "Calibration check" for scheduled verifications of the simulator or process drifts.

The added value of the MeP are:
1. Automation of the measurement parameters setting
2. Automation of the critical measurement operations, specifically the simulator's calibration and calibration checks
3. Monitoring and real-time reporting of the measurement anomalies and artifacts

The first point limits the number of the inputs that an operator must provide to define a measurement recipe. For instance, only the DUT area and temperature coefficients have to be provided which reduces the probability of entering incoherent parameters. By developing automated measurement settings, Pasan guides the customer's production staff through the measurement process. The resultant is to decrease the number of operator errors and thus the overall uncertainty and the associated costs. Calibration operations can also be complex and have major impact on the final uncertainty measurement. By providing automatic calibration procedures based on Meyer Burger's knowledge of sun simulators, this complex process is simplified for the customer.

By monitoring the measurement anomalies, such as transient effects for capacitive PV devices, the possibility of additional errors occurring is also further reduced.

What is the future of power measurement?

The expectations for reliable measurements are increasing as the solar industry matures. This is being driven by investors and their bankability requirements. Recent technological advances have improved the quality of the solar simulators although the standards still lag behind the technology. $A^+A^+A^+$ quality is now the new state-of-the-art standard. The next step, which Meyer Burger's Group member Pasan has already taken, will be to master the entire measurement process thus guaranteeing the overall measurement uncertainty and minimizing the cost of uncertainty.

Figure 3: MeP principle

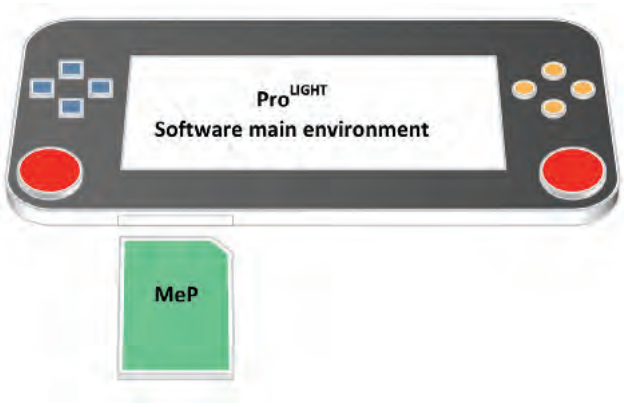


Figure 3.1: An analogy between the MeP concept and a games console

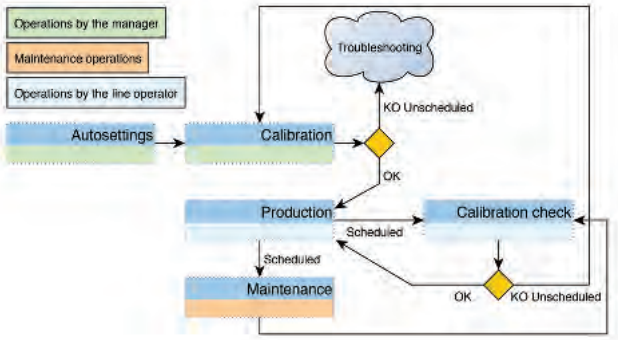


Figure 3.2: The main components of a MeP and their interactions

The standards that rate solar simulators must also evolve following in the footsteps of improvements in solar simulators technology. Furthermore, a number of international standards are already striving to evaluate the energy harvesting, taking into account the performance of modules in real world conditions. These may push out the frontiers and open up new ones for photovoltaic performance/power measurements in the future.

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Every percentage point of uncertainty counts. For instance, to cover an increase of the measurement uncertainty of 1% for a production output of 200 MW at 0.5 $/Wp could cost the module manufacturer up to 1 million $ a year

Record year despite changing dynamics

The global solar industry had a record year for installations in 2013. While the overall industry had positive returns the situation was not so simple when looked at geographically. The EPIA has released an overview of the year looking at where the 37GW of new installations was implemented.

Record-year for photovoltaic markets in 2013, Asia taking over the leading role

With at least 37GW of newly-added capacity globally, 2013 was another record-year for photovoltaic (PV) installations. The internationalisation trend of PV markets already observed in 2012 accentuated in 2013, with Asia taking the lead over Europe as the number one region for new PV installations.

Brussels, 06 March 2014

According to preliminary figures gathered by the European Photovoltaic Industry Association (EPIA) the world added at least 37GW of new PV capacity in 2013. The global PV cumulative installed capacity reached an impressive 136.7GW at the end of last year, which represents a 35% increase compared to the year before.

These globally positive figures result from a much qualified situation at regional level, with Europe losing its leading role in the PV market in 2013. While it concentrated more than 70% of the world's new PV installations in 2011 and still around 59% a year later, of the 10GW of new capacity installed in 2013, Europe only accounted for 28% of the world's market.

Dynamic Asian markets, led by China and Japan (around 11.3GW and 6.9GW respectively), partially explain this trend reversal, as the Asia-Pacific region represented 57% of last year's global market. Such trend is expected to continue, with China experiencing robust and sustained volumes which should enable the country to remain the number-one market in the coming years.

Conversely, the relative slowdown of European PV markets should not be underestimated.

Changing of the guard

"In a number of European countries, harsh support reduction, retrospective measures and unplanned changes to regulatory frameworks that badly affect investors' confidence and PV investments viability have led to a significant market decrease", said Gaëtan Masson, EPIA Head of Business Intelligence.

This is particularly the case for Italy - third global market in 2012 - which experienced a 70% market decrease compared to the year before. Germany - formerly the top global market - also experienced in 2013 a steep PV market decrease (57% decrease compared to 2012), originating from intentional regulatory changes.

"Despite our preliminary 2013 results, solar photovoltaics remains on the way to becoming a major source of energy for Europe and the world. Last year, PV was the second new source of electricity generation installed in Europe. From 0.3% of Europe's electricity needs in 2008, PV already covers as much as 3% only five years later", added Winfried Hoffmann, EPIA President. "Only with coherent, dynamic, stable and predictable support policies can Europe regain a leading position in the energy revolution and further develop PV markets.

In view of that, a truly ambitious climate and energy policy framework for 2030, that would include a meaningful and binding renewables target for each individual Member State, is absolutely crucial", he concluded.

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Global market and regional trends

- At least 37GW of PV systems were installed globally, up from 29.9GW in 2012 (30.2GW in 2011).
- At least 10GW of PV capacity were grid connected in Europe, compared to 17.6GW in 2012 (22.4GW in 2011).
- Asia took over the lead after 10 years of continuous European leadership in new installations.
- PV remains the third most important renewable energy source in terms of globally installed capacity (after hydro and wind power).

Evolution of European markets

- Germany was the top European market with 3.3GW (down from 7.6GW in 2012).
- Several European markets were close to the gigawatt mark: Italy (between 1.1GW - 1.4GW), UK (between 1GW and 1.2GW), Romania (1.1GW) and Greece (1.04GW).
- Other European markets that performed well in the past went significantly down in 2013, resulting from political decisions aimed at reducing the level of support to PV: Belgium (from 600MW in 2012 to 215MW in 2013), France (from 1.1GW to 613MW), Denmark (from 300MW to around 200MW).
- Over the last three years however, outside Germany and Italy, the size of the European PV market has been relatively stable, at around 6GW per year, thanks to the growth in some countries that has balanced the decline in others.
- Some markets in Europe have an almost untapped PV potential, Hungary, Poland and Turkey for instance. The PV potential in countries like France and Spain is still largely unexploited.

Evolution of Asian markets

- China and Japan have led the dynamism of the Asian PV market (with respectively around 11.3GW and 6.9GW).
- Several Asian markets continued to grow at a moderate pace: India (1.1GW), Korea (442MW), Thailand (317MW).

Evolution of American markets

- US reached 4.2GW, making it the number 3 market in 2013.
- Overall, American markets grew slower than expected but growth was observed, in particular in Canada (235MW).
- PV markets are expected to grow in the future in countries such as Chile and Brazil.

PV as a policy-driven market

- Declining political support to PV has led to declining PV markets in several European countries: Germany, Italy, Belgium, France and Spain for instance.
- Conversely, new feed-in tariffs in China and Japan have led to a very dynamic market in these countries.

PV in the electricity mix

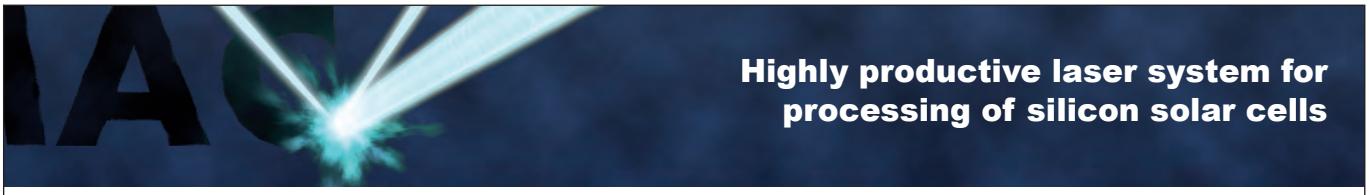
- PV now covers 3% of the electricity demand in Europe and 6% of the peak electricity demand.
- For the third year in a row, PV is in the top-2 newly-added generation capacity in Europe, together with wind.
- As the share of renewables in the energy mix increases, grid and market/system integration challenges are becoming more and more important for the future PV development.

3D-Micromac to supply a laser system to Hanwha Q CELLS for removing backside passivation on PERC cells

With Hanwha Q CELLS, 3D-Micromac AG could win one of the leading global photovoltaic companies as a customer for its microSTRUCT OTF laser system. The system creates a selective opening of backside passivated multi- and monocrystalline solar cells, thereby achieving a throughput of 3,600 wafers an hour.

For this purpose, 3D-Micromac makes use of an innovative on-the-fly technology. The laser processing is realized during the continuous transport of the cells under the laser source, whereby the relative motion of the cells is automatically compensated for. Stops for the positioning of the individual cells are completely eliminated. The handling of the solar wafers is contactless. The wafer surface thus remains unaffected. This ensures a gentle and frictionless transport of the wafers, cell breakage or micro cracks are avoided and a higher yield is achieved. The continual movement of the conveyor belt results in an almost 100-percent capacity utilization of the laser source.

"We are delighted that Hanwha Q CELLS will further develop its Q.ANTUM cell technology manufacturing processes (PERC process) using 3D-Micromac equipment. This shows that our strategy of supporting cell manufacturers with our process know-how in the implementation and development of new cell technologies is paying off," states Tino Petsch, 3D-Micromac CEO. "The microSTRUCT OTF has been consistently designed for productivity, performance and cost efficiency. This is reflected, for example, by the number of customer projects we are currently dealing with. Moreover, following the successfully concluded qualification phase of our laser process, we are hopeful for follow-up orders from Hanwha Q CELLS" according to Petsch.



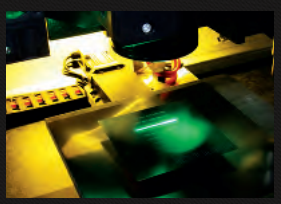
Highly productive laser system for processing of silicon solar cells

microSTRUCT^{OTF}

On-the-fly laser contact opening of PERC solar cells

Benefits:

- Efficient machine design with
  - 2 parallel working areas
  - On-the fly laser processing
  - Suitable for the integration of different laser sources
- Contactless wafer handling
- High throughput and efficiency (≥ 3,600 wafer/h)
- Low cost of ownership and CAPEX



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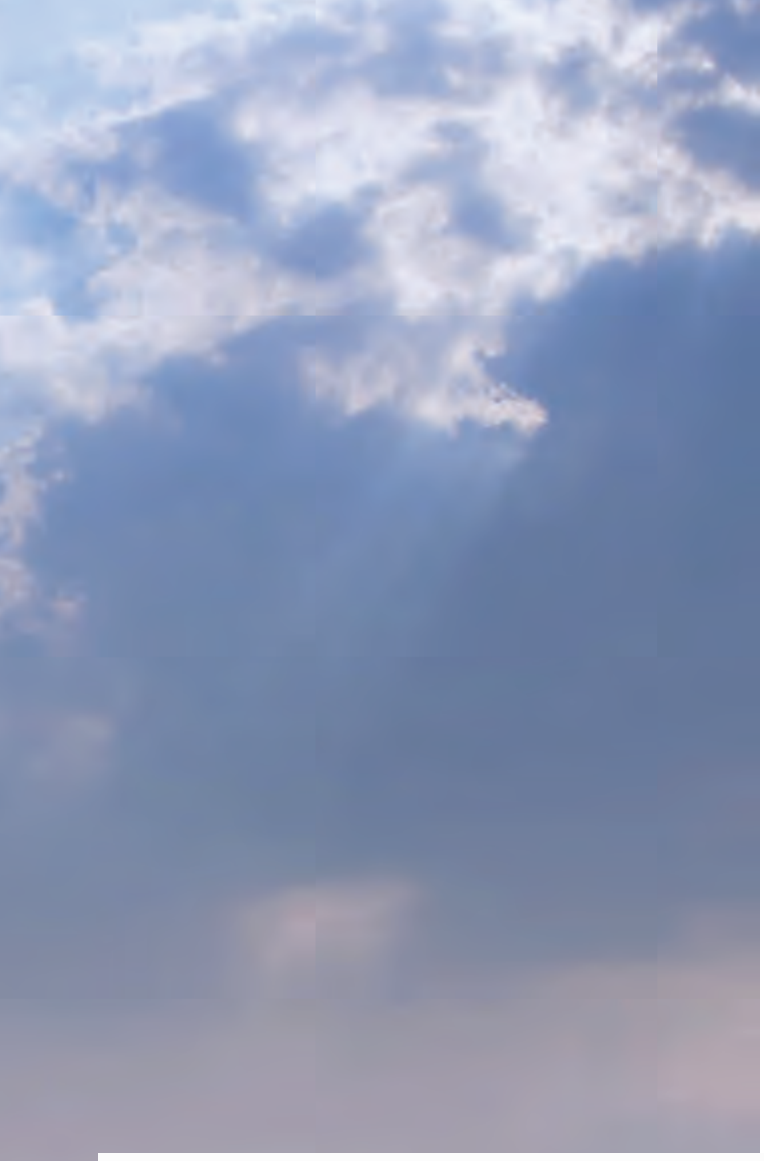
3D MICROMAC

String together **maximum benefit**

Investing in solar at large scale is creating hundred's of power plant operators who need to maximise benefits at every point of construction and operation. Danfoss has been making string inverters for some time and discusses strategies they have developed for maximising PV power plants.



WHEN PLANNING A PV PLANT, the objective is to obtain a high return on investment (ROI) and low levelized cost of energy (LCoE). On the one hand, this requires the use of inverters and medium-voltage transformers with optimum efficiency, focus on how to limit cable loss and losses due to shading, as well as detailed plant monitoring. On the other hand, planning, material and installation costs should be reduced as much as possible.

To some extent, today's string inverters offer the advantages of central inverters, such as a high DC system voltage range and 3-phased output. This results in systems with low losses in both AC and DC cabling, ensuring high yields. Many trackers allow you to cope with shading situations, while keeping shading losses to a minimum. The losses incurred by the time spent in a deliberate shade are counterbalanced by the ability to place more modules in the same area.

Special training is not required to install, maintain or exchange string inverters. When surge voltage protection is not required, junction boxes can be omitted on the DC side thus service on the DC side is also avoided. To find the optimal solution for a specific plant, both a string inverter and a central inverter solution should be considered.

Advantages on the DC side

Depending on the model and location of the plant, the high maximum voltage of inverters (1000 VDC) permits strings of up to 23-25 standard 60 cell crystalline modules.

In addition, if external surge voltage protection on the DC side is not required for the project, junction boxes/ string combiners can be omitted and the DC cables are laid directly from the string of modules to the inverter. With this layout, Ppv / Pinverter factors of 1.15 and 1.3 can be achieved for FLX Pro 17 and FLX Pro 15, respectively, with 260 Wp modules.

For long strings, the string voltage at NOCT (Normal Operating Cell Temperature) is usually close to 700 V. The highest inverter efficiency values are reached when VMPP is around 700 V, ensuring that under normal working conditions the highest efficiency levels are achieved. Additionally, DC cable losses are greatly reduced when operating at these voltage levels.

The individual MPP tracking and monitoring for each string, which is a major advantage of string inverters, enables maximum energy yield per string, due to lower mismatch losses.

Additionally, if each row of modules per PV substructure is connected to its own MPP tracker, and the PV Sweep feature is activated, losses due to partial shading, snow coverage, or clouds are greatly reduced. Even if a string disconnects due to insufficient solar radiation or a failure, the other strings keep generating power.

Advantages on the AC side

AC combiners can also be supplied with an enclosure suitable for the outdoor environment. The most suitable place to mount both is behind the modules on the back side of the module substructure. The substructure can easily carry this extra weight and it is at the same time very convenient and requires no extra ground work.

One or more of the following size transformer station could be selected, depending on the characteristics of the project: 1 MVA, 1.25 MVA and 1.5 MVA/1.6 MVA. By choosing a string inverter setup you can buy transformer stations with standard LV voltage. These are among the most commonly used transformer stations for electricity distribution and have short lead times.

Compact, pad-mounted transformer stations are recommended for this type of layout. They normally include:

- Short-circuit/over current protection by fuses on the LV side
- Transformer
- HV switchgear.

They can also include surge voltage protection on the LV side. The compact dimensions and low weight of these standard transformer stations enable an easy transport, and small trucks and cranes can be used for mounting. Access to the site is therefore easy, and access roads and open space required for mounting are less restrictive. Furthermore, the work required for

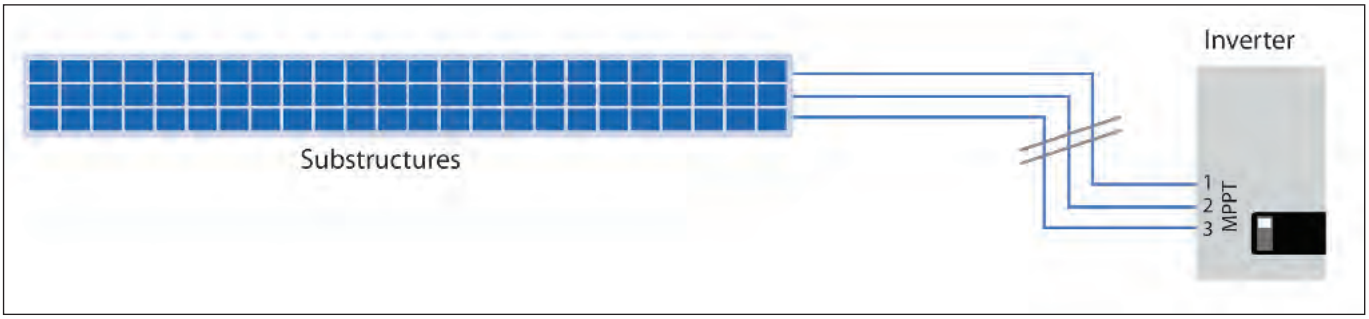


Figure 1. Module Wiring Based on Crystalline Modules. Each module row is connected to its own MPPT

installation is kept at a minimum.

Land use requirements

Better management of shading losses can be achieved by means of the multiple MPPTs and a PV Sweep feature. In combination with other design decisions, such as tilt angle reduction and the use of multi-row structures, a more aggressive approach can be employed in terms of shading angle and/or distance between structures. Consequently, high land utilisation and low rated costs (land rental, fencing, trenches, cabling (DC, AC, MV, and monitoring), security system, etc.) can be achieved.

Land utilisation is optimised, as no additional space is required for positioning the inverters and the AC combiners (both can be mounted on the same support structure as the PV modules). The transformer can be placed inside the N-S or E-W roads, or in the space of a removed module substructure with almost no shading impact.

Monitoring System

Inverters tend to include a cost-efficient solution to obtain logging and monitoring functionalities.

A web interface allows you to monitor or change:

- Inverter/plant setup
- Power plant, inverter group and inverter status (with string level information of a resolution down to 5 kW)
- Graphics and curves (yield, or reduced CO2 emission, etc.)
- Communication setup (SMS via GSM option or online data storage via FTP upload), and ancillary services
- Dynamic language selection

The data can also be exported in different formats, and data analyses and comparisons can be performed. All individual and accumulated system parameters are accessible through the master inverter, providing a single point of access for up to 99 followers.

The master inverter is also where control and grid management parameters can be set up. This means that subplants of up to 1.7 MVA can be monitored, controlled and managed, using a single master inverter. The consequent network simplicity, and reduced HW costs for monitoring are add-on benefits. This single point of access also provides service and commissioning capabilities for software updates, configuration changes, remote fault analysis, replication of settings from master to follower inverters.

Logging intervals can be changed (every minute, every 10 minutes, or every hour). The inverter can be accessed using a web browser via a LAN connection, either locally or remotely. Remote access requires internet access through a VPN tunnel provided by a router. Professional routers/switches

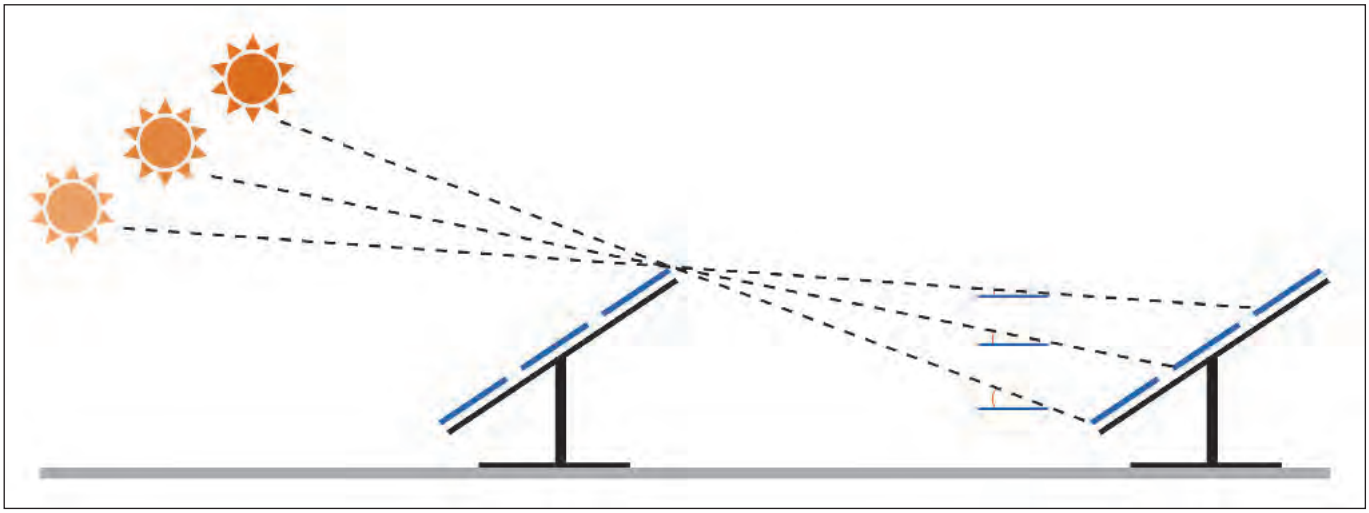


Figure 2. Shading on Modules. As each row has its own MPP tracker only a part of the table is affected by the shadow cast by the table placed in front of it. As the sun rises in the horizon the strings can perform optimally unaffected by the performance of the other strings connected to the inverter

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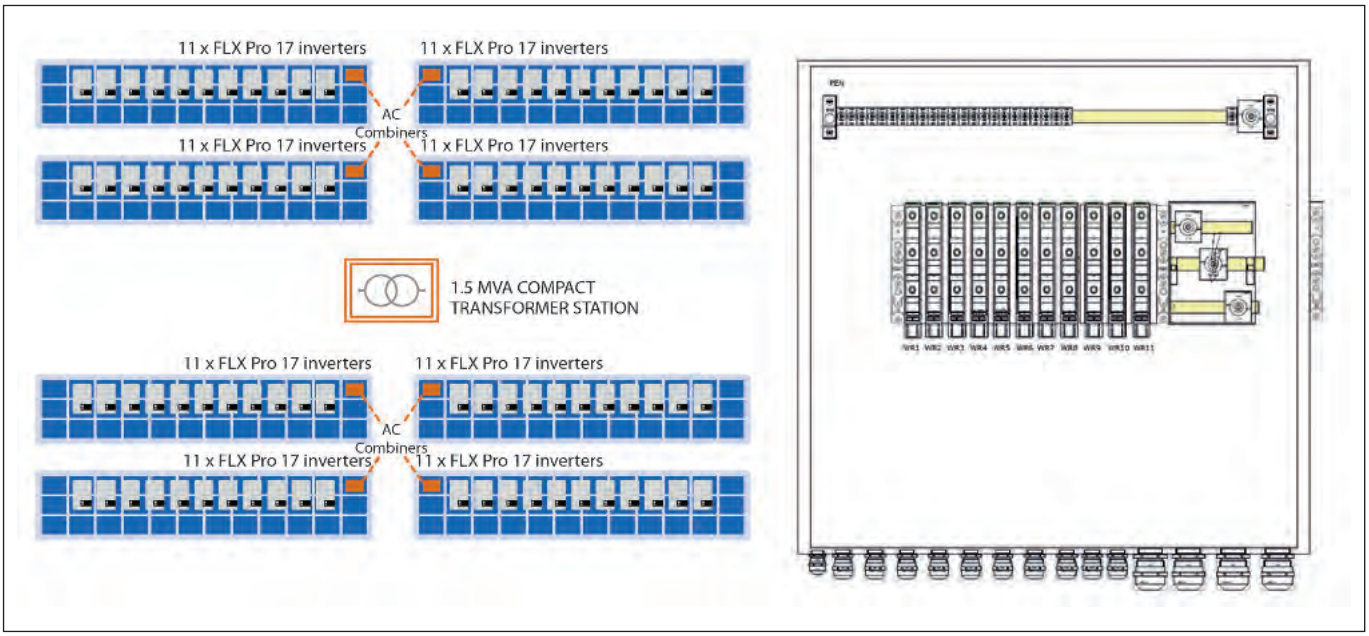

Figure 3. Inverter Location and HIS brand AC combiner

are recommended for large plants in order to achieve a good network performance.

Power for the switches/routers can be taken from the low voltage side of the transformer, as only a small amount of power (<20W) is required. If the transformer station is disconnected and the switches/routers are powered off, inverter data will be fetched from the integrated logger in the inverter once power is restored.

With the inverters placed centrally in close proximity to the transformer station, it is easy to carry out the wiring for data transmission. Inverters can be connected in daisy-chain using a standard Cat5 cable. The cable can be connected directly to the inverter by prefabricated cables with RJ-45 connectors. For inverters in a decentral position, it is possible to install switches between groups of inverters or to use fibre optics cabling in order to cover long distances.

For all inverter inputs, which can be as little as 5 kW, it is possible to monitor current and MPP voltage individually. This provides very thorough error detection possibilities without additional equipment.

PV Field Layout

Determining the optimal layout for each of the PV fields in a plant is not an easy task. The optimal shape (the one with the lowest cabling costs) can be quadratic, rectangular (or even irregular) in shape, depending on the shape of the land. Design parameters such as the number of rows of modules per structure, the number of modules per string, landscape or portrait orientation of modules, etc. must also be considered. Each case should be treated individually as there is no general rule. Several approaches can be followed for correct location of

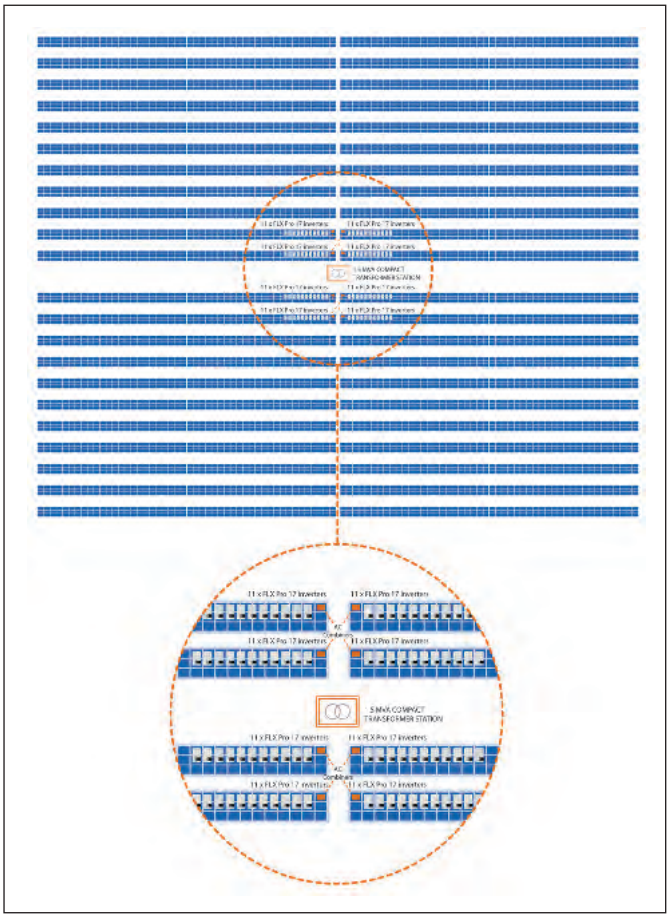

Figure 4. 1**647 kWp PV Field Layout based on 60-cells Crystalline, 260 Wp Modules**. Figure 4 illustrates an example for a wide piece of land. It consists of 22 rows of structures, each having 4 substructures with 3 rows of 24 modules in a landscape orientation. The transformer station is located in an East-West road. 88 FLX Pro 17 inverters and 8 AC combiners are placed centrally in the vicinity of the transformer station. Tilt angle: 20°. Shading angle: 20° (approx.162 x 127 m)

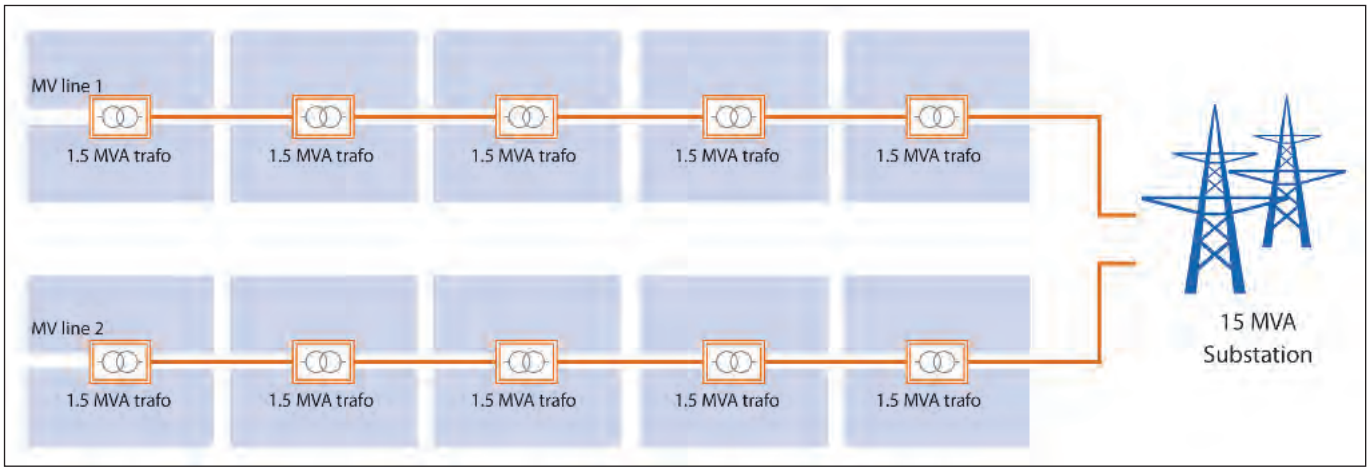

Figure 5. Schematic of a 15 MVA PV Plant. Figure 5 represents 10 x 1647 kWp PV fields, similar to the example shown in figure 5. 2 x MV lines and the connection to an MV/HV substation are shown

the transformer stations: it can be placed inside the N-S or E-W roads, or in the space of removed module substructures. Apart from the parameters described in the paragraph above, the optimal choice will depend on the size of the PV subfield and the rated cost of road construction.

Inverter and AC combiner placement

Two different approaches can be followed for the location of the string inverters and AC combiners. Once again each plant should be treated individually as there is no general recommendation

1) Centrally placed inverters and AC combiners

Inverters, see figures 4 and 5 and AC combiner are placed in the vicinity of the transformer station as shown in figure 4. In this approach, it is possible to utilise the high DC voltage limits. This enables long strings and lower distribution losses. AC cabling costs and losses are also significantly reduced due to the short distances. Ethernet monitoring cabling (daisy-chain) is also reduced and simplified as all inverters sit together.

All the LV AC protection for the inverters can be installed in one or several AC combiners close to the transformer station (or integrated). LV AC protection depends on the grid type. TN-S or TN-C grids that have a low impedance path for the fault loop can use 32 A gL/gG fuses or a circuit breaker per inverter to provide residual current protection. Due to the short cable lengths you can achieve low impedance paths by using an adequate cable cross section.

In TT grids or TN-S grids, where it is not possible to maintain a longterm low impedance path for the fault loop, it is necessary to include Residual current protection devices (RCDs).

2) Distributed inverters and AC combiners

In this approach, the cabling distribution is divided between DC and AC. Each group of inverters has its own AC combiner. In addition each inverter has its own 32 A gL/gG fuses or circuit breaker, for disconnection and short-circuit protection.

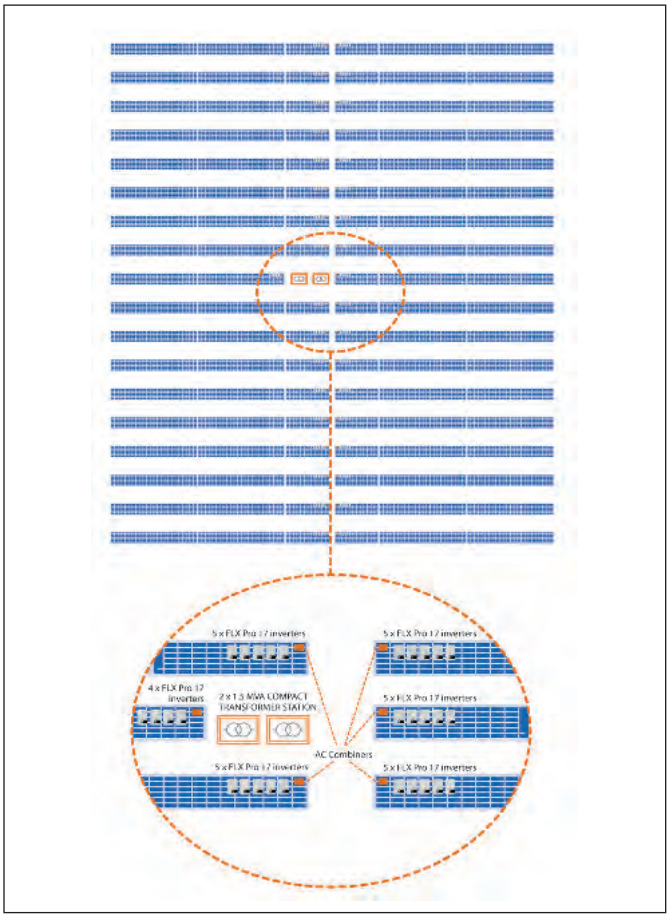

Figure 6. 1666 + 1685 kWp PV Fields Layout based on 60-cells Crystalline, 260 Wp Modules. Figure 6 illustrates a solution for a long piece of land. It consists of 18 rows of structures, each having 4 substructures with 6 rows of 24 modules, and 2 of 6 rows of 12 modules, in landscape orientation. One substructure has been removed to place 2 x 1.5 MVA transformer stations. Distributed inverters and AC combiners are placed close to the North-South road: 35 groups of 5 FLX Pro 17 inverters and 1 group of 4. Tilt angle: 20º. Shading angle: 20º (approx. 205 x 199 m)

In TN-S or TN-C grids with low impedance path for the fault loop, these fuses/circuit breakers also provide residual current protection . Low impedance paths are harder to achieve than in the “centrally placed inverters” approach, due to the longer cable lengths, requiring a larger cable cross section.

In TT grids or TN-S grids, where it is not possible to maintain a long-term low impedance path for the fault loop, it is necessary to include Residual current protection devices in a box close to the transformer station (or integrated).

When distributing the inverters throughout the plant, longer distances between the nodes of the Ethernet monitoring network (Ethernet) are seen. It must therefore be addressed in the plant design that cable lengths from one inverter to the next must always remain below 100 m (below 80 m is recommended).

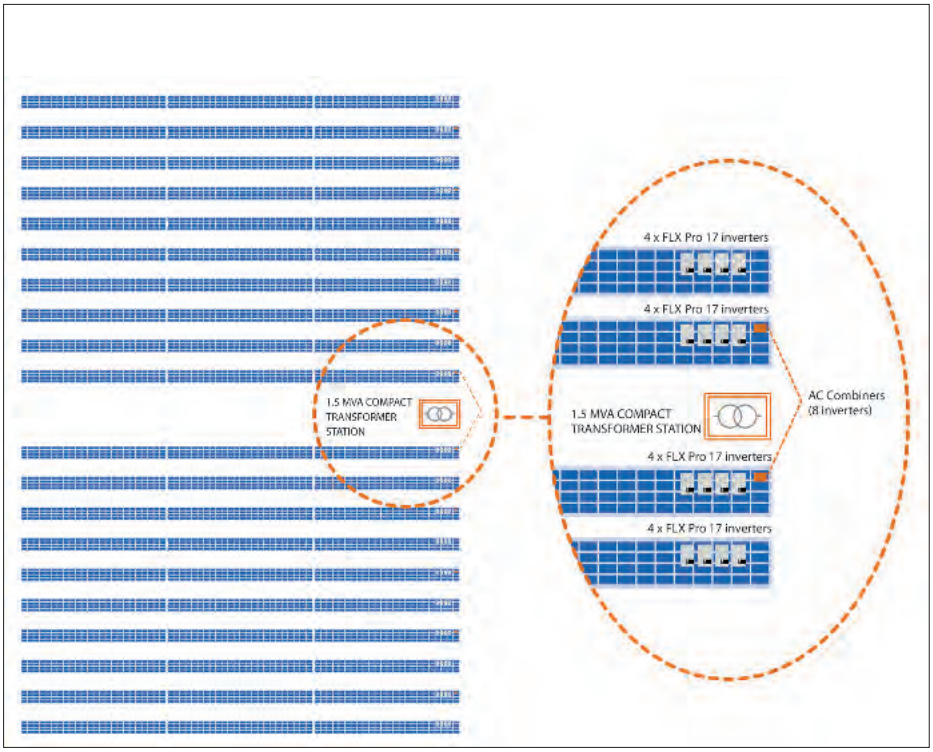

Figure 8. 1647 kWp PV Field Layout based on 60-cells Crystalline, 260 Wp Modules. Figure 8 illustrates a solution for a wide piece of land. 22 rows of structures, each having 3 substructures with 4 rows of 24 modules in landscape orientation. The transformer station is located in the East-West road. Distributed inverters and AC combiners sit close to the right hand border of the PV field: 11 groups of 8 FLX Pro 17 inverters. Tilt angle: 20º. Shading angle: 20º (approx. 122 x 167 m)

Output and after care

The FLX inverter has the benefit of being a standard component, which is commercially available. This means it is possible for a local installer with some experience to carry out the exchange of inverters or the plant maintenance without additional training. Extra inverters can also be kept in stock locally for fast exchange.
In case of failure only a small part of the system will be affected. With the 15 MW plant, more than 9 inverters must completely fail before the loss reaches 1% of production. No service is required on the DC side as there are no junction boxes installed. To aid the installer or plant supervisor during fault finding, each inverter comes with a display.

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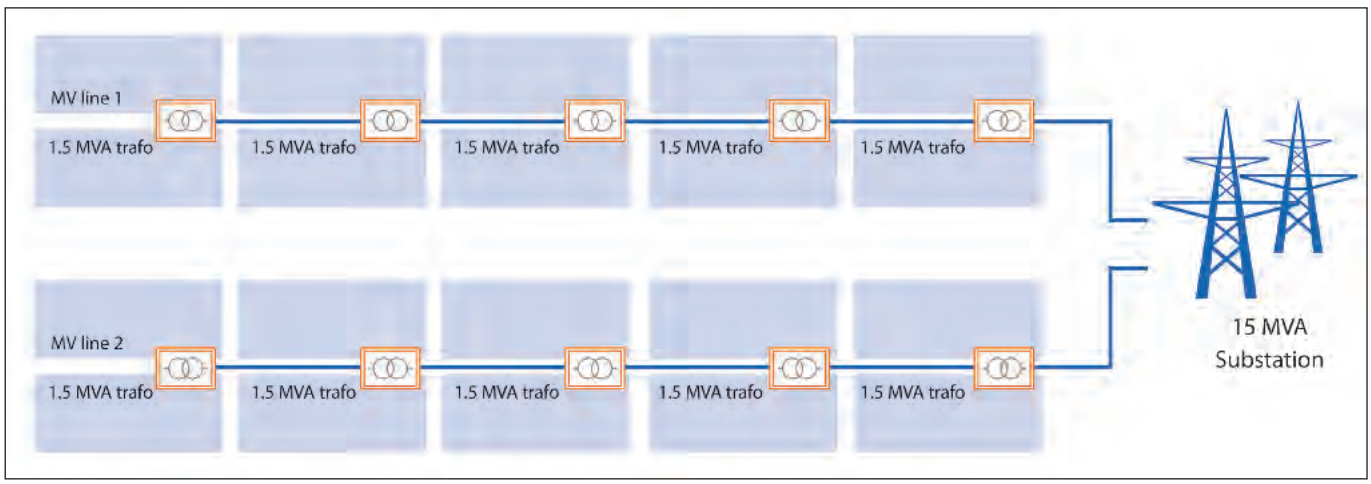

Figure 9. Schematic of a 15 MVA PV Plant. 10 x 1647 kWp PV fields, similar to the example shown in figure 8. 2 x MV lines and the connection to an MV/HV substation are shown

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Powering improvements



Solar inverters are the engines of a PV installation and initial concerns regarding their ability to control intermittent electricity flow seem to be unfounded. Richard J. Bravo of Southern California Edison and Mathieu van den Bergh of CNS Inc., with contributions by Bill Ruff of AMETEK Programmable Power discuss recent test results that show that solar inverters can improve power quality and network stability.

OVER THE PAST 10 YEARS, manufacturers have significantly improved solar photovoltaic (SPV) inverter technology. In the past, utilities were concerned that high penetrations of solar inverters would destabilize public electricity supply networks, but testing has revealed that inverters with advanced features may improve power quality.

As society moves towards scenarios where many SPV inverters are connected to the public electricity network, these advanced features appear necessary. These include volt/var control, voltage ride-through (VRT) [1] capability, frequency ride through, real power/ frequency control, ramp rate control, and communications.

This article discusses a series of tests that were conducted a few years ago to characterize typical ”legacy” inverters, including an assessment of their contribution to distortion, anti-islanding issues, and potential aggravated disturbances. Also more recent test results are presented for an off-the-shelf advanced commercial SPV inverter

designed to operate according to recent German grid codes.

Testing set up

The initial tests on legacy inverters were aimed at verifying that the inverters function safely in accordance with US and other international standards. The test setup is shown in Figure 1. The grid simulator handles bidirectional power flow, just like the electric grid. The inverter is being fed with a DC power supply that simulates the PV panel's I-V curve.

The programmable load provides both linear and non-linear current loads, effectively simulating typical "household load" patterns, such as those produced by PCs, cooking appliances, TVs, air conditioners, etc. The power analyzer provides information on the current flow in the load, as well as into or out of the public supply and the inverter.

Figure 2 shows a typical display from the power analyzer. The top graph shows the voltage (green) and the current (black) flow of the grid simulator, i.e. the electric grid. The bottom graph shows the load current (red) and the inverter current (blue). The inverter delivers 1274.9 Watt to the household (load) and 1766.5 Watt to the grid.

The public supply rarely has such a nice sinusoidal voltage. Voltage distortion of 2 – 5 % V-thd is not uncommon. To evaluate the PV inverter response to a distorted voltage, the grid simulator was programmed in 1 % steps to have from 3 - 9 % voltage distortion, at harmonic order 9 (VH9).

As the graph in Figure 3 shows, the current distortion into the grid is about double the programmed voltage distortion. This is due to the fact that the inverter "tracks" the supply voltage, i.e. adds about the same amount of current distortion that is already present.

If the inverter were to be "permitted" to compensate, it could reduce the current distortion into the public supply. Modern

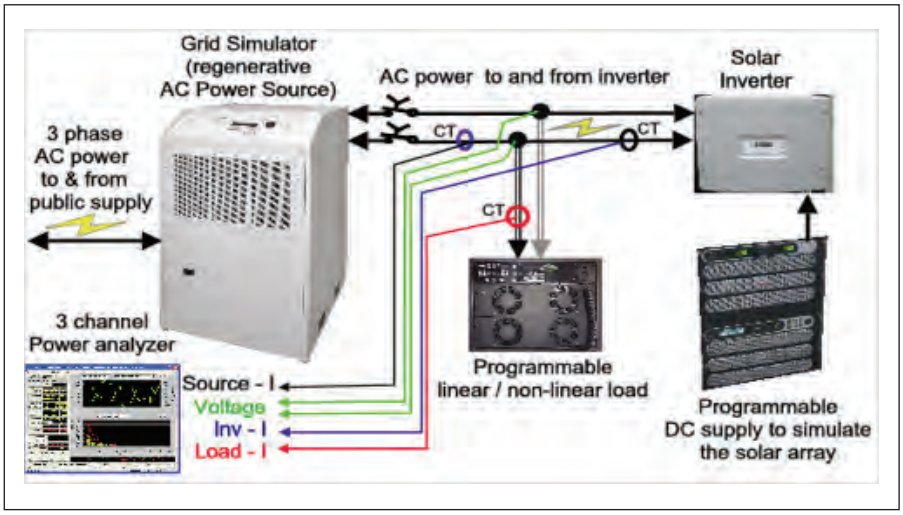

Figure 1. Test setup to evaluate solar photovoltaic inverters

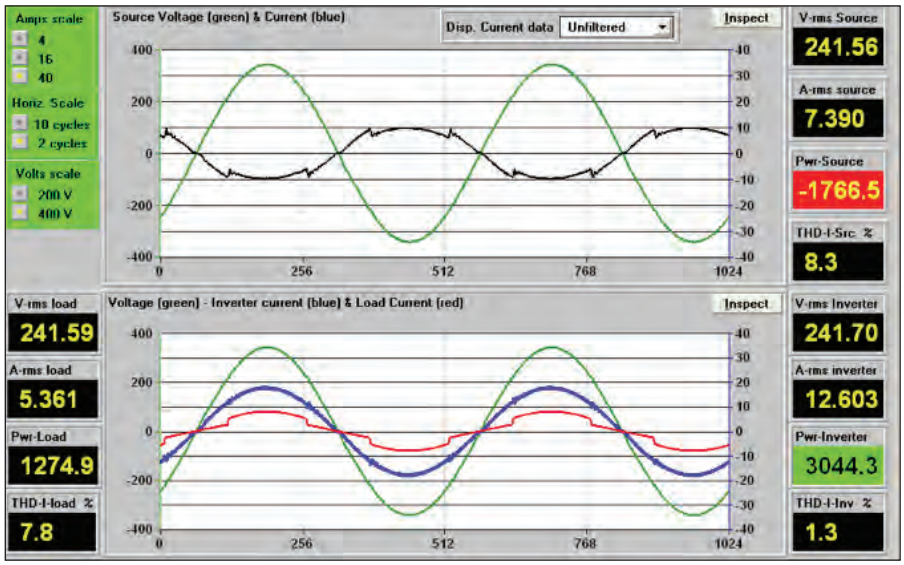

Figure 2. Inverter delivering 3 kWatt

inverters have this capability.
Another undesirable consequence of early requirements placed on PV inverters is their response to voltage dips and short interrupts to avoid "islanding operation." Standards require that the inverter separate itself from the electric grid within 160 ms in the event that the supply voltage goes outside specified tolerances (usually about ± 10 % from V-nom).

Figure 4 shows the inverter response to a short voltage dip. The PV inverter disconnects within 10 ms and remains "off-line" – sometimes for as long as several minutes. Such a response will generally aggravate the "dip" as the power contribution from the inverter "goes away". It is now recognized that a certain amount of low voltage ride through (LVRT) is much more desirable.

Advanced solar inverter capabilities

In order to evaluate how advanced solar inverters may affect the electric grid, Southern California Edison (SCE) acquired several residential and

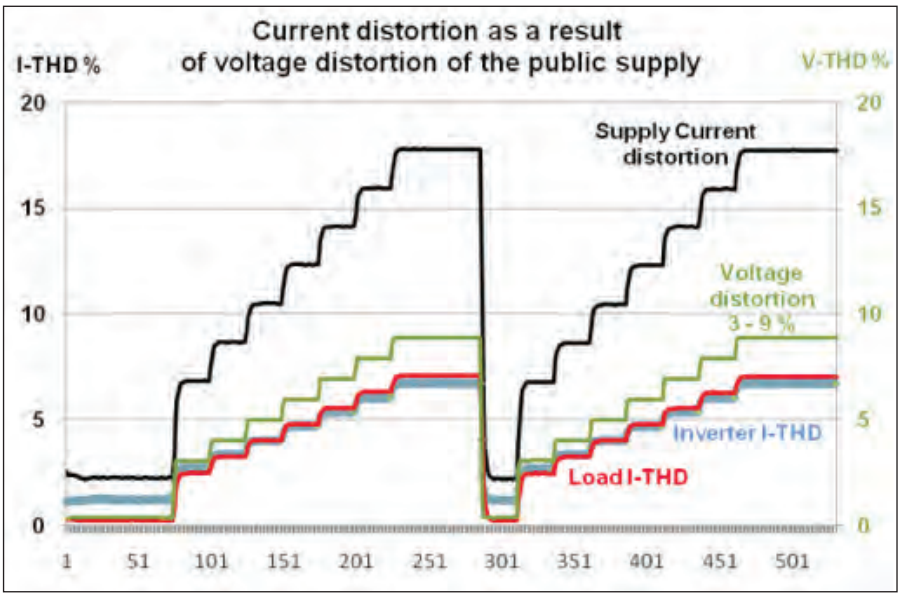

Figure 3. Inverter distortion contribution

commercial solar PV inverters designed to operate according to German grid codes.

These inverters have advanced features not presently available in the inverters with U.S. standards. This section will contain some of the testing of the commercial German inverter tested at SCE DER laboratory.

Newer inverter designs permit voltage ride-through capabilities, such as the low voltage ride-through which can be adjusted between 40% and 100% of voltage. When the system voltage is above this lower limit, the inverter continues generating power and DOES NOT disconnect from the electric grid When the system voltage falls below the lower limit, the inverter ceases generating power to the grid.

The inverter can stay connected to the grid for an adjustable time (minimum of 0.04 seconds and maximum of 10 seconds for the unit tested at SCE), but will not export power to the grid until the voltage returns above the lower limit plus a dead-band amount (hysteresis).

Figure 5 illustrates this capability. The voltage (blue line) briefly falls below 47 % of V-nom, causing the inverter (green line) to cease generating power, but as soon as the voltage goes back to > 47 % plus the 3 % hysteresis band, the inverter ramps its power back up (just before second # 8).

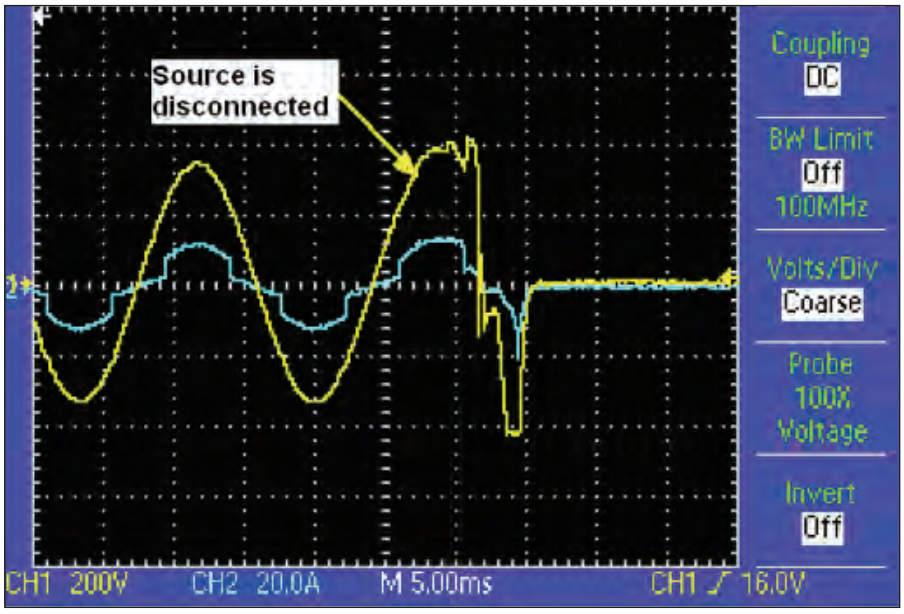

Figure 4. Inverter response to voltage dip

When the public supply voltage exceeds V-nom, at second # 17, the inverter scales back its power contribution, and after the voltage stabilizes at V-nom (second # 27) the inverter resumes full power.

This type behavior is much preferred vs. the "traditional response" where the inverter simply disconnects from the grid when the voltage falls below say 90%, and stays disconnected for several minutes.

Strengthening the weak links

Solar inverters can greatly improve voltage stability in "weak networks" as shown in Fig. 6. For this test, the grid simulator was set as a "weak source" where its output current was progressively limited in approximately 5 second intervals.

The purpose of this was to decrease the generation-to-load ratio of the test setup so the system voltage steadily drops (as in a weak – rural – system). This test allows the assessment of the inverter (VAR) voltage support capabilities. Figure 6 shows three scenarios: Inverter voltage support turned on at a 3% ramp rate

(green plot), voltage support turned on at 1% ramp rate (orange plot), and voltage support turned off (blue plot).

When the voltage support is enabled and voltage falls below 98%, shortly after the 5 second mark, the inverter immediately increases its VAR output, raising the system voltage. The data clearly shows the advantages of implementing voltage support on solar PV generation, with the voltage remaining within 5 % of V-nom when voltage support is turned “on”.

During over-voltage situations, the inverter can behave in an inverse manner, i.e. reduce the effect of over-voltage (such as happens when loads disconnect). Figure 7 illustrates this scenario.

Advanced inverters typically have several communication capabilities, via serial and even via Bluetooth interfaces. For both tests – illustrated in Fig.6-7, the inverter was programmed with the following parameters when voltage support was enabled:

- VAR support: maximum of 50% of full power
- Q/V gradient: 0% (NO-VAR), 1%, and 3% (This gradient is the relationship between reactive power and voltage.)

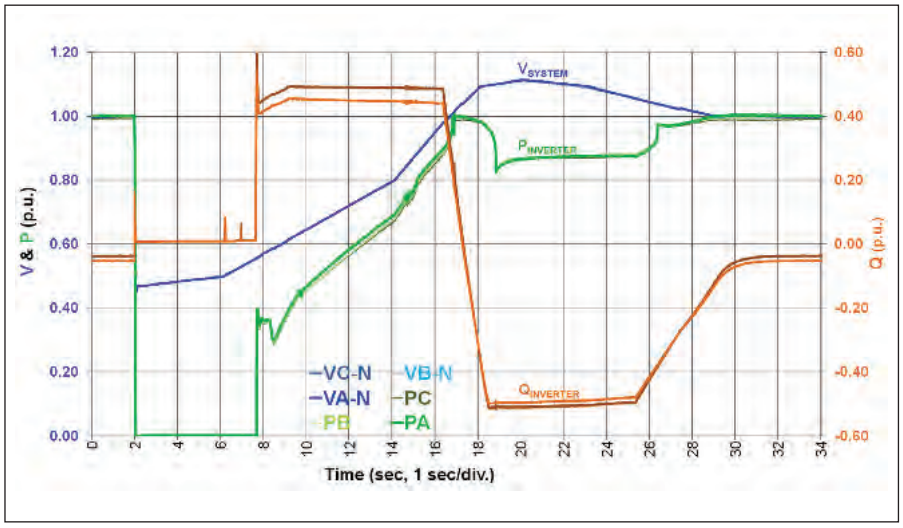

Figure 5. LVRT capability of modern PV inverter type

Simulated effect

Before beginning the test shown in Figure 7, the grid simulator voltage was set to 120% of nominal voltage, but its output current was limited so that the load was pulling the grid simulator voltage down to the desired nominal value. During the test, the grid simulator output current was progressively increased manually in approximately 5 s intervals. This simulates the increase in generation-to-load ratio so that the system voltage steadily rises, which in turn permits the assessment of the inverter’s voltage support functions. As with the previous test, Figure 7 plots

Before beginning the test, the grid simulator voltage was set to 120% of nominal voltage, but its output current was limited so that the load was pulling the grid simulator voltage down to the desired nominal value. During the test, the grid simulator output current was progressively increased manually in approximately 5 s intervals

three scenarios: voltage support at 3% ramp rate (green plot), at 1% ramp rate (orange plot), and turned off (blue plot). When the voltage increases above 102%, shortly after the 5 second mark, the inverter immediately absorbs VARs from the system, and thus helps to stabilize the system voltage.

Obviously, this is much preferred over the situation where the voltage increases substantially (up to 120 % of V-nom in this case) without voltage support turned “on”.

As part of under-and-over voltage support, advanced inverters can adjust their Power factor (PF). This is illustrated in Figure 8. The inverter adjusts its PF as a function of power output, in this case from a PF of 1.00 at 60 % output to just over 0.8 at 80 % output.

Conclusions

The results of our tests indicate that certain advanced features could benefit the operation of the grid, if they are incorporated into IEEE 1547 and California Rule 21.

Several IEC standard committees, as well as national committees of individual countries that have, or expect to have, the number of solar photovoltaic inverters connected to their grids to increase have already embraced these advanced inverter capabilities.

They are, in fact, counting on the improved characteristics to improve power quality in the public supply network.

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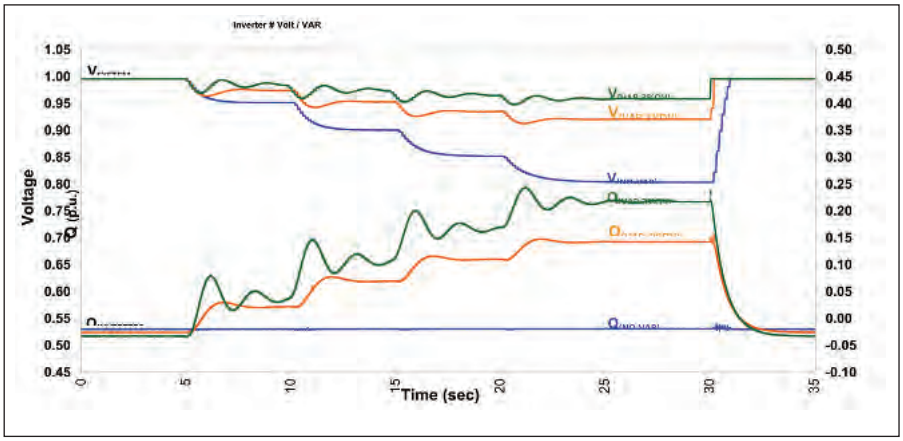

Figure 6. Inverter voltage support during under-voltage

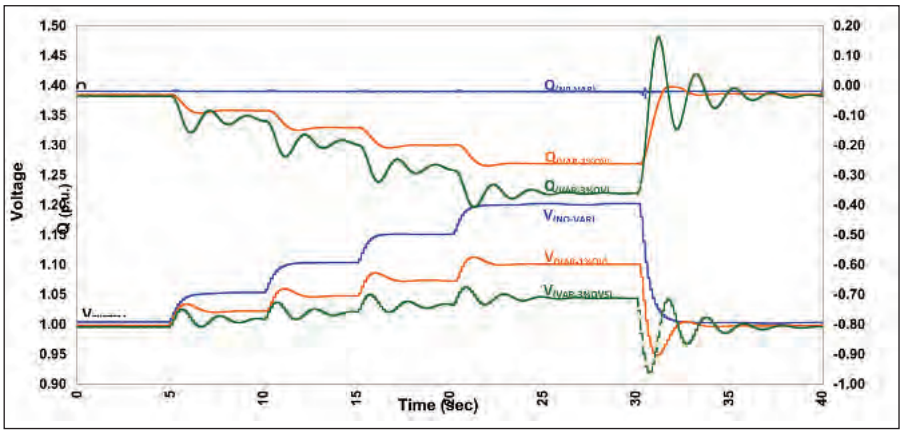

Figure 7. Inverter VAR support during over-voltage situations

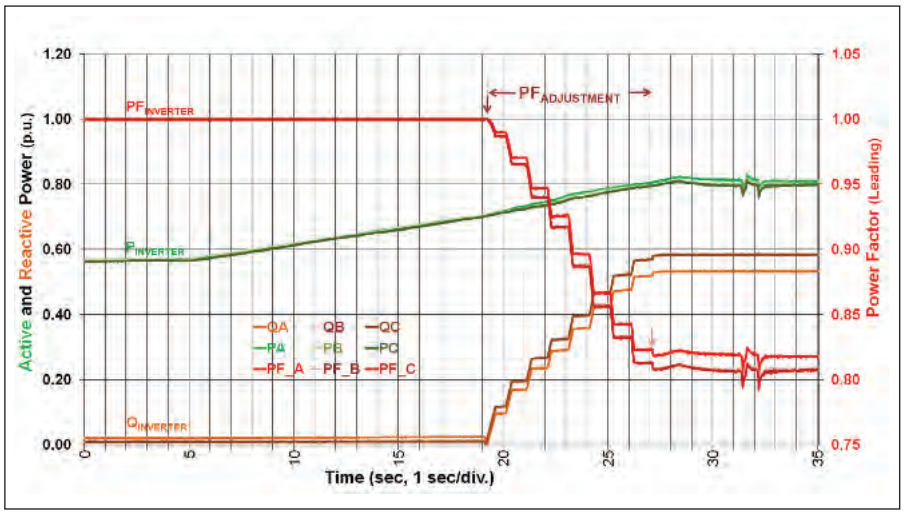

Figure 8. Dynamic inverter voltage (Power Factor) support

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Maintaining equilibrium in the European power grid

The energy industry must come to terms with a growing mix of energy sources providing national grids with power. In Europe a conference will examine the role of renewable energies in national grids. Dr. Franco Rosatelli of Ansaldo Energia and conference board member discusses how the integration of Europe's energy systems must continue if grid stability is to be sustained.

THE LIBERALISATION OF ENERGY markets in Europe and the separation of generation, transmission and distribution in most countries have played a crucial role in increasing the efficiency of energy systems for the benefit of industrial users and consumers alike. New players have strengthened their presence in the energy markets, endowed with higher efficiency, a greater propensity for investment, and greater generation capacity compared with former monopoly players.

At the same time, a significant improvement has been achieved in the transparency of decision-making processes at a regional and pan-European level regarding development of an interconnected European grid. This has been enabled by the publication of the Ten-Year Network Development Plan of the European Network of Transmission System Operators for Electricity (ENTSO-E) as part of the framework set out by the European Union's Third Energy Package.

Processes to harmonise European-wide requirements in light of current and future system developments have also been discussed regularly among network operators, stakeholders and regulators. In 2013, ENTSO-E released its latest Network Code on 'Requirements for Generators' (NC RfG) and published NC RfG Implementation Guidelines to support the code by highlighting the impact on specific technologies, the link with local network characteristics, as well as the need for coordination between network operators and grid users.

Utilities caught unprepared

Good progress has undoubtedly been made in respect of both market liberalisation and EU policy, however the economic and financial crisis in 2008/9 hit at a time when energy systems were just starting out on their transformation journey. Unfortunately, it caught most utilities unprepared. Following a period of significant CapEx and increased mergers & acquisitions activity, most found themselves loaded with debt. This is why European utilities have been ranked among the worst-performing sectors in the global share indexes over the last five years.

The biggest challenge they face however, is the integration of new generation sources to arrive at a well-balanced mix among the different types of generation technologies, especially since stagnating electricity demand and the resulting deterioration of the equilibrium in the generation mix could lead to a slowdown in the progress of energy market integration in Europe.

In an ideal world, the secure integration of growing amounts of renewable energy, together with wide-scale deployment of storage units, would meet demand at any time and ensure a stable frequency and voltage if steered via a robust backbone of combined-cycle power plants. In reality, the majority of conventional plants needed to sustain a secure supply are barely operating for a sufficient number of hours during the year to cover payback and maintenance costs.

This is particularly true in markets such as Italy and Germany, where there has been a significant generation overcapacity due to the rise in renewable energy. The severe problems that arose in late 2013 with the power grid in Germany exemplify the uncertain realities of renewable energy sources. A result of high wind power feed-in, alongside sudden load variations and power fluctuations provided by wind farms and solar parks raised

significant concerns over the risks to grid stability. Moreover, the claims from clean-power groups that major European grids would be stable if renewables were the only sources of energy have also been called into question. The resulting price rise from the oversupply of renewable power has served to reinforce the belief that favouring green power generation, whilst maintaining secure and stable supply, represents a combination of incompatible objectives.

From gas to renewables

Certainly, a complex relationship has emerged given the wider deployment of renewable energy sources and how they impact on existing sources of energy. Stagnating electricity demand and the resulting deterioration of equilibrium in the generation mix could lead to a slowdown of energy market integration in Europe, as well as a rise in electricity bills and CO_2 emissions due to the increasing contribution of coal-fired generation in parallel to the increase in renewables. A more integrated approach is therefore advisable, given that an overcapacity of conventional power is needed to counterbalance sudden variations in the availability of renewable energy. Here, natural gas power stations can play a crucial role in assuring the stability and continuity of

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the power generation system. In the early 2000s, the focus was mostly on Combined Cycle Power Plants (CCPP), as these were considered crucial to liberalisation. Increased use of CCPPs for power generation over the past decade can also be attributed to their high efficiencies, short execution times and relatively low investment costs. By 2010, gas technologies reigned in Europe, representing more than 50 per cent of the total power generation market.

Since then, wind and solar PV have taken the place of gas technologies and in the last few years have grown to account for more than 60 per cent of the power generation market. But given that the output of wind and solar power is highly variable, and depends on factors such as time of day and prevailing weather conditions, overcapacity of conventional power is needed in order to counterbalance these sudden variations.

Shifting role

In scenarios where renewable power has priority access to the grid, fossil fuel power plants will have to increasingly shift their role from providing base-load power to providing fluctuating back-up power to meet unpredictable and short-noticed demand peaks, in order to control and stabilise the grid. This change in requirements throws down a real challenge to fossil fuel power plants (both CCPP and CHP) and for each component of the plant (Gas Turbine, Steam Turbine, Heat Recovery Steam Generators and other pressure parts) in terms of improving their operational flexibility for cycling and fast start-up and shut-down times.

Plants should be able to run both at the lowest part load possible and at the highest possible efficiency. Moreover they will be required to operate across the entire load range with high load-change velocities, and even operate in start/stop mode with full turndown and very fast re-start, all at minimal emissions and fuel consumption.

This forces base-load plants to operate closer to their design limits, mainly in terms of increased thermal cycles. However, projects are underway that should lead to new technology that delivers more cost-effective and highly flexible solutions for new and current power plants capable of meeting demand peaks and renewable output reductions at minimal fuel consumption, while mitigating the effects of cycling operation to avoid strong reductions in plant service lifetime.

Conclusion

The challenges shouldn't be underestimated, but with technology developments promising greater plant flexibility and physical interconnection of the energy systems across Europe, there is an opportunity to build on the progress so far and realise the better balance between affordable, clean and reliable electricity in Europe. Certainly, this will be a key topic of debate at this year's POWER-GEN Europe conference.

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China takes stock

With final market figures for 2013 now released, the industry can take stock of the impact of punitive tariffs against China. Despite last year's resolutions, Chinese manufacturers face further trade disputes.

THE SOLAR AND PV GLOBAL MARKETS have undergone an enormous change in the last couple of years with consolidation and market growth. With subsidies still driving most of the local growth there is still a sense of artifice to the industry as it moves towards self-sustainability. Another issue that has impacted on industry expectations has also been created with the punitive charges placed on Chinese manufacturers.

The China Chamber of Commerce for the Import and Export of Machinery and Electronic Products (CCCME) has released solar market figures for 2013. Industry officials were quick to point out the reason Europe had slipped behind Asia as the largest export region was due to plummeting sales amid trade disputes.

Sales of solar cells, modules and related products to Europe fell about 62 percent last year to $3.7 billion. In contrast, sales to Asian customers soared 124 percent to $5.5 billion, according to the solar division of the CCCME.

Sun Guangbin, secretary-general of the chamber commented that sales to Europe started to contract in 2012, after the European Union launched an anti-dumping probe into Chinese solar products. Chinese producers have been forced to scour new emerging markets for buyers. But it hasn't been easy to find enough of them to replace sales lost in Europe.

In 2013, China's total solar exports dropped 17.9 percent to $12.3 billion. Japan become the largest customer, accounting for nearly 25 percent of the total, while exports to Germany fell 75 percent to $507million.

Further USA cases

With the USA announcing tariffs and the EU striking the deal with manufacturers most people thought the issue was dealt with and the time had come to move forward on the trade issues. SolarWorld, the German based company who had spearheaded the initial dispute, had more to add and instigated further USA trade investigations.

SolarWorld announced that it is was taking further steps to shore up loop holes in the earlier ruling that allowed Chinesse companies to manufacture part of their module elsewhere to avoid the tariffs. Once again SolarWorld claimed to be acting on behalf of the entire US solar industry but the resounding sound of dissent showed that at best it was a small part of the industry backing the new claims.

"We're finishing the job of presenting the facts to our trade regulators to prevent China from further damaging yet another manufacturing industry and another rich base of employment", was the announcement from SolarWorld officials as they submitted anti-dumping and anti-subsidy cases at the end of

2013. The case cited Taiwan as the major region China was using as a back door manufacturing area to avoid tariffs.

In response to new U.S. trade petitions filed by SolarWorld USA against crystalline silicon solar products from China and Taiwan, Rhone Resch, president and CEO of the Solar Energy Industries Association (SEIA), did not appear to agree that the action was on behalf of the industry and offered the following comment, "We oppose today's escalation of the U.S.-China solar trade conflict. More litigation is the wrong approach. Trade litigation is a blunt instrument and, alone, incapable of resolving the complex competetiveness issues that exist between the U.S. and Chinese solar industries. It's time to end this conflict and negotiations must play a role."

SEIA have pushed both governments to seek resolution and cited the European outcome as proof that a solution could be reached. They claim their proposal provides a mutually-satisfactory resolution which recognizes the interests of all solar stakeholders and not just one segment of the industry. Once it was clear the US had decided to continue with the new case Resch decided to once more reach out to his membership suggesting the dispute was going from bad to worse.

"Without a negotiated settlement," he stated. "We're facing a double whammy this year with significant job losses across the entire U.S. solar supply chain and higher prices to American consumers. If imposed, the tariffs sought by SolarWorl, in excess of 165 percent on China and 75 percent on Taiwan, could result in a sharp increase in the cost of solar energy in the US."

It's time to end this needless sabre rattling. There are common sense ways to address SolarWorld's competitiveness concerns while ensuring the continued growth of the U.S. solar market – and one good way to do that is through a settlement proposal offered by SEIA. As an organization, we remain committed to developing a win-win solution, which would resolve SolarWorld's latest complaint, in addition to the broader U.S.-China trade conflict. It's time to negotiate a settlement – not litigate one. As a nation, too much is at stake for us to fail."

Tit for tat

The trade dispute that was begun by SolarWorld has had other impacts as other regions pursue similar paths and China also decided to instigate its own investigation into polysilicon material from the US, charging the same concerns regarding government support. The decision was not greeted warmly by the US solar coalition supporting the SolarWorld claim.

The Coalition for American Solar Manufacturing (CASM) protested the government of China's imposition of duties against U.S. and Korean producers of polysilicon. Calling the China position retaliatory and claiming it was using a tactic that it had abused, CASM was not shy about their stance.

CASM said the imposition of retaliatory tariffs came even as China heralded new opportunities for its solar-panel industry to access illegal, export-intensive subsidies.

CASM also chose to attack the Chinese court system and stated the procedure was 'neither transparent nor shown to be supported by facts, yet it will harm U.S. producers anyway.' . The group went on to suggest the US had been more effective in their approach and suggested China's case was only to divide US manufacturers.

The chairman of German solar manufacturer SolarWorld Frank Asbeck went as far as writing a letter to President Obama claiming the US solar industry was at threat, ignoring the fact that their counterpart in CASE disagreed with the view proposed.

In fact Jigar Shah, President of the Coalition for Affordable Solar Energy (CASE), wrote to Obama himself to refute the claims of SolarWorld and ensuring the public battle was no longer between USA and China but also within the US solar industry itself.

Shah called Asbeck's letter bizarre and reckless and suggested that any resolution lay with SolarWorld, who CASE consider the threat to the US industry.

It's time to end this needless sabre rattling. There are common sense ways to address SolarWorld's competitiveness concerns while ensuring the continued growth of the U.S. solar market. It's time to negotiate a settlement – not litigate one. As a nation, too much is at stake for us to fail

"Like the last effort from SolarWorld in 2012," wrote Shah, "There is no credible case that tariffs will lead to increased US solar panel manufacturing or employment. SolarWorld's reckless trade petition would destroy the demand for affordable solar which is creating tens of thousands of jobs per year. It is irresponsible and frankly contrary to American interests for a German company to suggest otherwise in a letter to the President of the United States."

Companies continue to abide

Regardless of the political reality of such trade disputes, the solar one turned into a flashpoint for a range of larger issues for the countries involved. There are companies impacted deeply. There are company losses but this is not just down to Chinese growth and dominance.

The industry is also consolidating and the dynamics are changing daily. Through it all the Chinese manufacturers continue to adhere to the requirements of the trade battles regardless of where they come from.

ReneSola a Chinese based provider of solar PV products, chose to comment after receiving a letter from the U.S. Department of Commerce in which ReneSola was named as one of the mandatory respondents related to the anti-dumping investigation.

It is common practice for the Department to selects certain companies with relatively large market share in the United States to participate in the investigation. ReneSola made it clear they intend to cooperate and expect the Department to make a preliminary ruling in June of this year.

"This investigation may result in certain retroactive tariffs being applied on products shipped to the United States within the investigation scope, including modules with Chinese and Taiwanese cell elements, if the Department finds sharply increased Chinese shipments to the United States from March to the preliminary ruling date," said Mr. Xianshou Li, chief executive officer of ReneSola. "In the interests of our clients and investors, we are temporarily reducing our United States product shipments in question.

"However, we have overseas capacity through our network of OEM facilities that we can use to continue shipping to the United States without any potential tariff risk. While we oppose the petition raised against certain products from China, we are well prepared and well positioned to meet this challenge and will continue to support U.S. consumers."

Wuxi Suntech was more direct and called for an end to the disputes. Eric Luo, the CEO of Wuxi Suntech, warned that unless the trade issues between the U.S. and China are resolved, the PV Industry would dramatically shrink.

"The real danger we're facing as an industry is not if a Chinese or American company goes bankrupt," said Luo. "But if the entire industry value chain collapses. China can manufacture high-end panels at truly competitive prices, but it cannot replace inexpensive, high quality American silicon, or a talented American workforce which would be the first to suffer from a spike in prices of solar energy."

As the Chinese solar industry representative to the EU-China anti-dumping negotiation deal, alongside the China Chamber of Commerce for Import and Export of Machinery and Electronic Products (CCCME), Luo has accumulated vast experience in China's solar trade disputes.

In a statement on the issue he added that "the selection of Wuxi Suntech by the DOC reflects not only our influence in the US market but also, I hope, a way for us to lend support in resolving this matter quickly. As a leader of a company which was shaken up by the sudden drop in prices of solar modules, I can share my American competitors' concerns over extreme price declines, but I also need to highlight the greater risks of industry instability - which the current trade disputes are contributing to. China has significant environmental challenges which the government is trying to meet. It has an ambitious goal for its renewable energy mix which is both bringing down the price of PV modules and helping many markets reach grid parity.

We are keen to work closely with our American stakeholders to assure that developments made in the Chinese PV industry complement those made in the U.S. PV industry."

Such issues divide industries as any outcome will affect a portion of the market differently to another. With such a scenario it is hard to see the companies involved prepared to negotiate an outcome that is not beneficial to their own needs. While many call for decisions that are based on what is best for the entire industry, no-one is actually sure what is best for the industry. It is not as simple as wanting the disputes to go away but an assurance of clear guidelines respecting international trade agreements.

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Calls for a better storage framework

The storage industry met in Düsseldorf earlier this year and more than 850 experts joined in discussions that will shape the European energy storage market. The conference provided a positive overview of proceedings and encapsulated the main issues.

Prof. Dr. Eicke R. Weber, Chairman of the Energy Storage Program Committee, President of the German Energy Storage Association (BVES) and Director of the Fraunhofer Institute for Solar Energy Systems, stated in a speech at the conference that, “The energy storage market is in the same situation today as photovoltaics a decade ago; only development in the area of storage must proceed significantly faster.”

“The storage industry,” he said. “Must achieve in three years what photovoltaics took ten years to achieve. “

In the keynote speech, the North Rhine-Westphalia Minister for Economics, Garrelt Duin, demanded that the general conditions and financial support for energy storage be more clearly organized and enforced. The public sector could, as a “visible consumer”, help to facilitate the breakthrough of energy storage technologies.

With the conference held in Germany there was a strong focus

on the reform of the German Renewable Energy Sources Act (EEG). As this has become the template for many other countries the topic was important to all attendees. Tobias Rothacher of Germany Trade and Invest hoped that the last word had not yet been said on the matter of EEG surcharge on industrial own consumption. Rothacher believes the big breakthrough for energy storage will come in the next two to three years, when no more feed-in subsidies are paid after the "flexible cap" has been reached.

"It is a logical step for the owners of photovoltaic plants to then purchase energy storage, in order to avoid throwing away the energy generated," explained Rothacher.

Rothacher stated that, in Germany, it will be possible to store approximately 3.8 TWh PV energy on an economically viable basis by 2020. That would allow for an installed battery storage capacity of more than 12 GWh.

Many companies and research institutes presented their latest products and research findings at the accompanying exhibition. Exhibitors included, among others, Siemens, Areva, FIAMM Energy Storage Solutions, SMA Solar Technology, Younicos, Hydrogenics, Varta Storage, RWE and E.ON. One of the highlights of the event for attendees was the new e-car with iDrive technology presented by BMW.

Global growth opportunities

Frank Wouters, Deputy Director-General of the International Renewable Energy Agency (IRENA) iterated a growing consensus that the market share of renewable energies will increase worldwide.

"Without increasing costs, the share of renewable energies in the energy supply worldwide can reach 36 percent by 2030," Wouters claimed.

IRENA held an international workshop during which promising energy storage technologies and applications that are to be included in IRENA's global technology roadmap for energy storage were presented in detail.

Many speakers felt that for the market to grow at its potential there was a need for corresponding regulatory conditions that could facilitate the breakthrough technology for energy storage and for market growth worldwide.

Dr. Ilja Pawel, Cellstrom GmbH/Gildemeister energy solutions, emphasized: "Energy storage still has a long way to go until it is used worldwide in an economically viable manner, but we are moving in the right direction. For this, we also need the right legal framework."

Whether energy storage is economically viable is a very complex

This new era of renewables will be driven not primarily by direct public support, but by private sector investment. It is through the establishment of bankability that renewable energy projects can attract the necessary funding to become a reality

question and depends heavily on the respective local conditions as was demonstrated by Tobias Cossen of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

During the session on "Building the Global Ecosystem for Grid Storage," Cossen reported on an example in the Philippine islands where diesel for energy production currently has to be flown in by helicopter. Here, a photovoltaic plant with energy storage amortizes itself very quickly.

Investment required

The 3rd Conference Power-to-Gas of the Ostbayerisches Technologie-Transfer-Institut (OTTI e. V.) also took place at the event. Annegret Agricola of the German Energy Agency (dena) explained in her opening speech that Power to Gas brings flexibility to the energy system.

It is an important technology for reaching the German climate and renewable energies targets. Agricola called for a tax exemption on energy storage for end-consumers, as well as amendments to the laws on renewable fuels made from hydrogen and synthetic natural gas.

"This new era of renewables will be driven not primarily by direct public support, but by private sector investment. It is through the establishment of bankability that renewable energy projects can attract the necessary funding to become a reality," stated Wilfried, Jäger, Managing Director of the VDE Testing & Certification Institute, in his speech at the VDE Financial Dialogue Europe.

Although the energy storage market is still in the early stages, there is strong momentum from the sector to overcome its hurdles.

"The business models for energy storage systems that we see today are not yet bankable from a non-recourse financing perspective, as pointed out by players in the financial industry. A lot of work has to be done, but we can learn from other sectors like solar photovoltaics, to avoid the same mistakes and be faster in some aspects," explained Matthias Jäger, Head Risk Advisory & Services, Allianz Climate Solutions.

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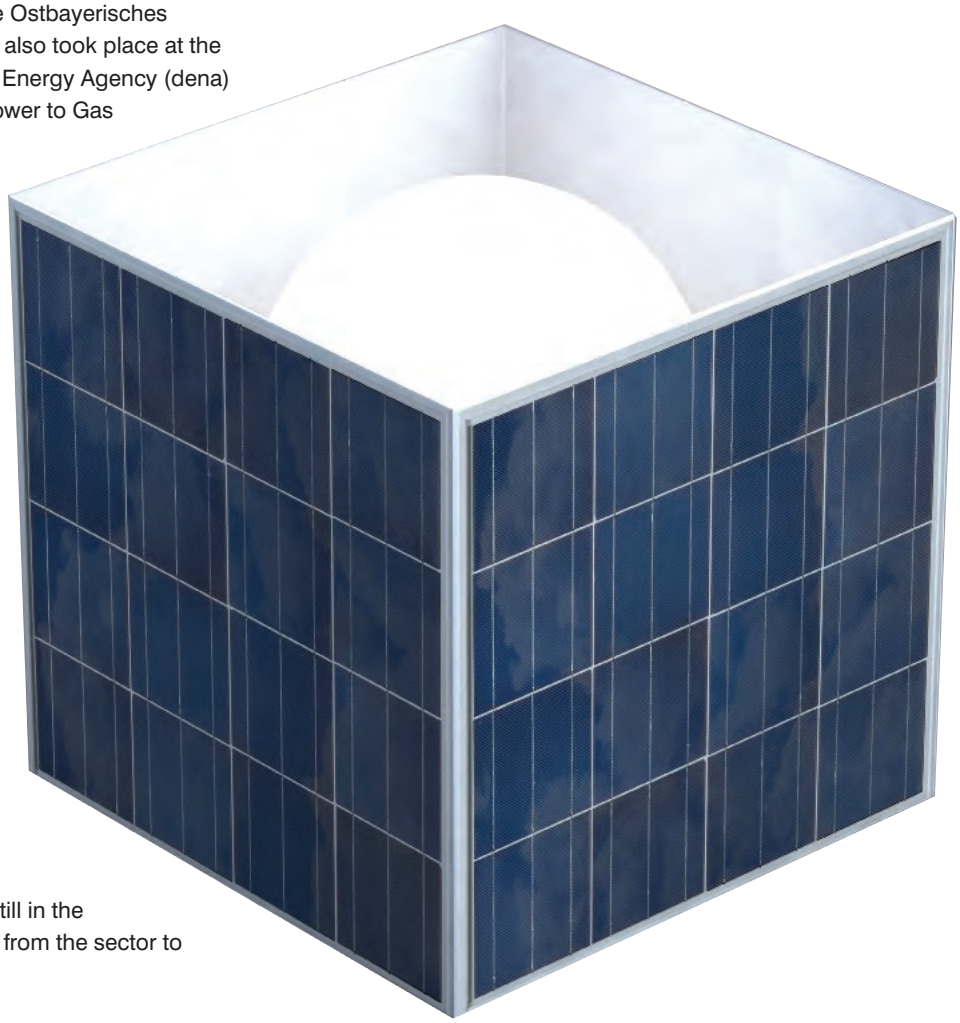

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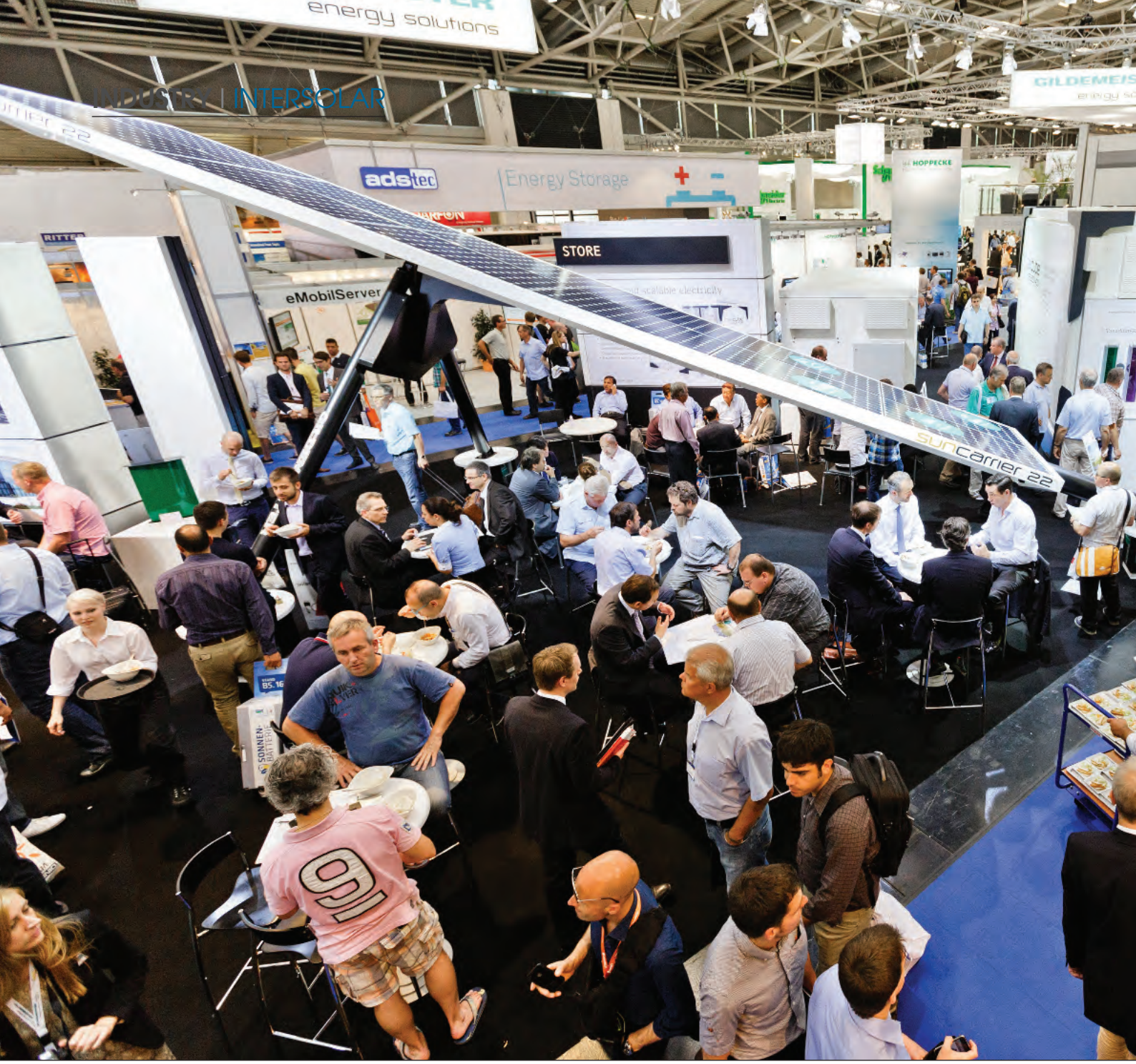
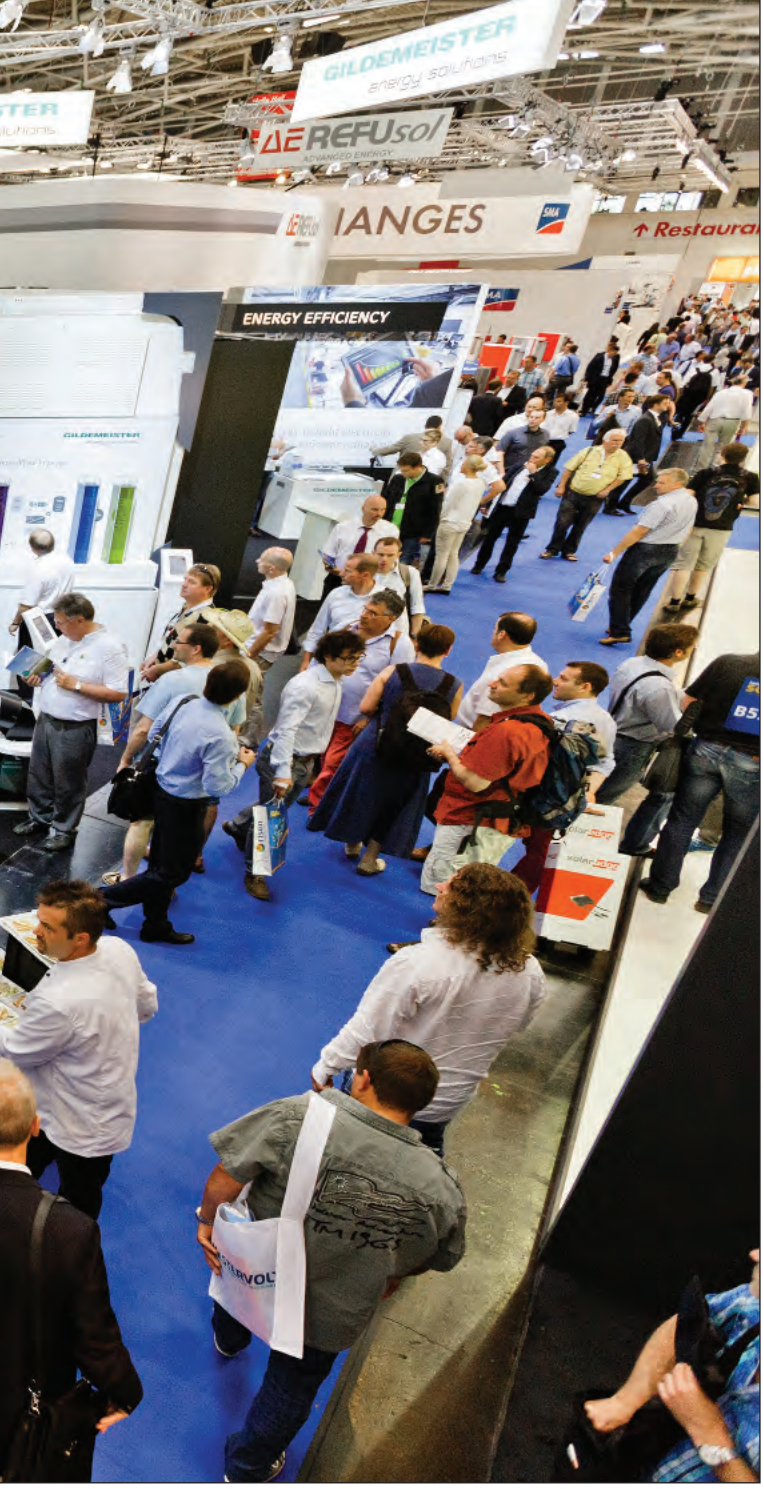


Solar on show

Intersolar Europe remains the world's largest conference and exhibition although the dynamics of the event have been changing with the industry. The conference continues to allow technological advances to take centre stage showing the innovative possibilities that sustainable energy production can bring.



FOLLOWING A CONSOLIDATION PHASE in the photovoltaics industry over the last two years, the international solar market looks poised to continue expansion. Current forecasts estimate a growth of at least 18% in 2014, with Asian markets expected to be the main driving force behind this development, followed by North and South America.

The industry is also predicting future PV booms in the Middle East, Africa and Turkey, positioning new regions on the future PV map alongside established markets. Newcomers benefit from the expertise and experiences collected by the European industry over recent years, ranging from intelligent grid integration, monitoring and maintenance of the installed capacity to the increasing level of storage of surplus solar power.

Europe is also leading the way in new business models for photovoltaics. Intersolar Europe 2014 promotes exchange between market participants and connects people from all four corners of the globe.

Global concerns

Despite working with different scenarios, market research companies and analysts are almost completely in agreement about market developments. NPD Solarbuzz, Santa Clara, USA, estimates a global photovoltaic demand of 45–55 gigawatts (GW) in 2014, which would mean a growth of 29% or more. However, even more conservative forecasts of 41 GW, as predicted by IHS Inc., Eaglewood, USA, point towards a growth of 18% from 2013.

International photovoltaics markets are often driven by solar power feed-in tariffs, which are based on the German EEG (Renewable Energy Sources Act) and have now been introduced in over 60 countries worldwide. International market incentive programs are not only limited to using the solar power feed-in tariff as the basis for investment security; most importantly, they ensure a structural shift towards renewable energies, resulting in an increased share of renewable power in the grids. In many cases, they also regulate the amount of power transferred by providing clear instructions on grid integration.

Many countries link this to a shift in focus in the energy supply – moving away from nuclear and fossil fuels and towards solar power. Many also see photovoltaics as a financially attractive alternative, especially due to the extremely high subsidies that conventional energy sources frequently enjoy.

Sunny outcomes

Large-scale PV plants provide an interesting alternative for governments all over the world when it comes to national tenders for new power plant capacities or power purchase agreements. Even now, renewable energy often puts less strain on state budgets than the costs generated by conventional power production. In particular, this can be seen in new PV markets in countries with high solar irradiation and rapidly growing electricity demands, such as Saudi Arabia, Chile and South Africa.

In addition to positive international development, the European market has also consolidated its position following reductions in installation costs in particular. Even without a feed-in tariff, solar power is already competitive in many European countries. Europe will therefore remain one of the most important regions for photovoltaics as the expected addition of 10 GW in 2013 corresponds to a share of 25% of the entire world market.

Solarbuzz predicts the European photovoltaics market to stabilize at around 2.5 GW of new capacity per quarter in the first half of 2014, and then start to gather speed in the second half of the year. Germany, Great Britain, Italy and France in particular will be the driving forces for getting the industry back on its feet.

Conference call up

The Intersolar Europe Conference will take place alongside Intersolar Europe. Over 2,000 attendees and some 300 speakers from all corners of the globe are set to meet at the conference and its side events. The conference covers current conditions and developments in the solar industry, as well the latest technologies and trends around the world.

The focus is mainly on developments in the markets, and the new area of Renewable Heating. Energy storage will also occupy a special place in the program this year, with several conference sessions dedicated to the topic. The electrical energy storage (ees) exhibition is being hosted by Intersolar Europe for the first time.

On June 4, the opening event of this year's Intersolar Europe will be a panel discussion shedding light on the energy transition in Germany and the progress so far. Prominent representatives from the world of politics, research and industry focus primarily on the different proposals and decisions of the new German government concerning the EEG amendment. Like last year, spectators and attendees can look forward to a controversial discussion about energy policy and industry conditions.

Dynamic markets

There is the usual focus on the various political, economic and legal conditions and requirements in different markets. Latest figures from the European Photovoltaic Industry Association (EPIA) showing that some 37 gigawatts (GW) of photovoltaic capacity was added globally in 2013. The largest increase in 2013 was recorded by the Chinese market with 11.3 GW.

Europe is however not far behind, with around 10 GW of capacity added in the same period. In five sessions, experts from all corners of the globe give a detailed account of the individual photovoltaic markets in Europe, Asia, North and South America, Middle East and Africa and how they are developing. What's more, off-grid PV applications can be an important means of energy supply, particularly in rural areas. In the session Off-Grid Markets, professionals therefore discuss the status quo and potential of selected regional markets.

New business and financing models are being unveiled in a dedicated session. Industry representatives will discuss the need to develop new business models for the industry and demonstrate new approaches. Topics such as the renting or leasing out of roof space to be used for industrial or commercial PV systems will be discussed and represent a promising area of business.

Technology leads the way

Speakers will turn their attention to technology in sessions on solar cell & module manufacturing, and module & power plant quality assurance, where various manufacturers are set to showcase their technical innovations. Representatives of selected testing and certification institutes are presenting quality assurance approaches and practices.

The sustainability of the product life cycle will also be covered, with the recycling of discarded panels rapidly increasing and their correct disposal now mandatory since 2012 under the WEEE (Waste Electrical and Electronic Equipment) Directive.

Intersolar Europe 2014 has expanded its range of topics. The area of renewable heating not only includes solar heat generation but also covers renewable heating systems, such as pellet and wood-chip heating systems, as well as energy-efficient technologies, such as mini combined heat and power plants or cogeneration systems and heat pumps. Discussion here on energy-efficient buildings looks particularly at the amended European Buildings Directive (nearly zero energy buildings) and the energy label that is soon to be mandatory in Europe to

There is the usual focus on the various political, economic and legal conditions and requirements in different markets. Latest figures from the European Photovoltaic Industry Association (EPIA) showing that some 37 gigawatts (GW) of photovoltaic capacity was added globally in 2013. The largest increase in 2013 was recorded by the Chinese market with 11.3 GW

provide information on energy consumption. According to the market research institute IHS Inc. (Englewood, USA), the market for grid-connected energy storage systems is on the verge of rapid expansion. The worldwide capacity of grid-connected energy storage systems currently stands at 340 megawatts (MW) but IHS are expecting this figure to rise to 6 gigawatts (GW) by 2017 and to a staggering 40 GW by 2022.

The market research institute has identified the USA, Germany and Japan as the sector's key markets. It puts the dramatic market growth down to the burgeoning demand for storage capacities brought about by the increased proportion of power generated using renewable energy as well as the resulting objectives and incentive systems.

Storing solar power not only enables private and commercial installation owners to enjoy independence from rising energy costs but also allows them to make an active investment in the generation of environmentally friendly energy. When used intelligently, the systems also benefit the public power grids by allowing the power generated to be increasingly consumed on site, which may protect the power grids from being overloaded, particularly at peak times.

This set of circumstances has resulted in energy storage systems becoming one of the key technologies for securing the success of the energy transition. Batteries and energy storage systems also play a vital role in the development of e-mobility.

Plan your entry

The key to any good conference is planning your event as much as possible. With a conference and exhibition as big as Intersolar this is more vital than usual. Dropping in on potential customers may not always result in a meeting as most people's schedules are filled up well in advance.

Absorb the knowledge as best as possible and enjoy the growing array of energy solutions that are being enabled by the continuing development of solar and PV technologies.

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Bright future for the solar power jobs market

An important selling point for any growing industry is the amount of people it can employ as it grows. The solar industry has gone through massive change and despite consolidation there remains consistent growth in employment opportunities. Sarah Kerr, Renewable Energy Recruitment Consultant at Allen & York takes a look at global market opportunities.

ALTHOUGH EUROPE is still leading the way in global solar PV energy production but the US, China and Japan are hot on their heels as dynamics change.

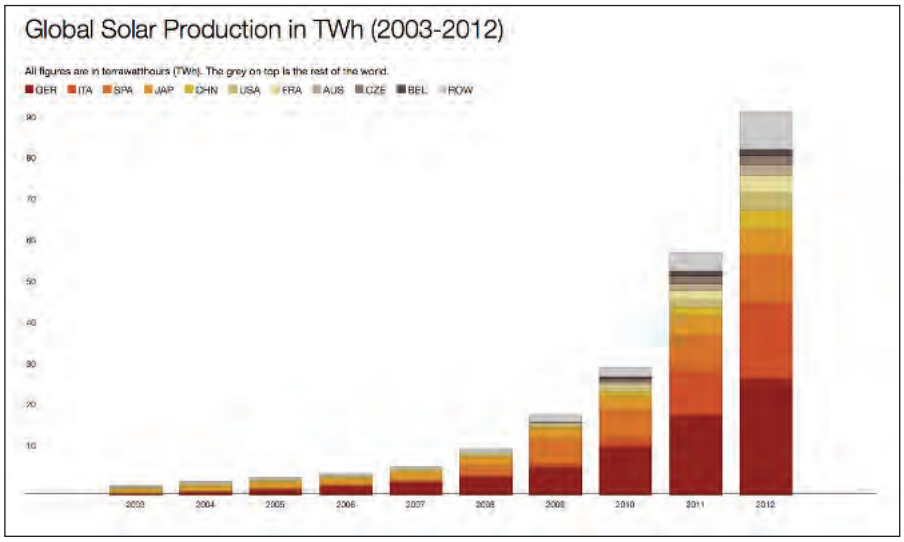
The US recorded record-breaking growth in 2013 Q3 and plans announced in March, Xcel Energy, a major US energy player will seek proposals to add 10 times more solar to its grid by 2017, and to double the amount of solar energy installed by 2020.

In 2012 solar power produced just 0.5% of global electricity. It's not huge compared to coal (42%), natural gas (21%), hydro (15%) and nuclear (12%), however this is a start-up industry and as graph 1 shows, the initial growth looks pretty healthy.

It is worth mentioning that although China may be in 5th place for Solar PV production, they are leading the way in Solar thermal water heating. By the end of 2012 all the solar PV capacity in the world totalled about 100 GW. Meanwhile in China solar water heating capacity alone had reached roughly 178GW.

Fast changing opportunities

Solar technologies have moved on significantly in recent years and a number of new options are coming into play. Installation costs have been estimated to have fallen by around 80% in the last 5 years, with a solar module costing approximately 1% of what it did 35 years ago, this, coupled with increasing oil, gas and coal prices and rising utility rates for electricity, the solar industry has piqued the interest of the investment markets, as well as bolstering the renewable energy jobs market.



Strong performance from renewables stocks has helped HSBC's Climate Change Index (CCI) outperform wider markets in 2014, with its solar index up 23% so far this year. The CCI, which now tracks 363 companies, has returned 4.6% from the start of 2014 and indicates that solar is leading the way: "HSBC analysts believe that in a number of US states and European markets solar has now reached grid parity, making it increasingly attractive to a growing pool of investors, because it does not need subsidies to be financially viable." (Environmental Finance, pub. 18/03/2014).

Impacts of these developments on the renewable energy jobs market have varied by country and technology, but globally the number of people working in renewable industries has continued to rise. An estimated 5.7 million people worldwide work directly or indirectly in the sector.

The Solar PV jobs market has been pretty volatile, with dramatic reductions in manufacturing costs coupled with massive overcapacities, as well as national fluctuations of Feed in Tariff (FiT) rates. However, the solar energy jobs market is still strong and globally Solar PV is currently employing an estimated 1.3 million as indicated in Graph 2 taken from the from the Renewables 2013 Global Status Report.

Global activity

The U.S. solar industry is one of the fastest growing industries in the U.S. Not only did the solar industry exceed its growth expectations, but the pace of hiring in 2013 was more than 50% higher than in 2012. (National Solar Jobs Census 2013, pub by The Solar Foundation, Jan 2014).

This fourth annual Census confirms that the solar industry continues to play an important role in the US's overall economic recovery by providing good-paying, high-skilled jobs opportunities to more than 142,000 workers at 18,000 locations in all 50 states. It's a 20% growth rate over the last year, more than ten times the overall US national employment growth rate during the same period.

So what are the predictions for future growth?

Although the jobs market in Spain has generally been erratic, analysts point out that the country has seen its first unsubsidised 1MW solar project connected to the grid, implemented by privately held company Grupo Enerpro, which has plans to develop a further 10 schemes this year alone.

China is expected to retain its title as the world's fastest growing solar energy market this year, followed by Japan – both benefiting from particularly supportive government policy. (source: Environmental Finance). China is targeting 14GW of solar PV installations over the course of the year, with a new FiT scheme making the market more attractive to investors.

The analysts predict that the 11% reduction in Japan's FiT rate will not deter investors, and the country will see 7.5GW of solar PV projects built in 2014.

Attention will increasingly turn to emerging solar markets in Latin America, with Brazil agreeing 122.8MW of installations to be delivered by July 2015, and initiatives in Chile and Peru to be carried out in coming years.

Example of possibilities

The UK Renewable Energy market has also reported strong growth in 2013 Q3. Bioenergy had the largest share of the renewable energy generation at 45%, with 25% coming from onshore wind, 18% from offshore wind, 7.3 % from hydro and 5.6% from solar PV . The UK market had been the fastest growing market and is tipped to be Europe's largest for the first half of 2014. The growth was late started allowing the country to learn from others mistakes. The goals of the industry seem large but they keep meeting the goals with manufacturing even developing.

UK Solar PV capacity increased by 119 MW during 2013 Q3, and by the end of September was at 2.5 GW, which is 13% of all renewable capacity. (source: Department of Energy & Climate Change (DECC)- Energy trends section 6: renewables - Updated 13 March 2014)

TABLE 1. ESTIMATED DIRECT AND INDIRECT JOBS IN RENEWABLE ENERGY WORLDWIDE, BY INDUSTRY

Technologies	Global	China	EU	Brazil	United States	India	Germany	Spain
	Thousand Jobs							
Biomass[a]	753	266	274		152[f]	58	57	39
Biofuels	1,379	24	109	804[e]	217[g]	35	23	4
Biogas	266	90	71			85	50	1
Geothermal[a]	180		51		35		14	0.3
Hydropower (small)[b]	109		24		8	12	7	2
Solar PV	1,360	300[d]	312		90	112	88	12
CSP	53		36		17		2	34
Solar heating/ cooling	892	800	32		12	41	11	1
Wind power	753	267	270	29	81	48	118	28
Total[c]	**5,745**	**1,747**	**1,179**	**833**	**611**	**391**	**378[h]**	**120**

Installed solar PV capacity has increased 25 fold since the end of 2010 in the UK and the new Solar PV Energy Roadmap set out by DECC, will work with businesses and industry to build on this unprecedented growth. DECC published the 'UK Solar PV Strategy Part 1: Roadmap to a Brighter Future' in October 2013, as a precursor to publishing their eagerly awaited 'Solar PV Strategy' in spring 2014 which will assist the development of policy and the growth of the solar energy sector.

Ray Noble, Co-chair of the Government's Solar Strategy Group, has a vision that the UK could eventually develop its own solar-module manufacturing base. "I think what's going to happen is exactly what happened with Honda, Toyota and Nissan in the UK automotive industry. They built assembly plants which have become manufacturing plants and they've ended up exporting back to Japan. Transferring modules around the world is a waste of time because you've got a container full of fresh air. Within two to three years I can see assembly being done in Europe and the UK. It's a super-fast-moving industry. The problem is trying to keep up with it."

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Superabsorbing design to lower thin film costs

Researchers from North Carolina State University have developed a "superabsorbing" design that may significantly improve the light absorption efficiency of thin film solar cells and drive down manufacturing costs.

A SUPERABSORBING DESIGN developed by researchers could decrease the thickness of the semiconductor materials used in thin film solar cells by more than one order of magnitude without compromising solar light absorption.

"State-of-the-art thin film solar cells require an amorphous silicon layer that is about 100 nanometers (nm) thick to capture the majority of the available solar energy," says Dr. Linyou Cao, an assistant professor of materials science and engineering at NC State and senior author of a paper describing the work. "The structure we're proposing can absorb 90 percent of available solar energy using only a 10 nm thick layer of amorphous silicon.

"The same is true for other materials. For example, you need a cadmium telluride layer that is one micrometer thick to absorb solar energy, but our design can achieve the same results with a 50 nm thick layer of cadmium telluride. Our design can also enable a 30 nm thick layer of copper indium gallium selenide to fully absorb solar light. That's a huge advance."

Cao notes that the deposition of semiconductor materials stands as a major bottleneck for improving manufacturing productivity and lowering the cost of thin film solar cells. "A decrease in the thickness of semiconductor materials by one order of magnitude would mean a substantial improvement in manufacturing productivity and reduction in cost," Cao says, because the cells would use less material and the thin films could be deposited more quickly. In cross-section, the new design looks like a rectangular onion. The light-absorbing semiconductor material coats a rectangular core. The semiconductor, in turn, is coated by three layers of anti-reflective coating that do not absorb light.

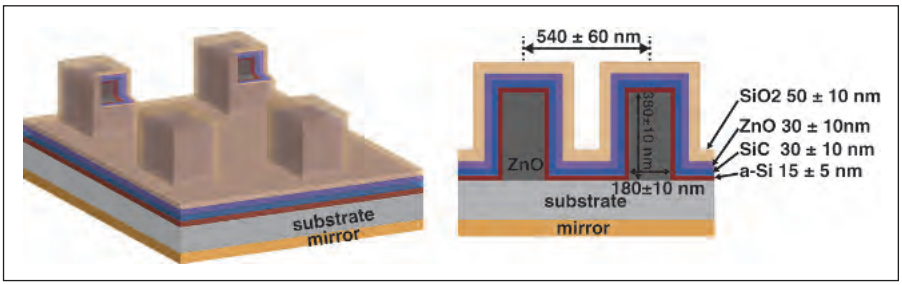

Image courtesy of North Carolina State University

To develop the design, the researchers began by examining the maximum light absorption efficiency of semiconductor materials using light-trapping techniques.

They found that maximizing solar absorption requires a design in which the light-trapping efficiency for solar light is equal to the intrinsic absorption efficiency of the semiconductor materials. In other words, in order to maximize solar absorption, you need to match the amount of solar light trapped inside the structure and the amount of solar light that could be absorbed. The researchers then designed the onion-like structures to match their light-trapping efficiency with the absorption efficiency of the semiconductor materials in thin film solar cells.

"We first theoretically predicted the maximum solar light absorption efficiency in given semiconductor materials, and then proposed a design that could be readily fabricated to achieve the predicted maximum. We developed a new model to do this work, because we felt that existing models were not able to find the upper limit for the solar absorption of real semiconductor materials," Cao says "And if this works the way we think it will, it would fundamentally solve light-absorption efficiency problems for thin film solar cells.

"The superabsorbing structure is designed for the convenience of fabrication, and we are looking for partners to produce and test this design," Cao adds. "The structure should be very easy to produce with standard thin film deposition and nanolithography techniques. We are happy to work with industry partners to implement this design in the production of next-generation solar cells."

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The paper, "Semiconductor Solar Superabsorbers," was published in the journal Scientific Reports. Lead author is Yiling Yu, a Ph.D. student at NC State. Co-authored by NC State Ph.D. student Lujun Huang.

Tiny crystals to boost solar

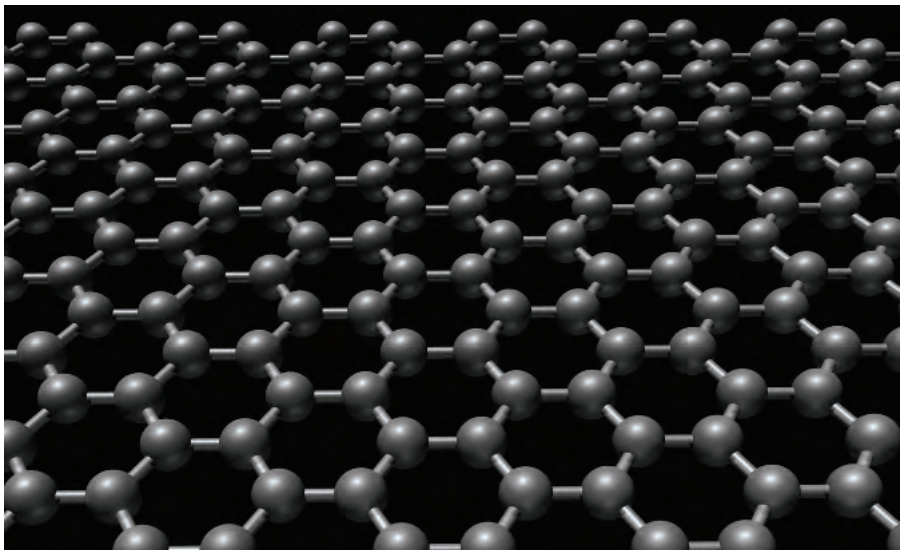
A new approach to studying solar panel absorber materials has been developed by researchers in France.

A NEW APPROACH to studying solar panel absorber materials has been developed by researchers in France, [Lafond et al. (2014). Acta Cryst. (2014). B70, 390–394]. The technique could accelerate the development of non-toxic and available alternatives to current absorbers in thin film based solar cells.

The development of solar panel materials that are both non-toxic and made from readily available elements rather than rare and precious metals is a priority in developing a sustainable technology. Sulfide materials containing the relatively common metals copper, tin and zinc, so called kesterites, have been proposed as solar cell absorber materials because they comply with these two demands. Experimental solar cells using Cu_2ZnSnS_4 (CZTS) have demonstrated energy conversion efficiencies of 8.4% and 12% for a seleno-sulfide analogue. New structural information is crucial to improving on these figures still further.

Unfortunately, kesterites are not amenable to conventional X-ray diffraction because copper and zinc ions are indistinguishable. Now, Alain Lafond and his colleagues at Nantes University and Pierre Fertey from Soleil synchrotron have demonstrated that it is possible to carry out resonant diffraction of a single crystal of the semiconductor CZTS.

The powdered precursor was prepared using a ceramic synthesis at a high temperature (1023 K) from the corresponding element Cu, Zn, Sn and S. The product is heated for a further 96 hours to anneal it before it is plunged into ice-water to lock in the chemical structure



present at that elevated temperature, a process known as quenching. Tiny single crystals of sufficient quality for X-ray diffraction were picked out of the powder. The researchers used laboratory powder X-ray diffraction and energy-dispersive X-ray spectroscopy analyses to test the purity of their product. They then carried out high-performance resonant diffraction on the CRISTAL beamline at the Soleil French synchrotron, which gives them the possibility to adjust the radiation wavelength in order to enhance the contrast between copper and zinc.

The data they obtained showed the annealing process generates a disordered structure that can be distinguished from the order kesterite structure despite the otherwise similar X-ray scattering pattern that would be generated by the copper and zinc ions in the ordered form.

The team points out that the fabrication process for making a thin absorber film from CZTS in a solar panel is carried out at an elevated temperature and the disordered form is likely to be the active form produced which probably precludes high PV performance.The findings offer important clues for the development of CZTS and related materials that avoid expensive and rare materials such as indium and tellurium in solar cells.

“The next step in this research is to determine the relationship between the synthesis conditions (quenching or slow cooling) and the actual Cu/Zn distribution in the kesterite structure,” Lafond told us. He revealed that a new proposal to the Soleil French Synchrotron Facility has been deposited for the next experimental period and in the meantime structural disorder in kesterite materials can be investigated by solid state NMR and Raman spectroscopy.

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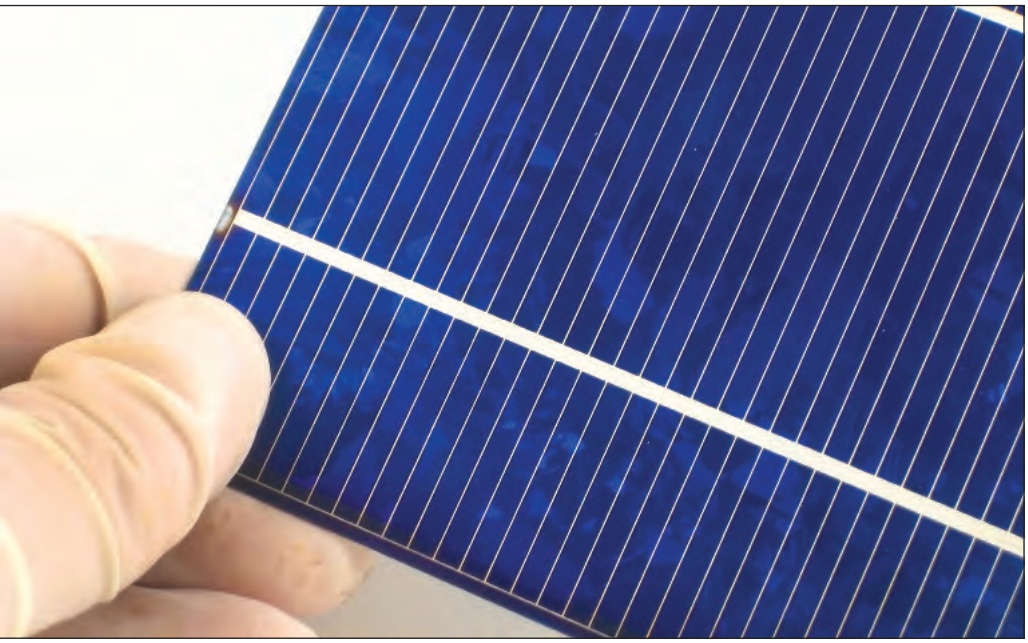

Surprise discovery for researchers

Multidisciplinary ORNL team discovers unexpected effect of heavy hydrogen in organic solar cells.

PHOTOVOLTAIC SPRAY paint could coat the windows and walls of the future if scientists are successful in developing low-cost, flexible solar cells based on organic polymers. Scientists at the Department of Energy's Oak Ridge National Laboratory recently discovered an unanticipated factor in the performance of polymer-based solar devices that gives new insight on how these materials form and function.

"One of the dreams is to bring home some polymer paint from the hardware store, spray it on a window and make your own solar cell because it self-orders into a structure that can generate electricity," ORNL's David Geohegan said. "But right now there are many unknown things that happen when you spray it down and it dries. Changing the electrical property of a polymer also changes its structure when it dries, so understanding this process is one of our big science mysteries."

When ORNL scientists Kai Xiao and Kunlun Hong analyzed neutron scattering data obtained at the lab's Spallation Neutron Source to measure the structure of seemingly identical polymer-based solar devices, they stumbled upon a new piece to the scientific solar puzzle. The key to their finding was deuterium, also known as "heavy hydrogen," which is commonly used in neutron scattering analysis. Scientists use the isotope as a labeling tool, replacing hydrogen with deuterium in organic samples because deuterium's extra neutron helps reveal soft materials' structure.

"Normally scientists assume that the deuteration doesn't change the electronic structure at all," said Xiao, a materials scientist at ORNL's Center for Nanophase Materials Sciences. "But when we used it to study conducting polymers in solar cells, the devices' electronic performance changed significantly."

To understand the mechanisms behind deuterium's effects, the team turned to ORNL's Bobby Sumpter and another lab strength -- supercomputer simulation. Modeling the system through quantum calculations helped the researchers determine that heavy hydrogen changes the molecules' vibrations, which indirectly but significantly affects the material's electronic properties.

In the case of the team's organic solar cells, deuteration turns out to have a negative impact, decreasing the devices' electrical efficiency. But the ORNL researchers note that other organic electronics such as organic spintronics or light emitting diodes (OLEDs) could benefit from deuterium's effects. "Overall, deuterating polymers helps us understand how energy flows in organic electronics so we can improve and optimize them in the future," Xiao said. "It's opening our eyes to the fact there is an impact."

The researchers' unexpected results could also inform future neutron studies in the organic electronics field. Xiao notes, for instance, that the precise position of deuterium in the polymer chain determines whether the overall electrical properties will be altered.

"We need to carefully control the deuteration of polymers for neutron experiments," Xiao said. "Adding deuterium to the polymer's side chain doesn't affect the neutron results, but deuterating the main backbone of the polymer chain does change the structure of the films."

The team's study, supported by the Department of Energy's Office of Science, is published in Nature Communications. The researchers plan to continue integrating their polymer synthesis and neutron research through a new project to study polymer solutions as they dry.

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Part of this research was conducted at the Center for Nanophase Materials Sciences, which is sponsored at ORNL by the Scientific User Facilities Division in DOE's Office of Basic Energy Sciences.

Creating solar materials by sunlight

In a recent advance in solar energy, researchers have discovered a way to tap the sun not only as a source of power, but also to directly produce the solar energy materials that make this possible.

A BREAKTHROUGH by chemical engineers at Oregon State University could soon reduce the cost of solar energy, speed production processes, use environmentally benign materials, and make the sun almost a "one-stop shop" that produces both the materials for solar devices and the eternal energy to power them.

The findings were just published in RSC Advances, a journal of the Royal Society of Chemistry, in work supported by the National Science Foundation.

"This approach should work and is very environmentally conscious," said Chih-Hung Chang, a professor of chemical engineering at Oregon State University, and lead author on the study.

"Several aspects of this system should continue to reduce the cost of solar energy, and when widely used, our carbon footprint," Chang said. "It could produce solar energy materials anywhere there's an adequate solar resource, and in this chemical manufacturing process, there would be zero energy impact."

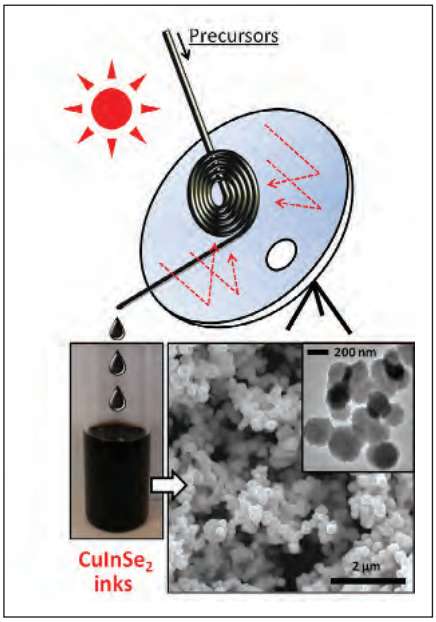
The work is based on the use of a "continuous flow" microreactor to produce nanoparticle inks that make solar cells by printing. Existing approaches based mostly on batch operations are more time-consuming and costly. In this process, simulated sunlight is focused on the solar microreactor to rapidly heat it, while allowing precise control of temperature to aid the quality of the finished product.

The light in these experiments was produced artificially, but the process could be done with direct sunlight, and at a fraction of the cost of current approaches.

"Our system can synthesize solar energy materials in minutes compared to other processes that might take 30 minutes to two hours," Chang said. "This gain in operation speed can lower cost."

In these experiments, the solar materials were made with copper indium diselenide, but to lower material costs it might also be possible to use a compound such as copper zinc tin sulfide, Chang said. And to make the process something that could work 24 hours a day, sunlight might initially be used to create molten salts that could later be used as an energy source for the manufacturing.

This could provide more precise control of the processing temperature needed to create the solar energy materials. State-of-the-art chalcogenide-based, thin film solar cells have already reached a fairly high solar energy conversion efficiency



of about 20 percent in the laboratory, researchers said, while costing less than silicon technology. Further improvements in efficiency should be possible, they said. Another advantage of these thin-film approaches to solar energy is that the solar absorbing layers are, in fact, very thin - about 1-2 microns, instead of the 50-100 microns of more conventional silicon cells. This could ease the incorporation of solar energy into structures, by coating thin films onto windows, roof shingles or other possibilities.

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Additional support for this work was provided by the Oregon Nanoscience and Microtechnologies Institute, or ONAMI, and the Oregon Built Environment and Sustainable Technologies Center, or Oregon BEST.

Swedish researchers advance nanotubes for solar

Swedish research has shown that controlled placement of nanotubes will provide boost to performance.

Carbon nanotubes are becoming increasingly attractive for photovoltaic solar cells as a replacement to silicon. Researchers at Umeå University in Sweden have discovered that controlled placement of the carbon nanotubes into nano-structures produces a huge boost in electronic performance. Their groundbreaking results are published in the journal Advanced Materials.

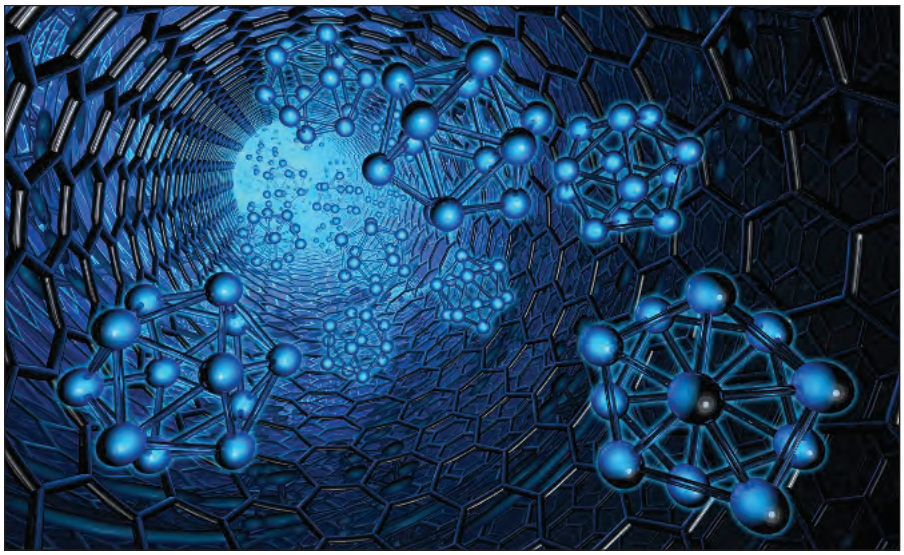
Carbon nanotubes, CNTs, are one dimensional nanoscale cylinders made of carbon atoms that possess very unique properties. For example, they have very high tensile strength and exceptional electron mobility, which make them very attractive for the next generation of organic and carbon-based electronic devices.

There is an increasing trend of using carbon based nanostructured materials as components in solar cells. Due to their exceptional properties, carbon nanotubes are expected to enhance the performance of current solar cells through efficient charge transport inside the device.

However, in order to obtain the highest performance for electronic applications, the carbon nanotubes must be assembled into a well-ordered network of interconnecting nanotubes.

Unfortunately, conventional methods used today are far from optimal which results in low device performance.

In a new study, a team of physicists and chemists at Umeå University have joined forces to produce nano-engineered carbon nanotubes networks with novel properties.



For the first time, the researchers show that carbon nanotubes can be engineered into complex network architectures, and with controlled nano-scale dimensions inside a polymer matrix.

“We have found that the resulting nano networks possess exceptional ability to transport charges, up to 100 million times higher than previously measured carbon nanotube random networks produced by conventional methods,” says Dr David Barbero, leader of the project and assistant professor at the Department of Physics at Umeå University.

The high degree of control of the method enables production of highly efficient nanotube networks with a very small amount of nanotubes compared to other conventional methods, thereby strongly reducing materials costs. In a previous study (Applied Physics Letters, Volume 103, Issue 2, 021116 (2013)) the research team of David R. Barbero already demonstrated that nano-engineered networks can be produced onto thin and flexible transparent electrodes that can be used in flexible solar cells. These new results are expected to accelerate the development of next generation of flexible carbon based solar cells, which are both more efficient and less expensive to produce.

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Journal reference

Nano-engineering of SWNT networks for enhanced charge transport at ultralow nanotube loading. D. R. Barbero, N. Boulanger, M. Ramstedt, Department of Chemistry, Umeå University, J. Yu, Department of Physics, Umeå University . Advanced Materials. DOI: 10.1002/adma.201305718.

Fraunhofer ISE develops tech for solar tower power plants

The Fraunhofer Institute for Solar Energy Systems ISE develops new technologies for more cost-efficient solar tower power plants using solar thermal energy.

AS PART OF THE COOPERATION PROJECT "HelioPack", Fraunhofer researchers together with the industrial partner Solar Tower Technologies AG (STT) of Starnberg develop solutions that allow for significant cost reductions in solar thermal power generation. The project partners aim at cost savings and efficiency gains from an optimised construction of heliostats as well as an improved tracking and control to achieve a more precise concentration of solar beam radiation onto a newly developed receiver.

In solar tower power plants, solar beam radiation is redirected by a multitude of tracked mirrors (heliostats) onto a central receiver mounted at the top of a tower. Therefore, the technology sometimes is referred to as central receiver technology. The extreme concentration of radiation generates very high temperatures at the receiver unit where the thermal energy is transferred to a heat transfer fluid. The thermal energy is used to drive a turbine and generate electricity in a power block. As an alternative, the energy may be completely or partly stored in a thermal storage, to be used for electricity generation at a later time. In this way, solar tower power plants can generate dispatchable power around the clock and thus can contribute significantly to grid stabilization in regions of high direct solar irradiation.

Besides other technologies for solar thermal power like parabolic trough or linear Fresnel collectors, which have been under investigation at Fraunhofer ISE for some time now, power towers are particularly suited for the combination with thermal storage due to the potentially very high temperatures and the low distance between receiver and storage. "In the project HelioPack we will cooperate closely with our industrial partner to develop technologies contributing to cost reductions. With the know-how generated in this project, we will be able to offer future customers R&D services to further improve components for solar power towers or to manufacture them at reduced cost," emphasizes Dr. Peter Nitz, project manager of "HelioPack" at Fraunhofer ISE.

"STT welcomes this collaboration with Fraunhofer ISE," adds Dr. Antoine Bittar, Chief Science Officer at STT. "Through this cooperation we want to further develop and strengthen the advantages of STT technology: reliability and cost competitiveness."

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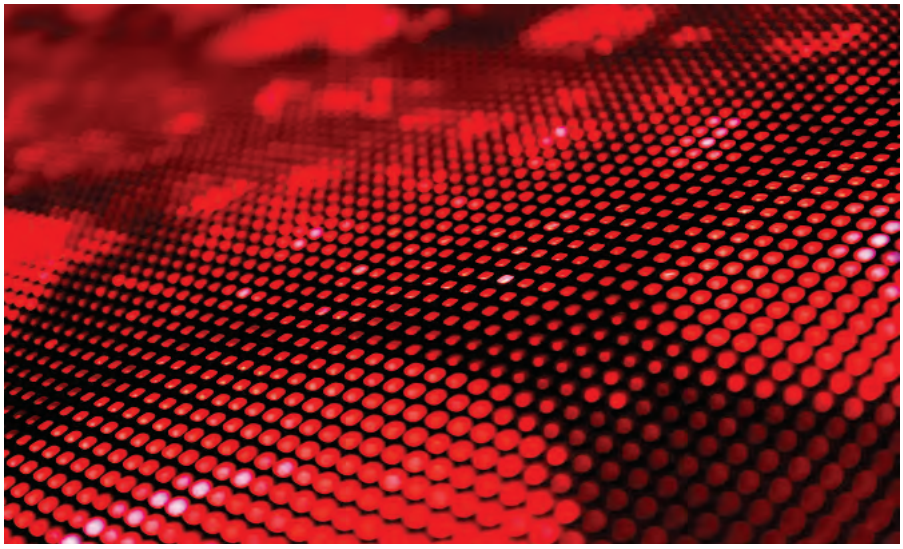
Singapore scientists develop multi purpose perovskite solar cells

Nanyang Technological University (NTU) scientists have developed a next-generation solar cell material which can also emit light, in addition to converting light to electricity.



A NEW SOLAR CELL has been developed from Perovskite, a promising material that could hold the key to creating high-efficiency, inexpensive solar cells. The new cells not only glow when electricity passes through them, but they can also be customised to emit different colours. This discovery, published in top academic journal Nature Materials, was discovered almost by chance when NTU physicist Sum Tze Chien, asked his postdoctoral researcher Xing Guichuan to shine a laser on the new hybrid Perovskite solar cell material they are developing.

Assistant Professor Sum said to the team's surprise, the new Perovskite solar cell glowed brightly when a laser beam was shone on it. This is a significant finding as most solar cell materials are good at absorbing light but are generally not expected to generate light. In fact, this highly luminescent new Perovskite material is also very suitable for the making of lasers.

"What we have discovered is that because it is a high quality material, and durable under light exposure, it can capture light particles and convert them to electricity, or vice versa," said Asst Prof Sum, a scientist at NTU's School of Physical and Mathematical Sciences (SPMS).

"By tuning the composition of the material, we can make it emit a wide range of colours, which also makes it suitable as a light emitting device, such as flat screen displays."

His research partner, Assistant Professor Nripan Mathews from the School of Materials Science and Engineering (MSE) said this newly discovered property is expected to enable the industry to adopt the material into existing technology.

"What we have now is a solar cell material that can be made semi-translucent. It can be used as tinted glass to replace current windows, yet it is able to generate electricity from sunlight. The fact that it can also emit light makes it useful as light decorations or displays for the facades of shopping malls and offices," said Dr Mathews, who is also the Singapore R&D Director of the Singapore-Berkeley Research Initiative for Sustainable Energy (SinBeRISE) NRF CREATE program.

"Such a versatile yet low-cost material would be a boon for green buildings. Since we are already working on the scaling up of these materials for large-scale solar cells, it is pretty straightforward to modify the procedures to fabricate light emitting devices as well. More significantly, the ability of this material to lase, has implications for on-chip electronic devices that source, detect and control light," he added.
This NTU breakthrough has already won praise from experts. Professor Ramamoorthy Ramesh, the Purnendu Chatterjee Endowed Chair in Energy Technologies professor at the University of California, Berkeley in the United States said: "This work from the NTU SinBeRISE team clearly shows the promise of such new materials in a broad range of applications, including solar cells and now for lasing. It also shows the power of interdisciplinary, basic science in making fundamental discoveries that will impact in a broad sense."

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The inner workings of the new NTU solar cell material were published in the scientific journal, Science, in October last year by the same NTU research group.The advanced material, which is currently patent pending, is five times cheaper than current Silicon based solar cells. This is due to its easy solution-based manufacturing process of combining two chemicals. The NTU team, consisting of eight scientists and researchers, has been working on this Perovskite project since early 2013.

Spanish researchers reveal infrared PV cell

A group of researchers have announced a PV cell that responds to infrared light.

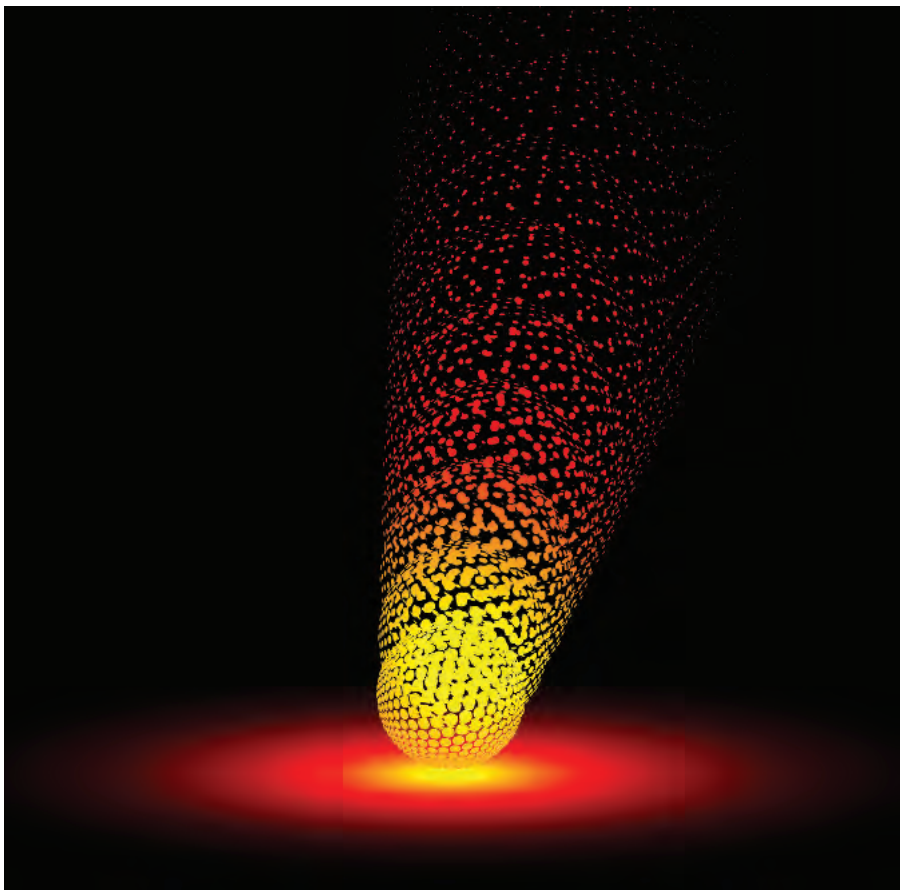
RESEARCHERS of the Universitat Politècnica de València, the Spanish National Research Council (CSIC, in Spanish), the Universitat Politècnica de Catalunya-BarcelonaTech (UPC) and the Universidad Rovira i Virgili de Tarragona have developed a silicon photovoltaic cell capable of turning infrared radiation into electricity. A paper led by Francisco Meseguer professor from the CSIC, at the joint lab UPV/CSIC has been published Nature Communications magazine.

The sun is an inexhaustible source of energy which well-exploited, could solve many of the energy suply problems we have today. The photovoltaic cell, commonly known as solar cell, is a device capable of turning solar light into electricity.

However, there are many obstacles that prevent a massive use, such as a relatively high cost (0.02 euros per watt generated) and the low efficiency of silicon based solar cells, around 17 per cent. The low efficiency is related to the material the solar cell is made of. Most solar cells are made of silicon which is relatively cheap to produce.

However these solar cells can generate electricity from the visible part of the sun spectrum, but the infrared region is, unfortunately, useless.

The professor Francisco Meseguer, explains that, “after three years of work, our research team has developed a new concept of silicon solar cells able to absorb infrared radiation from the sun and turning them into electricity.” Moisés Garín, a researcher from the CSIC and the Universitat Politècnica de Catalunya, adds that, “what we have done is create photovoltaic cells on silicon micrometre scale sphere, where infrared light is trapped until it is absorbed turning it into electricity”.



This work is a new scientific achievement for the development of high-performance photovoltaic cells in the future.

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M. Garín, R. Fenollosa, R. Alcubilla, L. Shi, L.F. Marsal y F. Meseguer. “All-silicon spherical-Mie-resonator photodiode with spectral response in the infrared region.”
Nature Communications 5, Article number: 3440 DOI: 10.1038/ncomms4440 .
Received 10 July 2013 Accepted 12 February 2014
Published 10 March 2014

Solliance consortium develop thin film interconnect tool

Dutch researchers announce new approach manufacturing tool for thin film PV.

A DUTCH CONSORTIUM consisting of CCM (Centre for Concepts in Mechatronics), IBSPE (IBS Precision Engineering), Smit Ovens, SPGPrints and the Solliance partners TNO (Netherlands Organisation for Applied Scientific Research) and ECN (Energy research Centre of the Netherlands) has produced a prototype process station for thin film interconnect in the production of solar cells.

The process station allows the serial connection of thin-film solar cells (ProDuZo) by splitting the rolls of photoactive substrate into sections and connecting them electrically. Because the manufacturing process is continuous, the solar cells can be produced more cheaply and there is greater flexibility in design than currently achieved with conventional processes.

The basis of the system is the Generic Substrate Carrier developed by CCM. This is a highly accurate metal conveyor and can transport a sheet of glass plate or a roll of flexible foil of maximum 60 centimetres wide at a speed of up to 2000 millimetres per second (7.2kph). The transportation has an accuracy of 10 micrometres, or one hundredth of a millimetre, and performs a number of processes over a distance of 2 metres. A laser is used to scribe the grooves in the material that separate the individual cells. The electrical connections (known as the interconnects), which consist of an insulating ink and a conductive silver ink, are then printed on these cells using inkjet technology.

ProDuZo was developed for two reasons. First of all, 'backend' production processes for printing the interconnects are required in order to ensure flexible form and function of the solar cell. The next step in the backend process involves cutting cells to size – large or small, flat or curved. This means that each of the production processes can be optimised separately and the desired form can be selected in the final phase. And the process station will allow such flexibility in manufacturing.

The second rationale for developing ProDuZo was to reduce the loss of surface area that is lost due to the presence of the interconnects, known as the dead zone. Thanks to the application of precision technologies, the interconnects made are much smaller than those of conventional systems, resulting in a greater total yield per solar cell. With the process steps on the conveyor belt conducted in quick succession and with the utmost of precision, the influence of impurities and movement of the roll is kept to a minimum.

The partners in the consortium each had a specific role in the ProDuZo project. CCM improved the precision of the Generic Substrate Carrier in order to achieve the required speed and accuracy. Solliance partner ECN developed an optical system that splits laser bundles in order to scribe large series of parallel grooves. SPGPrints developed the printing stations and optimised the process in which electrically insulated and conductive inks are loaded in the right cartridges in the right amounts. IBS Precision Engineering developed a monitoring system which enabled the quality of the electrical connections to be analysed in line. Solliance partner TNO provided expertise in the field of materials handling in a roll-to-roll installation and, in the role of system architect, combined the chosen design components into a total concept. Finally, Smit Ovens connected the consortium to the manufacturers in the solar industry.

The development of ProDuZo by the consortium was financed by the Netherlands Enterprise Agency (RVO), the Province of Noord-Brabant (including funds allocated to the Solliance alliance) and the Eindhoven Region Partnership (SRE).

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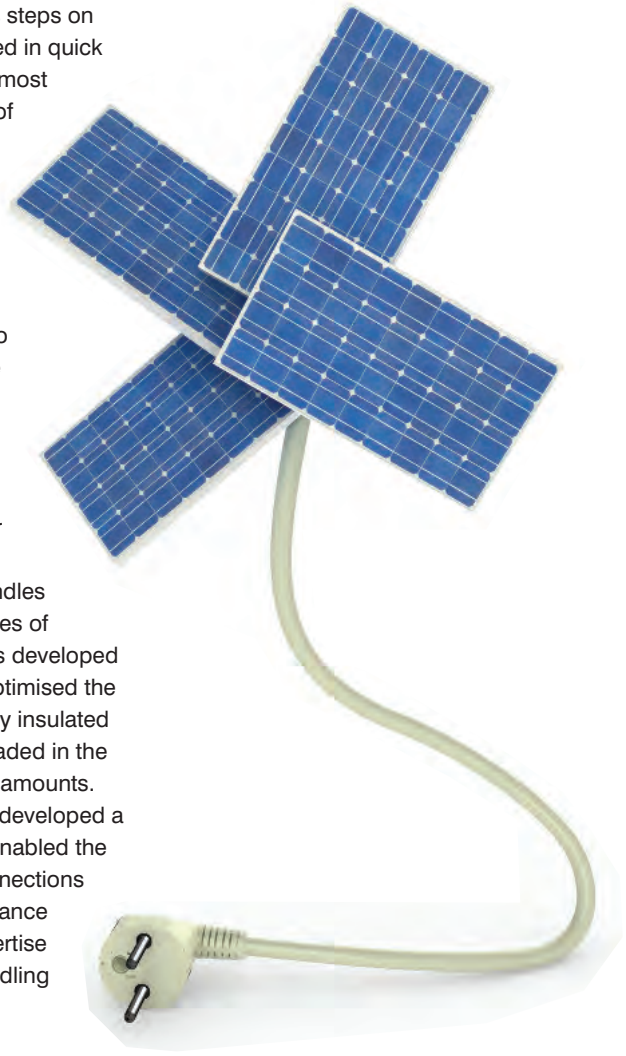


Researchers study cloud impact

SNL engineers begin a study on real impact of clouds on PV.

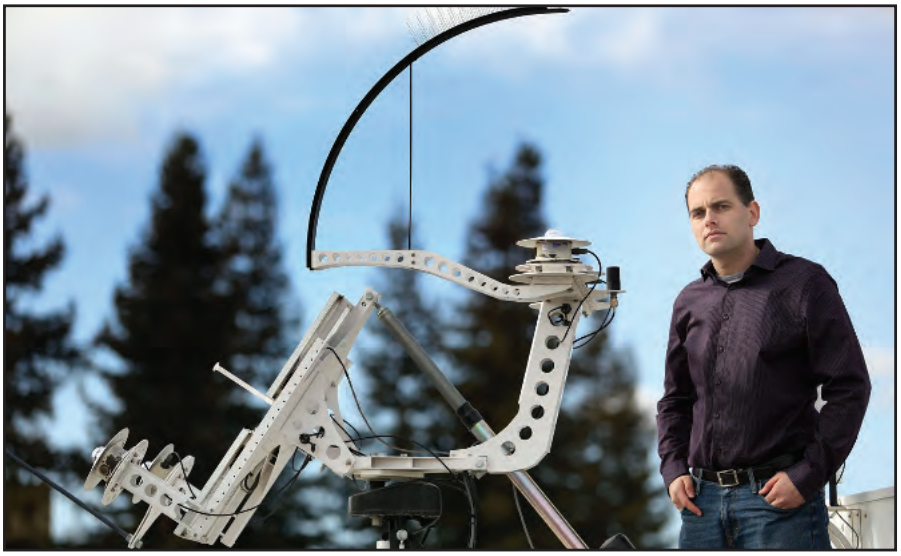
SANDIA NATIONAL LABORATORIES engineers have been studying the most effective ways to use solar photovoltaic (PV) arrays. Systems are relatively easy to install and have relatively small maintenance costs. They begin working immediately and can run unassisted for decades.

But clouds could dim industry growth: What happens when they cover part of a solar PV array and cause a dip in output, how big is the dip and how can a utility company compensate for it? Sandia researcher Matt Lave has been working to understand that drawback and determine just how much clouds can affect solar power plant output. Typically, sunlight is measured using a single irradiance point sensor, which correlates nicely to a single PV panel. But that doesn't translate to a large PV power plant.

"If a cloud passes over, it might cover one panel, but other panels aren't affected," Lave said. "So if you use the single point sensor to represent the variability of the whole power plant, you will significantly overestimate the variability."

To get a more accurate picture of how clouds affect PV power plants, Lave partnered with Sandia engineer Josh Stein and University of California, San Diego professor of environmental engineering Jan Kleissl to develop a Wavelet Variability Model. The model uses data from a point sensor and scales it up to accurately represent the entire power plant. The model uses measurements from an irradiance point sensor, the power plant footprint — the arrangement and number of PV modules in the plant — and the daily local cloud speed to estimate the output of a power plant.

In many cases, output measurements from the power plant aren't available,



but point sensor data is, so the model is useful for estimating how much energy must be stored to make up for cloud-caused fluctuations.

The variability is a concern for grid operators as unanticipated changes in PV plant output can strain the electric grid. At short timescales, measured in seconds, sharp changes in power output from a PV power plant can cause local voltage to flicker. At longer timescales, measured in minutes, generating less PV power than expected produces balancing and frequency issues, where load can exceed generation. Backup systems such as battery storage to mitigate the variability can substantially add to the cost of a PV power plant.

Lave points to Puerto Rico, where changes in power output are required to be less than 10 percent per minute. "With this tool, you can estimate how often you'll exceed that limit and determine how to mitigate those effects," he said.

The team recently published a book chapter in Solar Energy Forecasting and Resource Assessment. Chapter 7, "Quantifying and Simulating Solar-Plant Variability using Irradiance Data," offers metrics to characterize and simulate the variability of solar power plant output.

This work is supported by the Department of Energy's SunShot Initiative, a national effort to make solar energy cost-competitive with traditional sources of energy by 2020 and greatly increase how much solar energy safely and cost-effectively goes to the electric grid.

By helping grid operators solve variable short-term power generation problems, Lave said utilities will likely be more comfortable from a technical perspective with increases in the relative percentage of solar in their energy portfolios.

"It is important to accurately scale solar variability to ensure accurate grid integration studies and PV plant evaluations. Having a solid understanding of the effect of PV plant variability will encourage PV installations while helping to maintain a safe electric grid." Lave said.

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Innovative PV design

SOLAR IS INTEGRATING into building and design and becoming much more than panels to put on a roof or across a farmer's field. Photovoltaic energy has been used in mobile applications like calculators for decades but now the technology is advancing the applications are only limited by human imagination.

With PV technology popping up in high end design demonstrating new applications there are opportunities for PV technology.

The Current Table by Dutch designer Marjan van Aubel features a solar panel for charging mobile phones. It features a clear orange glass table top on triangular trestle legs, with two USB charging points that can top up the batteries in phones or tablets.

"The amount of sunlight the earth receives in one day could power all our electrical appliances for an entire year," explained the Royal College of Art graduate. "The question is how to capture and store it, and how to transport it to where and when it is needed."

Inside the glass panels is a dye-synthesised solar cell that uses the properties of colour to create an electrical current, in a similar way to how plants use green chlorophyll to convert sunlight into energy. This technique works by placing small particles of titanium dioxide on a piece of transparent glass that is then dyed orange. The dyeing technique helps the titanium dioxide absorb sunlight more efficiently. When sunlight is present, electrons stored in the titanium dioxide are released creating an electrical current. When not in use, the electricity is stored in a battery.

The table can charge itself using diffused sunlight found indoors, unlike traditional solar cells that require direct sunlight to generate a current. A USB charging point with a simple light display indicates how much charge is currently in the table.

"While you read a book or write emails, you can use your table to charge your iPad or mobile phone," said Aubel. "One cell needs about eight hours to fully charge a battery, and there are four cells for each USB port," the designer said.

Aubel believes the tables could be used in libraries, restaurants and meeting rooms as a simple way of providing power without the need to lay cables.

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