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Trading dilemma

THE NEXT YEAR OR TWO is likely to be defined by international trade courts as a number of regions battle it out in an effort to try and point a finger of blame for the current global oversupply of solar and PV products. Analysts are suggesting that the 2012 market fell 15GW shy of even providing a balance to the glut and as the worldwide output was just shy of 30GW that is a huge mountain of material to get through. The hope is 2013 provides some ballast to the global ship with new markets and a slow down of output but the casualties will be numerous before any such balance is reached.

The jury is still out on how such a lop sided situation arose and everyone has their favourite targets. The truth is there are numerous reasons and even if a larger number of players emerged from some markets there has been a global gold rush mentality to the industry. Much of which is the industry's own fault with an over hyping of the market potential amid suggestions that energy usage overall was the metric for which to measure potential.

Solar still only accounts for a tiny fraction of energy usage and found iself caught up in a romantic hope fuelled by futurists and governments alike trying to develop energy autonomy in an increasingly hostile world. Much of the rhetoric and fear drove market desire and every government in the world began providing 'ideal conditions' for a local industry. Companies that were already established could not keep up with the demand and the dream was for growth similar to the early days of semiconductors and double digit growth for many years. This impacted at every level and the sheer number of companies wanting to enter the industry was mind boggling.

With governments fearful of energy resources and the sudden rush focing material prices through the roof, the industry as a whole decided that the sky was the limt. Companies worked out their future plans based on financing they expected from government subsidies and intially the cash rolled in and a party of hope began. In truth it was the level of success and hope that sowed the seed of destruction but also some very bad assumptions on emerging markets.

The area that was most underestimated was China and much of the hype was based on the idea that there would be a shortage of raw materials with a market demanding more than could be manufactured. It turned out that those assumptions were based on outmoded and frankly poor misconceptions of emerging markets. Something that the establsihed capital markets have done time and again. They did it with Singapore. They did it with Japan. They did it with Taiwan. And once again those with the control forgot the golden rule. He who has the gold makes the rules.

And China proved how much gold they had and began to create a solar manufacturing base that would meet all the expected short falls. Except every other region attempted the same thing so in the end the global market place had too many players and not enough market and only ended up giving itself a bad name. Much to the delight of the traditional energy suppliers who initially worried at the competition. They are now sitting back and mopping up the pieces.

One thing has slipped many of the players by and that is the continual growth of the solar and PV industry. There may be a shake out occuring but the industry is doing what it always appeared it was going to do and that is grow to become a true energy alternative but now we wait to see who will own and control the final pieces.

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contents

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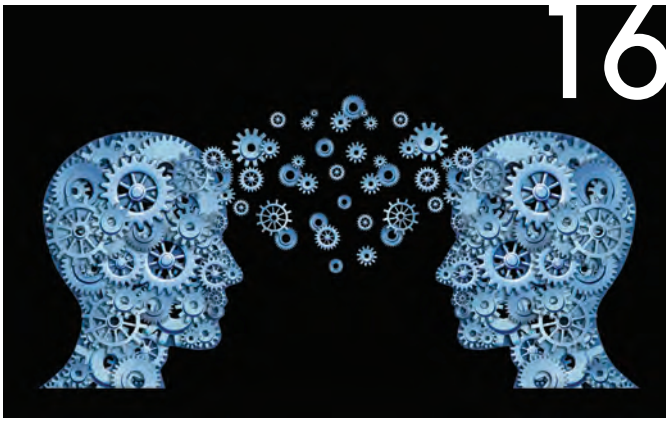

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DayStar invests in next generation solar technology

DAYSTAR TECHNOLOGIES, INC. has announced its board of Directors has approved the acquisition of a 20% equity ownership in BC-based Premier Global Holdings Corporation, which has successfully demonstrated solar cells that are the first to combine energy generation and power storage in one cell.

DayStar is to issue $12 million in preferred stock in return for the 20% equity ownership position in privately held Premier. The preferred can be converted to common stock at $1.60 per share, and will pay an in-kind dividend of 5% per annum.

According to its president, John Crawford, "Premier's photosynthesis photovoltaic (PV) system promises significantly lower total solar energy costs, good performance in low lighting conditions, along with a significantly reduced footprint, and a wide range of possible form factors." Crawford, who served as Director of Strategic Ventures for the Energizer Holdings (ENR) before resigning to become President of Premier said he "looks forward to a successful partnership with DayStar, and its important network of affiliates and advisors throughout the world."

Lorne Roseborough, DayStar President, said this new technology represents a "fundamental change" in the business model for solar energy, and "will provide Daystar with a significant competitive advantage in its efforts to facilitate utilities and their customers in designing more cost effective and profitable renewable energy projects."

Developed at the University Of British Columbia (UBC), the new technology integrates photosynthesis into the photovoltaic (PV) system permitting for the first time, simultaneous generation and storage in a single solar cell. The system addresses the natural intermittency of Solar (PV) and can make solar power available under low or no direct sun conditions; the result is a built-in solution for reducing total demand on the local electrical grid.

Each battery-like cell comes complete with two electrodes and an electrolyte. Light is absorbed by harvesting light molecules in the electrolyte. Charges are then transferred between the excited light harvesting molecules and mediator molecules that are also in the electrolyte with nearly perfect quantum efficiency. The mediators store the harvested energy, which can then be extracted at the electrodes on demand.

According to Roseborough, "The technology will enable the deployment of units that could be built into apartments, offices, homes, and industrial sites, providing power during utility system outages and natural disasters."

First solar panel made in Ethiopia

SKY ENERGY INTERNATIONAL and METEC of Ethiopia have made the first panel in Ethiopia. SKY Energy International was given the opportunity to install the first and only solar panel manufacturing facility in Addis Ababa, Ethiopia.

SKY Energy International recognized the huge responsibility associated with this feat and took the challenge.

SKY Energy International handled the logistics of the various machines involved in manufacturing the solar panels as well as the initial purchase of raw materials for the factory. Training was also conducted for the Ethiopian operators in the USA. The final phase of training at the factory is expected to take place on February 2013.

The installation of the factory was successfully completed in December 2012 at which time our engineers laminated, tested and produced the first solar panel made in Ethiopia.

Sultanate invest in Qatar

BOOSTED by its successful 2022 World Cup bid, Qatar is leading the charge to develop the alternative and renewable energy sector. Kahramaa (Qatar General Electricity and Water Corporation) is responsible for the country's alternative and renewable energy development with an estimated investment of USD 125 billion.The company has also started developing a 150 to 200 MW solar power generation unit by utilising the unused areas in its grid stations and water stations.

"Alternative and renewable energy is one of Kahramaa's strategic and main interests for providing Qatar with a sustainable power supply. Alternative and renewable energy is the main part of our new smart and intelligent grid that we are building for the future," said His Excellency Engineer Essa Bin Hilal Al Kuwari, President of Kahramaa.

As part of the company's continued commitment to the cause, His Excellency is also opening the 4th Annual Qatar Alternative Energy Investors Summit. The two-day platform will be held on March 24th and 25th in Doha.

While various alternative and renewable energy sources are being tested across the region, solar power, due to obvious geographical advantages, has emerged as the one technology being employed in most MENA countries. Recent reports indicate that the solar market alone in the region could reach 3.5 GW annually by 2015. Yet, as His Excellency has noted in the past, the potential of solar energy should not mean other resources like wind, biomass and nuclear energy are ignored.

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Meyer Burger announces production of acquired technology

MEYER BURGER'S SmartWire Connection Technology (SWCT) is on the market and the company claims the technology for solar cells achieves higher efficiency modules and reduces production costs in PV manufacturing. By replacing the traditional busbars on the side of the cell the company is reducing costs. The process was originally developed by Day4 Energy and became part of the Meyer Burger portfolio after acquisition.

SWCT's fine copper wires reduce shading on the solar cell by 3% in comparison to cells with 3 busbars. Coupled with it's 2% lower series resistance, SWCT technology increases the power output of a solar module by 5%. The round copper wires used in SmartWire technology increase the amount of sunlight reflected onto the cells resulting in SWCT contacted modules beginning to produce electricity earlier in the day and stop producing electricity later in the day. This leads to an increased energy yield of about 10% (kWh/kWp) compared to busbar technology. SWCT increases cell stability and reduces the impact of possible micro-cracks on the power of the solar module. Micro-cracks are the most common cause of energy loss in solar modules.

SWCT is compatible to all crystalline silicon cell technologies: selective emitter, PERC and Heterojunction (HJT) in both p- and n-type silicon cells. Wafer thickness can be as low as 100 μm and thinnest finger widths can be used in SWCT technology. This very future oriented technology can also be applied to the next generation of finger metallisation technologies.

Heterojunction (HJT) cells are very sensitive to high temperatures above 180°C that are typical of traditional busbar soldering. The innovative SWCT copper wire process takes place at lower temperature which not only enables contact to be made with high performance HJT cells, the lower temperatures further reduces energy costs during module production.

Modules combining HJT cell technology with the SmartWire Connection Technology have achieved active area efficiencies of over 20%. The SWCT process is self-aligning and omits complicated ribbon lay-out on the contact surface of the cell.

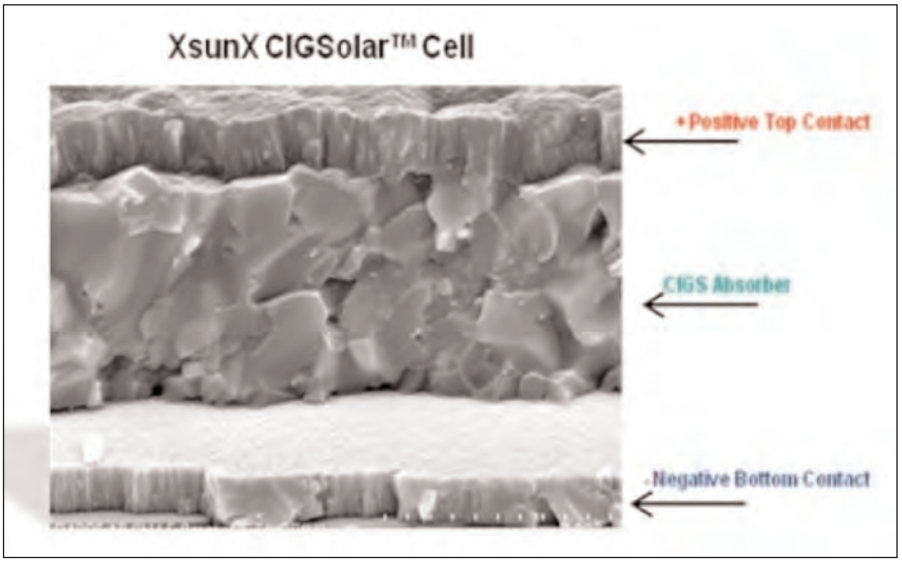
XsunX commences CIGSolar CIS processing

XSUNX has begun processing CIS films with its CIGSolar TFPV solar cell evaporation system. The company has been testing and calibrating the deposition source technology in its new evaporation system so that it could transition to processing CIGS films.

"Recently we initiated the last phase necessary for preparing our CIGSolar TFPV solar cell evaporation system for customer demonstrations with the initiation of CIS (Copper Indium and Selenium) film processing," says Tom Djokovich, CEO of XsunX.

"This represents a major step forward and allows us to then transition to CIGS (Copper Indium Gallium and Selenium) films and the completion of the system's readiness for demonstrations," adds Djokovich.

The firm's technology utilises multi-small area thermal co-evaporation technology to deposit the CIGS solar absorber onto thin stainless steel substrates. The stainless steel substrate can be sized to match silicon solar cells for use as a low cost alternative to silicon solar cells. What's more, the flexible aspect of the stainless steel substrate could also be used in applications where flexibility is required such as building-integrated PV (BIPV) applications. According to analysts, markets for BIPV installations are predicted to grow by $5 billion U.S. over the next two years. The flexibility of CIGSolar cells could offer BIPV manufacturers the potential to use cells manufactured using the CIGSolar process in their products, opening up new market opportunities for XsunX. With the closure of some thin film manufacturers and scaling back of production with others, the Company has begun to receive inquiries related to BIPV applications for CIGSolar cells.



"There was a lot of buzz over CIGS PV that began in 2009 and grew into 2010," states Djokovich. "But with the decline in silicon pricing, many companies focused on producing products to compete with silicon module assemblers have either closed or sold out."

JinkoSolar signs three year deal for 600 MW PV panels with China

JINKOSOLAR HOLDING CO., LTD has announced that it has entered into a strategic cooperation agreement with China Three Gorges New Energy Corp. ("CTGNE") to deliver, during the three years from 2013 to 2015, a total of 600 megawatts (MW) of its high-efficiency solar panels to be installed in western China.

"We are very pleased to sign this long term large contract and to further extend our cooperation with CTGNE, one of the largest and fastest growing developers of renewable energy projects in China, following our previous 50MW contract with CTGNE we announced in October 2012," commented Mr. Xiande Li, Chairman of JinkoSolar.

"China is becoming a major and fast growing market for solar PV modules, and we believe that our strategic cooperation with CTGNE reflects CTGNE's confidence in the advanced technology, high quality, and reliability of our products."

Hanwha SolarOne PV modules produce green energy on contaminated site
Hanwha SolarOne has supplied 11.050 high-quality modules for a PV park on a former tar acid disposal site in Neukirchen, Germany.

After 15 years of intensive remediation efforts headed by the Federal Government of Germany and the Land of Saxony, the site is no longer a source of air and soil pollution.

Strict controls on areas that remain contaminated limit the future uses of this land. Building a PV park proved to be the most viable and beneficial use of the former disposal site.

"The plant in Neukirchen demonstrates how even contaminated land can be utilized to generate green energy," said Anke Johannes, Director Sales Germany of Hanwha SolarOne GmbH. "Using remediated land for solar projects is also a profitable, future-oriented business strategy, as PV companies are constantly searching for more space to build energy-efficient decentralized production sites. As top-ten PV producer that embraces environmental responsibility and sustainability, Hanwha SolarOne is working with partners and customers to identify opportunities that maximize economic gain and ecological benefit."

Remediation specialist Baufeld was responsible for removing contamination from the site and preparing it for solar park construction.

Baufeld has leased the land to solar investor K&W Natural Energy for 20 years with an option to extend. K&W Natural Energy is specializing in the investment, project development and operation of solar projects.

The PV park was constructed within a few weeks and connected to the grid in November 2012. Hanwha SolarOne's 11.050 solar modules will produce an estimated 2.5 million kWh a year, which is equivalent to the amount of energy consumed by 500 to 600 households.

Czech company to invest EUR 400M in solar plants in Ukraine

A CZECH GROUP of companies Ekotechnik Czech plans to invest EUR 400 million into the construction of solar power plants in the Khmelnytskyi oblast, Ukraine. The total installed capacity of solar plants in the region will reach 160 MW, reported the Khmelnytskyi Oblast State Administration.

Ekotechnik Czech's intention to invest into Ukraine's photovoltaic market is recorded in the memorandum between the company's representative in Ukraine - Ekotechnik Ukraine - and Khmelnytskyi administration.

The photovoltaic units will be installed in 14 districts: Dunavets, Khmelnytsk, Vinkovets, Yarmolynets, Novoushytsk, Kamianets-Podolskyi, etc. In total, Ukrainian authorities plan to lease approximately 400 hectares to the company for the construction purposes.

Implementation of the project is aimed at improving the energy balance, social and environmental situation in the above mentioned districts. The construction and operation of solar power plants will offer 230 new jobs and increase annual revenues to the local budgets by 4.4 million USD.

In October 2012, Ekotechnik Czech completed the construction and put into operation the first solar power plant in Ukraine with designed capacity of 5 MW in Yasenovka, Khmelnitskyi region.

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Construction begins on Juwi's first South African EPC project

CONSTRUCTION WORKS on juwi's first South African engineering, procurement and construction (EPC) project has officially kicked off. Located a few kilometres south-east of the historic mining town, the seven megawatt solar park is also the first in the North West Province.

The free-field installation will not only provide clean and sustainable electricity to over ten thousand households, it will additionally boost the local economy. The project directly involves more than 200 people during engineering and construction phase, as well as some operational jobs for the entire lifetime of the plant (more than 20 years).

The owners of the solar park are Momentous Technologies, Momentous Solar Farm, Momentous Foundation and Evolution One Fund. The project's local content is more than 40 percent.The Rustenburg solar plant is the first of four EPC projects juwi Renewable Energies successfully won during the first tendering round under the Renewable Energy Independent Power Producer Programme (RE IPPP).

The company was 100 percent successful with its bids as an EPC contractor. "This is truly a great start for South Africa's energy transition towards 100 percent renewable energy power production as well as in terms of local economic development. The decentralized expansion of renewable energies offers regions great economic activities and increases the local value chain", Greg Austin, juwi Renewable Energies' Head of Operations, states.

A local community trust owns 17 percent of the plant. The trust is mandated to use the dividends from the projects for community upliftment programmes for all areas within a radius of 50 kilometres from the plant. The Rustenburg Local Municipality welcomes the solar park as it offers great potential in terms of job creation and community upliftment.

RustMo 1 Solar Park has been the largest investment in this area for many years. The solar farm near Rustenburg will have a total module surface of 94,650 square metres.

The PV system will produce more than 12.5 million kilowatt hours (kWh) of eco-friendly electricity per year. This equals the annual electricity consumption of over 10,000 households. The project also gives a major boost to South Africa's climate objectives as it reduces greenhouse gas emissions by about 6,000 tons annually. It supports South Africa's ambition to reduce carbon emissions by 34 percent by 2022.

The solar power plant is scheduled to be connected to the local Eskom grid in mid-October 2013 and to feed electricity into the grid a month later. Momentous Operations Services will maintain and operate the solar farm.

TSMC Solar CIGS module reaches 15.1 percent efficiency

TSMC Solar has announced what it says is a new world record for monolithic thin-film module efficiency. It was produced using the current manufacturing equipment and materials at the company's manufacturing facility in Taichung, Taiwan. TSMC Solar says that TUV SUD and UL have confirmed that its commercial-sized (1.09 m2) latest CIGS module has achieved 15.1 percent module total area efficiency.

"In just one year our process technology has made great progress. Our champion modules now have comparable module efficiency to mainstream multi-crystalline silicon modules, demonstrating TSMC Solar's ability to realise the high-efficiency potential of our CIGS technology. Our technology's superior competitiveness comes from its high efficiency, excellent high temperature performance and intrinsic cost structure advantages," says Ying-Chen Chao, President of TSMC Solar.

"Customers appreciate our ability to continuously improve module efficiency. In addition, TS CIGS Series modules deliver up to 5 percent additional energy yield over crystalline silicon in high temperature regions." points out Stephen McKenery, TSMC Solar Worldwide Sales Head. TSMC's solar business was founded in May 2009 and is headquartered in Taichung, Taiwan.

Research to probe deep within a solar cell

ENGINEERS and scientists from the University of Sheffield have pioneered a new technique to analyse PCBM, a material used in polymer photovoltaic cells, obtaining details of the structure of the material which will be vital to improving the cell's efficiency. The findings are published in Applied Physics Letters.

Working with the ISIS pulsed neutron and muon source at the Science and Technology Facilities Council Rutherford Appleton Laboratory, the researchers are the first to use a cutting-edge neutron scattering technique called SERGIS to analyse PCBM. The technique – still very much in development – has so far only been tested on samples with well-known, regular structures, such as diffraction gratings. The experiment focused on crystallites of PCBM which were on the surface of a thin film of the solar cell material as the researchers could then verify their findings using other analysis techniques, such as atomic force microscopy. But they believe the technique could in future be used to analyse the material's structure deep inside the active layers of a solar cell. This will enable them to understand how different fabrication methods impact on the cell's structure, and therefore its efficiency.

Dr Alan Dunbar from Sheffield's Faculty of Engineering explains: "The SERGIS technique uses polarised neutrons which are bounced off the sample being tested. Where the resulting neutrons end up and how their polarisation has changed tells us information about the structure within our samples. The advantage of this type of technique is that because neutrons only interact weakly with the sample we can probe much deeper where many microscopy techniques cannot see."

"This is the first time the technique has been used to look at this material which is of real interest to science. It enabled us to map the size of the PCBM crystallites and the distance between them, both properties which are key to improving efficiency."

Research into photovoltaics is one of many areas of energy research conducted at the University of Sheffield, including wind power, nuclear power, biofuels, district heating and carbon capture.

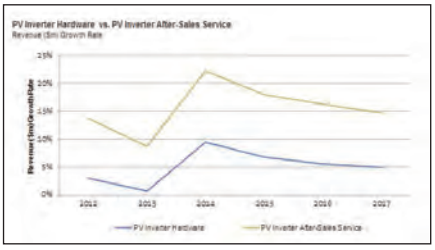
SERGIS – which stands for neutron spin echo resolved grazing incidence scattering – can only be conducted in a few places worldwide, among them the ISIS pulsed neutron and muon source in Oxfordshire.

PV inverter after-sales service market to double

THE MARKET for photovoltaic (PV) inverter service plans and extended warranties is forecast to grow by 110 percent between 2012 and 2017, according to a report entitled PV Inverter Service Plans & Extended Warranties from IMS Research. Despite PV inverter hardware profit margins being squeezed, the after-sales service market is forecast to more than double by 2017 to reach $1.7 billion, providing suppliers with a valuable additional profit source.

The analysis revealed that one of the key drivers of this growth will be demand for utility-scale installations which is forecast to be one of the fastest growing segments over the next five years. These systems will typically use large three-phase inverters which will often be purchased with an annual service plan to ensure optimal operation.

In 2012, 26 percent of high power three-phase inverters were sold with a service plan attached, and this is forecast to increase to 34 percent by 2017. In many cases, banks and finance providers will specify that inverter service plans are



required as a condition of the loan in order to ensure that PV installations operate efficiently and that inverter downtime is minimized.
Although the PV inverter after-sales service market will present revenue growth opportunities, a variety of challenges exist for suppliers, including coping with the PV market becoming more geographically fragmented.

"Along with local legislation stipulating varying minimum warranty lengths in different countries, suppliers will have to establish service offices in new emerging markets in order to provide customers with the adequate response times and minimum levels of after-sales service," explained Cormac Gilligan, PV analyst at IHS. "Industrial inverter manufacturers that are not solely focused on PV may initially be best placed to offer after-sales service in new PV markets, as they often have existing operations established in these regions to serve other industries, whereas pure-play PV inverter manufacturer may have to use third party service partners until they can establish a local service center in these new emerging markets."

In order for inverter suppliers to promote their after-sales service and distinguish themselves from the competition, they are developing different approaches and strategies for marketing and providing service plans and extended warranties.

As inverter suppliers are under increasing pressure to decrease their inverter hardware prices and as new competing technologies such as microinverters with longer standard warranty lengths are shipped in greater numbers, some inverter suppliers are offering longer standard warranties at no extra charge and some central inverter manufacturers are offering to provide full PV plant operations and maintenance.

World's PV capacity passes 100-gigawatt

PV electricity capacity surpassed 100 gigawatts (GW) in 2012, achieving just over 101 GW, according to new market figures from the European Photovoltaic Industry Association (EPIA). This global capacity to harness the power of the sun produces as much electricity energy in a year as 16 coal power plants or nuclear reactors of 1 GW each. Each year, the world's PV installations reduce CO2 emissions by 53 million tons.

The surpassing of the 100-GW mark occurred in yet another year of strong global PV development, with an estimated 30 GW connected to the grid and made operational in 2012 - roughly the same as the record-setting level of 2011. These results are preliminary, and the 30 GW figure could be increased by an additional 1 or 2 GW when final numbers come in. Final results for the year will be published in May, in EPIA's annual "Global Market Outlook for Photovoltaics 2013-2017."

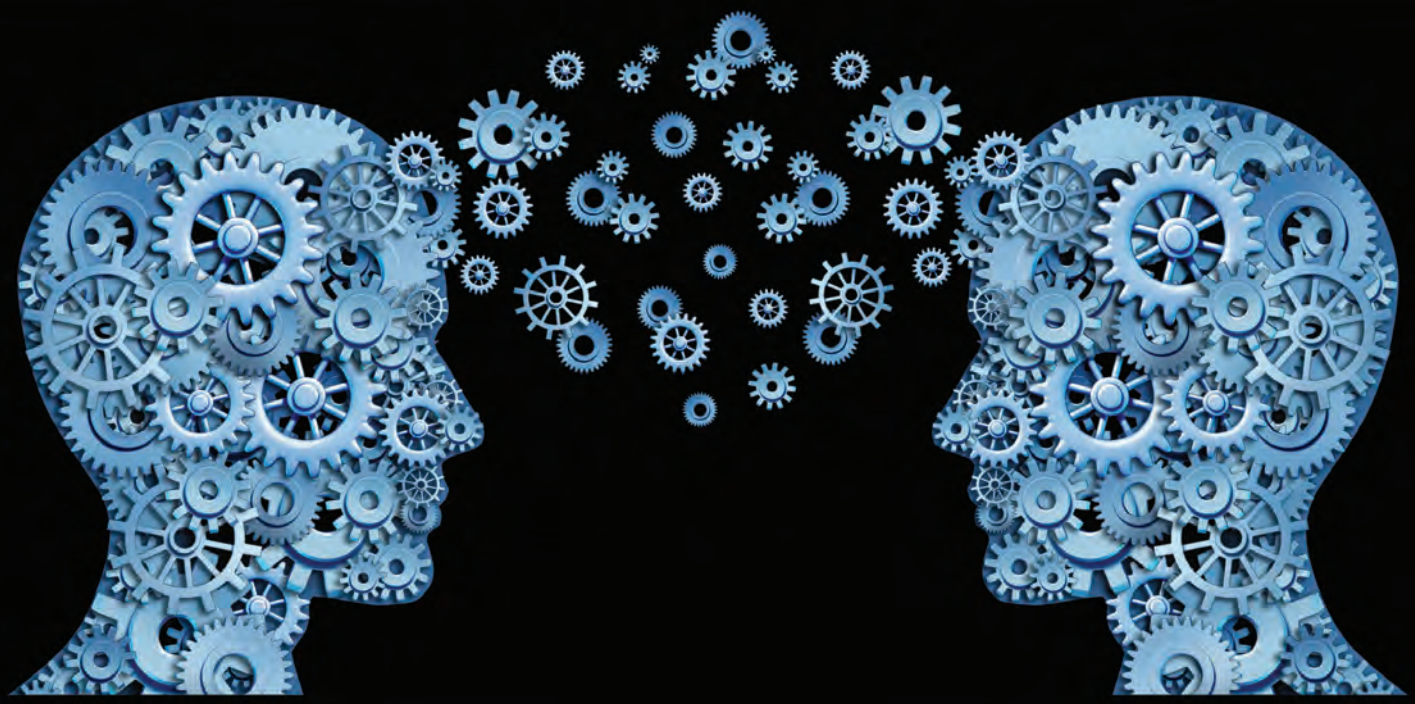
"No one would have predicted even 10 years ago that we would see more than 100 GW of solar photovoltaic capacity in the world by 2012," said EPIA President Winfried Hoffmann. "The photovoltaic industry clearly faces challenges but the results of 2012 show there is a strong global market for our technology. Even in tough economic times and despite growing regulatory uncertainty, we have nearly managed to repeat the record year of 2011."

But the year also showed an important shift towards a more global PV market, with 13 GW of PV installations occurring outside of Europe (compared to just under 8 GW in 2011) and nearly

17 GW in Europe (compared to nearly 23 GW in 2011). The top three European PV markets in 2012 were Germany (with 7.6 GW), Italy (3.3 GW) and France (1.2 GW). The top three non-European markets were China (with at least 3.5 GW and possibly as much as 4.5 GW), the U.S. (3.2 GW) and Japan (2.5 GW).

Added Hoffmann, "The key going forward will be to address these new market challenges and continue policies that help PV technology to grow sustainably, continuing its evolution to a mainstream electricity source."

The photovoltaic industry clearly faces challenges but the results of 2012 show there is a strong global market for our technology. Even in tough economic times and despite growing regulatory uncertainty, we have nearly managed to repeat the record year of 2011



Photovoltaics and IP:
The calm before the storm?

Whilst conducting recent research into the photovoltaics market, ClearViewIP were somewhat surprised to find that IP has played a relatively small role in the industry's development to date, despite the heavy reliance on technological development. However, it seems that this may all be about to change. Tim Butler, Technology Analyst at ClearViewIP discusses the future potential.

Over recent years, the solar power industry has experienced rapid growth, increasing by 70% in 2011 alone. Solar power is now the third most significant contributor to worldwide renewable energy generation (after hydro and wind power), with 69GW worth of solar panels having been installed worldwide by the end of 2011. Recent news, however, suggests that the near future may prove slightly more difficult with industry consolidation, trade barriers and the current economic climate, all causes for concern. There is a vast amount of research being conducted into photovoltaics on an international scale, but while improvements in the combination of efficiency and cost have played a part in its recent successes, there is still plenty of opportunity for development, with a typical commercially available panel only converting a mere 15% of energy.

The investment of time in photovoltaics research is reflected by the intellectual property generated in the field. To date, over 180,000 patent applications relating to solar power have been filed worldwide; at a rate that has been rapidly increasing since the turn of the millennium. Filtering down these filings to those directly related to the design of photovoltaic (PV) cells, rather than their application, we were able to analyse a representative sample of these filings. Figure 1 shows that the patent application rate (normalised for the overall increase in patent applications) and worldwide PV capacity have followed similar trajectories since 1998.

Though Japan has dominated the photovoltaics scene, in terms of patent filings, for most of the industry's history (Figure 2), the post-Kyoto (Dec '97) years have seen a surge in applications being filed in China, the US, Korea, and Taiwan; with the US and China overtaking Japan during the last decade. This is not reflected however by the relevant market sizes (Figure 3); with Germany having the greatest PV capacity by some margin (as of 2010).

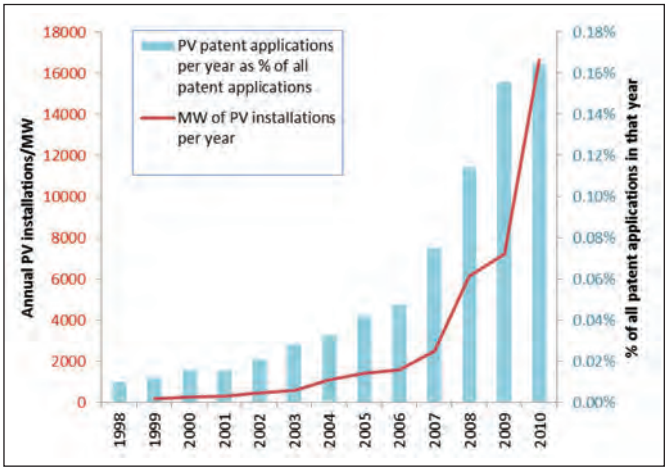


Figure 1: Comparison of the increase in solar power installations and patent applications (Earth Policy Institute)

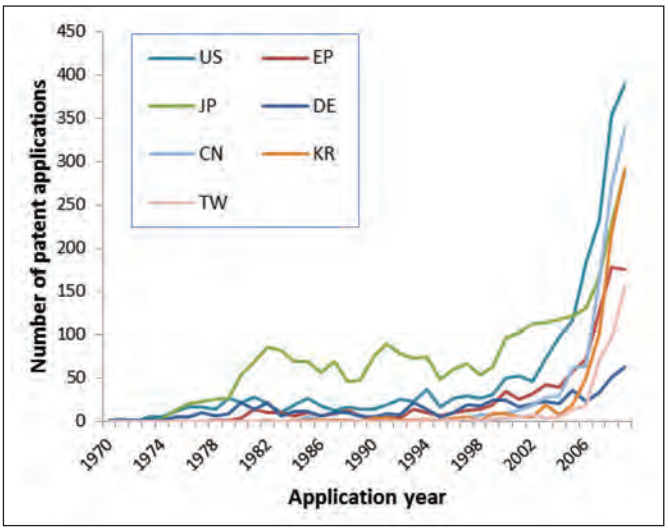


Figure 2: Annual patent filings by jurisdiction

Where the distribution of patent filing is reflected however is in the trends in manufacturing. In 2004 Japan produced just over 50% of the world's photovoltaics (by MW), but within 6 years this dropped to less than 10%, as the Chinese solar industry swung into action. It would seem therefore, that a long history of R&D in the PV sector does not necessarily correspond to commercial success in the current market.

This can also be seen when looking at the assignees of solar cell patents. The 20 assignees with the most patents in our focussed PV cell search are shown in Figure 5; in comparison, the top 10 solar module suppliers

in 2011 (by market share) are listed in Figure 6, along with the number of solar related patents they hold (using a much broader keyword search). Comparison shows that of the top 20 assignees in Figure 5, only Sharp and First Solar appear in the top 10 manufacturers – although it should be noted that companies such as DuPont do supply some of the top manufacturers.

In fact, some of these companies hold a remarkably small number of patents given their size, and it is clear from Figure 7, that the significant proportion of these patents are held in China. This is understandable given China's dominance in manufacture, but could leave companies such as Yingli, Trina, Jinko and LDK, who hold almost all of their patents in China, exposed when exporting their products.

Given this apparent disconnect between the prosperity of certain companies and their patent portfolios, it is perhaps unsurprising that there has been very little litigation in the industry, and the cases that have arisen have tended to focus on enabling technology such as interconnection and mounting devices. One such case was Westinghouse vs. Zep Solar. Westinghouse

claimed infringement of two of their US patents for their 'plug and play' installation design by Zep. Zep filed a similar case against Westinghouse in 2011 and the companies settled out of court in May 2012.

Another such case was Sunlink vs Sunpower, 2008. Interestingly the Westinghouse vs. Zep Solar case revealed that Chinese companies are attempting to (or have been forced to) strengthen their IP position by licensing technology from other firms with Trina Solar, Yingli and Canadian Solar all being revealed as licensees of Zep or Westinghouse. The desire of Chinese companies to strengthen their patent portfolios was also in evidence when the US Department of Energy used the Bayh-Dole act to block the sale of key patents belonging to the bankrupt US PV companies Evergreen Solar and Solyndra to said Chinese companies, on the grounds that the patents were based on state funded research.

The lack of litigation in the industry is an indicator of the maturity of the technology in use. With the exception of First Solar, who produce thin film CdTe cells, all the top manufacturers focus on traditional silicon solar cells. As a mature technology, improvements being made are incremental and a lot of the key patents in this technology have expired.

Figure 8 shows that the majority of recent patenting activity in the industry concerns second generation technologies, such as such as organic solar cells, which promise much for the future in terms of flexibility and cost to manufacture, but are not yet commercially viable due to issues with degradation and efficiency. One might expect that when this second generation enters the market, an increase in litigation will be seen, as has been the case in other technology areas such as the smartphone market.

The maturity of the technology has resulted in a commoditised market, in which consumers largely make choices based on the price of the product. As such, the market is greatly affected by external economic factors.As previously mentioned, China

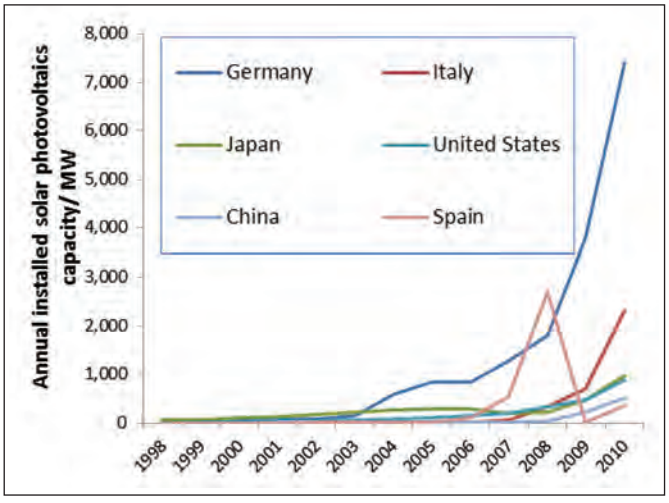


Figure 3: Annual PV Installations by MW

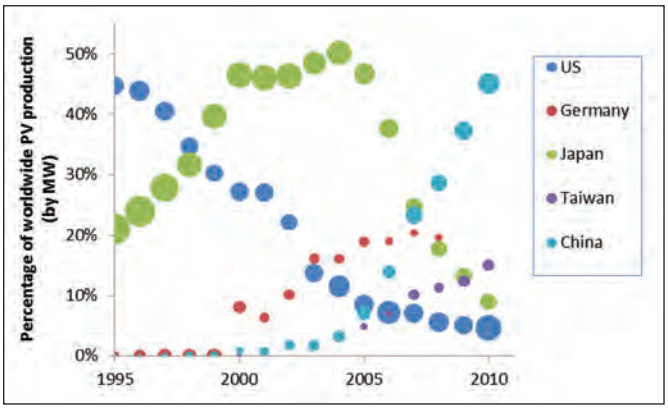


Figure 4: Percentage of PV related patents by jurisdiction. Bubble size represents percentage of that years/ PV patent applications made in that region

overtook Japan as the world's largest PV producer in 2008. There were a number of reasons for this shift in power: in 2005, the Chinese government identified solar power as a strategic emerging industry, making grants and low cost loans available to manufacturers; at the same time, the US and European governments triggered a surge in demand by beginning to offer subsidies and feed-in tariffs to encourage solar panel installation, in a bid to increase the uptake of renewable energy sources. China's ability to quickly build large manufacturing facilities and scale up manufacturing processes allowed them to simultaneously match this new demand and dramatically reduce the cost of manufacture. The Chinese government has also been raising its investment in scientific research institutions by 23% annually since 2001, and offering incentives for publications and patent applications - contributing to the sharp increase in Chinese patent applications seen in Figure 2.

Further evidence of the impact of economic incentives can be seen with reference to Figure 3. In 2006, the Spanish government introduced a generous feed-in tariff which resulted in a sharp rise in installations; however, the cost to the government was unsustainable and the tariff had to be cut, causing the number of installations to plummet. The gold rush the tariff had triggered meant that a lot of new companies had entered the field but often with limited expertise, resulting in many installations being poorly chosen and engineered, and consequently, unable to be maintained in the long term. In contrast, Germany's feed-in tarriffs have been maintained and their renewable energy market has gone from strength to strength, despite a lack of significant technological advance over the same timescale. Over a particularly sunny summer weekend in 2012, German photovoltaics produced 50% of the country's electricity.

This dependence on external economic factors clearly has its downsides as well as benefits and the meteoric growth of the industry has proved to be unsustainable, with several US solar companies going bankrupt in 2011 and even the Chinese bubble seemingly about to burst. Following a petition led by Solarworld, against what it perceived as the dumping of cheap

Following a petition led by Solarworld, against what it perceived as the dumping of cheap polysilicon in the US by Chinese companies at below market value, the US Department of Commerce confirmed in November 2012 that it is levying a tax of 14.78% to 15.97% on imports of panels and key components from China. Similar investigations are now being undertaken in the EU and India

polysilicon in the US by Chinese companies at below market value, the US Department of Commerce confirmed in November 2012 that it is levying a tax of 14.78% to 15.97% on imports of panels and key components from China. Similar investigations are now being undertaken in the EU and India. Factors, including this dispute, alongside the financial crisis hitting exports to Europe, an oversupply in China following their government stimulus, and falling natural gas prices, have combined to see the top PV companies reporting huge losses in the first quarter of 2012. The combined debt of China's top 10 solar companies was recently estimated at US$17.5 billion. Naturally though, the Chinese government has moved to bail out struggling Chinese firms and has committed to a substantial increase in domestic installations to boost sales.

We can see that huge amounts of investment have been made in developing photovoltaic technologies and patenting these developments. Despite this, IP has not really had a great role to play in shaping the industry we see today. The solar energy market, as it stands, is largely a commoditised one, where the companies who can produce the cheapest products, not necessarily those with the strongest IP positions, are the ones

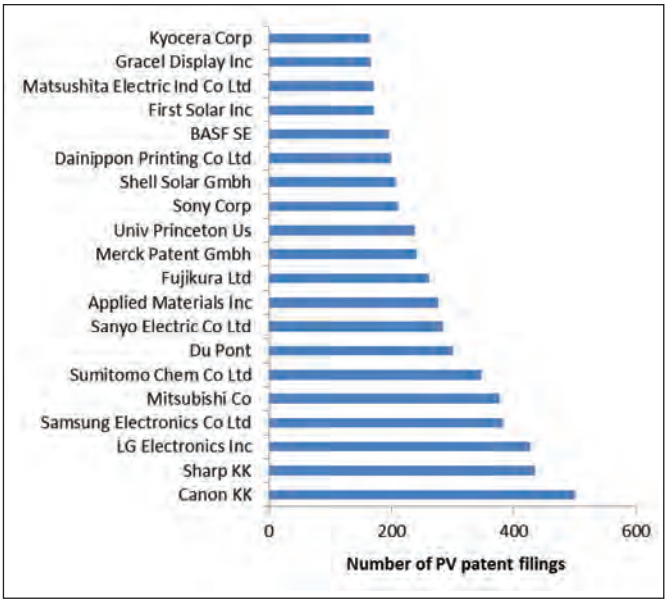


Figure 5: Top 20 assignees with the most PV patent filings

2011 Rank	Company	Country	% Global Module Production	Number of solar related granted patents	Number of solar patent related applications
1	First Solar Inc.	US	7	86	510
2	Suntech	China	6.5	62	199
3	Yingli Solar Co Ltd	China	5.5	10	117
4	Trina Solar Ltd	China	4.9	60	267
5	Canadian Solar Inc.	Canada/China	4.8	5	33
6	Sharp KK	Japan	4.1	807	2667
7	Hanwha Solarone	S. Korea	2.9	10	23
8	Jinko Solar Co Ltd	China	2.8	1	12
9	LDK Solar	China	2.7	10	74
10	Solarworld	US/Germany	2.7	115	246

Figure 6: Top 10 Solar Module manufacturers 2011 (Lux Research)

Figure 7: Geographical distribution of granted patents assigned to the top 10 solar module manufacturers

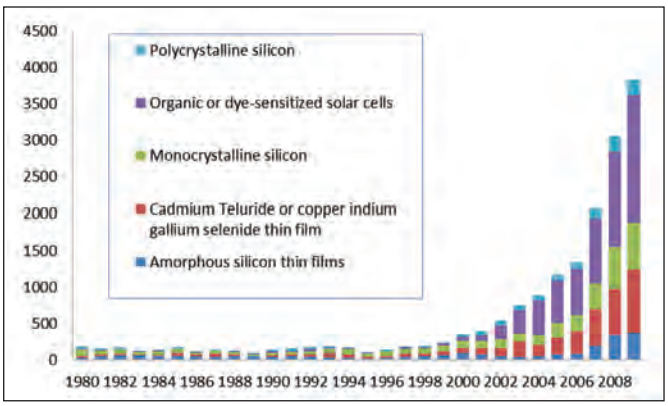


Figure 8: Patent applications by technology area 1980 -2009

that prosper. Economic policies such as government feed-in tariffs and import duties have had a far greater effect on the market behaviour than any activity involving the enforcement of patent rights.

The recent financial difficulties experienced by the industry demonstrate that it is not yet ready to stand on its own two feet, without the support of governments keen to promote renewable energy sources. For this to happen, a new wave of technology is desperately needed: one that provides investors with a much more certain return and end users with a shorter payback period for their investment; which will be achieved through low cost, but also highly efficient PV solutions.

There is no shortage of companies who have been willing to gamble on which of the up and coming technologies will be the one to provide this revolution.

ClearViewIP expects that with so many parallel technologies being backed, the IP owners of the winning technologies will seek to ensure market dominance; but perhaps their IP positions will be leveraged to ensure a positive outcome.

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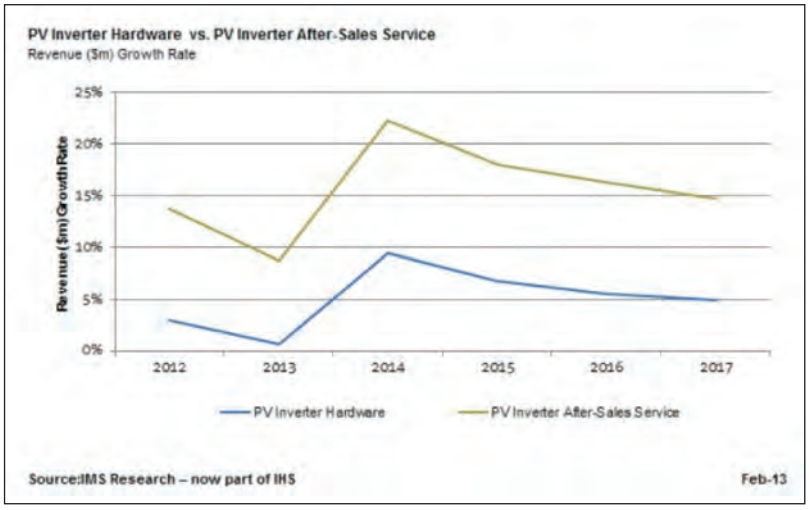
PV inverter after-sales service market to double by 2017

The market for photovoltaic (PV) inverter service plans and extended warranties is forecast to grow by 110 percent between 2012 and 2017, according to a recent report entitled PV Inverter Service Plans & Extended Warranties from IMS Research, now part of IHS Inc. Despite PV inverter hardware profit margins being squeezed, the after-sales service market is forecast to more than double by 2017 to reach $1.7 billion, providing suppliers with a valuable additional profit source.

The analysis revealed that one of the key drivers of this growth will be demand for utility-scale installations which is forecast to be one of the fastest growing segments over the next five years. These systems will typically use large three-phase inverters which will often be purchased with an annual service plan to ensure optimal operation. In 2012, 26 percent of high power three-phase inverters were sold with a service plan attached, and this is forecast to increase to 34 percent by 2017. In many cases, banks and finance providers will specify that inverter service plans are required as a condition of the loan in order to ensure that PV installations operate efficiently and that inverter downtime is minimized.

Although the PV inverter after-sales service market will present revenue growth opportunities, a variety of challenges exist for suppliers, including coping with the PV market becoming more geographically fragmented.

"Along with local legislation stipulating varying minimum warranty lengths in different countries, suppliers will have to establish service offices in new emerging markets in order to provide customers with the adequate response times and minimum levels of after-sales service," explained Cormac Gilligan, PV analyst at IHS. "Industrial inverter manufacturers that are not solely focused on PV may initially be best placed to offer after-sales service in new PV markets, as they often have existing operations established in these regions to serve other industries, whereas pure-play PV inverter manufacturer may have to use third party service partners until they can establish a local service centre in these new emerging markets."



In order for inverter suppliers to promote their after-sales service and distinguish themselves from the competition, they are developing different approaches and strategies for marketing and providing service plans and extended warranties. As inverter suppliers are under increasing pressure to decrease their inverter hardware prices and as new competing technologies such as micro inverters with longer standard warranty lengths are shipped in greater numbers, some inverter suppliers are offering longer standard warranties at no extra charge and some central inverter manufacturers are offering to provide full PV plant operations and maintenance.

Industry outcomes by trade commissions

A number of trade investigations are now occurring around the world involving the solar industry. There is no easy solution to the concerns being raised by groups with opposing opinions. David Ridsdale suggests that regardless of the outcomes the trade investigations will shape the industry in 2013.

Last year the USA trade commission held an anti-dumping and countervailing commission against Chinese manufacturers of solar cells and modules following complaints led by the US arm of German based company Solarworld. The outcome of that investigation led to the US trade commission imposing retrospective and future tariffs on all solar cells and modules manufactured in China. The resulting charges led to a reduction of Chinese imports in to the USA and hurt the profit margins of many Chinese manufacturers. The USA has not been the major solar and PV market for the global industry and many felt the overall impact would not be as great as feared.

In August last year a consortium of European companies, once again led by Solarworld, petitioned the European Commission to hold a similar proceeding against China. This led to the EC announcing on September the 6th 2012 that anti-dumping proceedings would begin against China to ascertain whether prices of Chinese product were manipulated so that a massive oversupply of PV products could effectively be dumped on the European market and therefore illegally reducing local product prices ensuring the demise of European PV companies. In November a parallel anti-subsidy proceeding also began.

In both cases opposing consortiums of solar based companies were set up and commenced a tit-for-tat media campaign with a virulent pro or anti stance on the issue. With no middle ground it was often difficult to ascertain any facts about the situation. While there was no doubt a massive over supply had hit the global market there were more factors involved in changing the industry dynamics than Chinese companies alone. Firstly there was a rush of companies around the globe attempting to take advantage of excellent market conditions in a growing industry that was artificially driven and bolstered by local governments kicking starting markets with subsidies and returns that enabled solar and PV companies to effectively sell financial packages offering a greater return of investment than banking products.

At the same time the number of solar companies was ramping up, with China ramping up the fastest, countries became very concerned that the amount of PV being installed vastly exceeded their highest projections and the economic realities of the financial world were screaming for a more austere approach. The result was for governments to put the breaks on and in some cases retrospectively reduce the amount of subsidy. The market could not put the brakes on and the influx of product led to a massive oversupply and competition drove prices down, often below cost. The result meant many companies found their well thought and well financed plans unravelling and the product with the lowest price tags seemed to be coming from China.

Trade interventions and implications

Once the USA had announced its investigation the Chinese began one of their own on whether the USA had dumped the raw product silicon on China in retaliation to the product review. With the USA imposing tariffs it is expected that China will do the same for the silicon imports which saw the raw price of silicon fall from around $300 a tonne to as low as $20 a tonne. This also had a great impact on solar prices and since the EU announcements China has included Europe and other parts of the world in the investigation into raw silicon prices and the impact on that market. The EU consortium has consequently added silica glass to the equation of the EU investigation requests and China has made it clear it may look at trade investigations in other industries important to Europe such as automobile. The on going tussles could take years to determine

and undermine trade relations around the world. Whatever the truth to it all solar has become the fulcrum to this battle and the trade battles are likely to be the defining driver for 2013.

A CEO of an American inverter company recently said to me that the USA trade outcome on Chinese solar products was only the entrée to the main course of the EU commission's trade investigations. This statement was based on the fact that Europe has contributed more than 50% of the market for the last decade and more than 70% for most of that. Any retrospective tariffs will have a much greater impact on the global market than the USA punitive actions.

Another important difference between the US and European markets is the size and location of manufacturing. Whereas the USA operates as a more singular concern in such matters, Europe is hampered by the differences in local countries despite belonging to the same Union. Many countries with a strong PV market do not have a strong manufacturing base and will be hit harder than countries with strong manufacturing, such as Germany does. These differences will be something the commission will have to look at. The cost to Chinese manufacturers could be exponentially much greater than the USA tariffs. China sold about 21 billion euros in solar panels and components to the European Union in 2011 alone. This was almost 60 percent of all Chinese solar exports.

The European coalition opposed to any EU investigation is called the Alliance for Affordable Solar Energy (AFASE) and they commissioned Swiss consultants Prognos to do a report on the likely potential of any EU punitive tariffs. The resultant report suggests any EU action will see a melt down in European solar markets with thousands of job losses and potentially billions of Euros in cost. This has been denied by their counterparts, ProSun who cite a similar USA report that was done before the American response as proof that such figures are unlikely to occur. There are too many differences to the USA and European landscapes to make like-for-like comparisons.

According to the Prognos report anti-dumping and/or countervailing duties at whatever level on imported Chinese solar products will lead to decreased demand for solar products translating into significant job losses and less value added along the whole European photovoltaic value chain. Prognos looked at three scenarios between 2013 to 2015 and based on three scenarios of duties: 20%, 35% and 60%.

According to the report a punitive tariff of 20% would cost 115,600 jobs in the European Union during the first year after the implementation. This would add up to 175,500 job losses until the third year. The value added lost would sum up to 4.74 billion euros in the first year and to 18.4 billion euros during three years with a tariff of 20%.

A punitive tariff of 60% would even lead to 193,700 job losses in the whole EU during the first year and to 242,000 in the third year. The total loss of value added would amount to 7.86 billion euros during the first year after the implementation. In total over three years 27.2 billion euros of value added would be at stake. "The potential positive impact of duties for the EU solar producers is dwarfed by the negative impact on employment in the EU. Due to the imposition of tariffs production of EU solar products increases and some jobs are being created. However, the jobs created by the EU solar producers represent at the very most 20% of the jobs lost along the PV value chain", says Thorsten Preugschas, CEO of the German project developer Soventix, a spokesperson of AFASE.

EU ProSun, the European counter group was quick to respond and made it clear that they saw any EU action against China would only result in fair competition and would not impact on any jobs in Europe. In fact they announced that anti-dumping measures against Chinese manufacturers will increase European employment.

"Fair competition benefits everybody. We need anti-dumping measures in the EU as soon as possible", said Milan Nitzschke, President of EU Prosun.

Nitzschke dismissed the Prognos study claiming, "It is quite cynical to use the jobs argument on a day when two major European solar manufacturers had to declare insolvency. Chinese dumping harms the entire solar industry, and has already caused thousands of Europeans to lose their jobs, many factory closures and over 30 major bankruptcies."

"The US case already disproves the claims made by AFASE and Prognos. None of the negative effects predicted by China took place. In the

middle of 2012 the US government introduced anti-dumping tariffs on Chinese solar products ranging from 30 to 250 percent. Contrary to a very pessimistic prognosis similar to the Prognos study, the number of solar installations has increased substantially, and consumer prices have remained stable or even decreased even though Chinese imports have drastically declined. It is a win-win situation. Today in the USA there are no more unfair trade practices, the domestic industry has survived, consumers do not have to pay more, and the solar market is growing!"

The report Nitschke refers to is the CASE, the US equivalent of AFASE, commissioned Brattle Group impact-assessment study that suggested an array of outcomes that have so far not being seen.

Nitzschke concluded, "It is ridiculous for China to dictate what is in Europe's interest. Only fair competition will keep jobs in Europe and lead to the sustainable development of solar energy in the EU."

No simple solution

Unsurprisingly Chinese companies and governments do not see the situation to be as clear cut as the opposing coalitions in the US and Europe claim them to be. In fact a number of groups point to the government support for European and USA companies as evidence that the playing field has being far from even. The director of the German Centre for Solar research has been quoted on record as stating it is unreasonable for some German manufacturers to accuse Chinese companies considering the millions of euros they have received as without such support they probably would not exist.

The company singled out the most for such accusations is of course Solarworld who have received over 137 million euros in financial support from the German government alone up to 2011. The Chinese perspective is that the reigning European giants simply underestimated the speed at which the Chinese companies where able to ramp up production while maintaining quality in the branded product that was comparable to anything in Europe or the US. The quality has been borne out in almost every subsequent study of solar and PV product produced around the world.

The idea that the USA and Europe did not expect China to compete so quickly is borne out at trade events and decisions made in the USA to pursue thin film over silicon PV based on the excessively high silicon prices of the time. There were a number of analysts who were stating publically that silicon prices would remain high as no-one could fill the shortage of silicon that was coming. The expectation was at least three years before new silicon could come into play and prices were expected to remain high. Many companies based their plans on these projections. And yet companies like LDK were able to produce high grade silicon within 13 months of beginning on brown field operations.

The Chinese companies have not being quiet on the topic and constantly make public announcements of the issues and call for a fairer way to deal with the industry concerns. Suntech Power Holdings has the following to say regarding the European Commission's anti-dumping proceedings

"Our industry's mission is to make solar affordable for everyone and we are concerned that trade barriers will only delay the industry from fulfilling this," said Dr. Zhengrong Shi, Suntech's Executive Chairman and Chief Strategy Officer. "As a global solar company listed on the NYSE, we are well-prepared to substantiate our strict adherence to fair international trade practices. We are currently reviewing the notice of initiation, and will cooperate fully with the European Commission in its investigation."

"Protectionist measures would increase the cost of solar energy in Europe, and adversely affect European jobs in the solar industry. We stand together with majority of European and global companies in the solar industry in supporting free trade. Until the issue is resolved, we will continue to work with our customers and partners to ensure business as usual," added Dr. Shi.

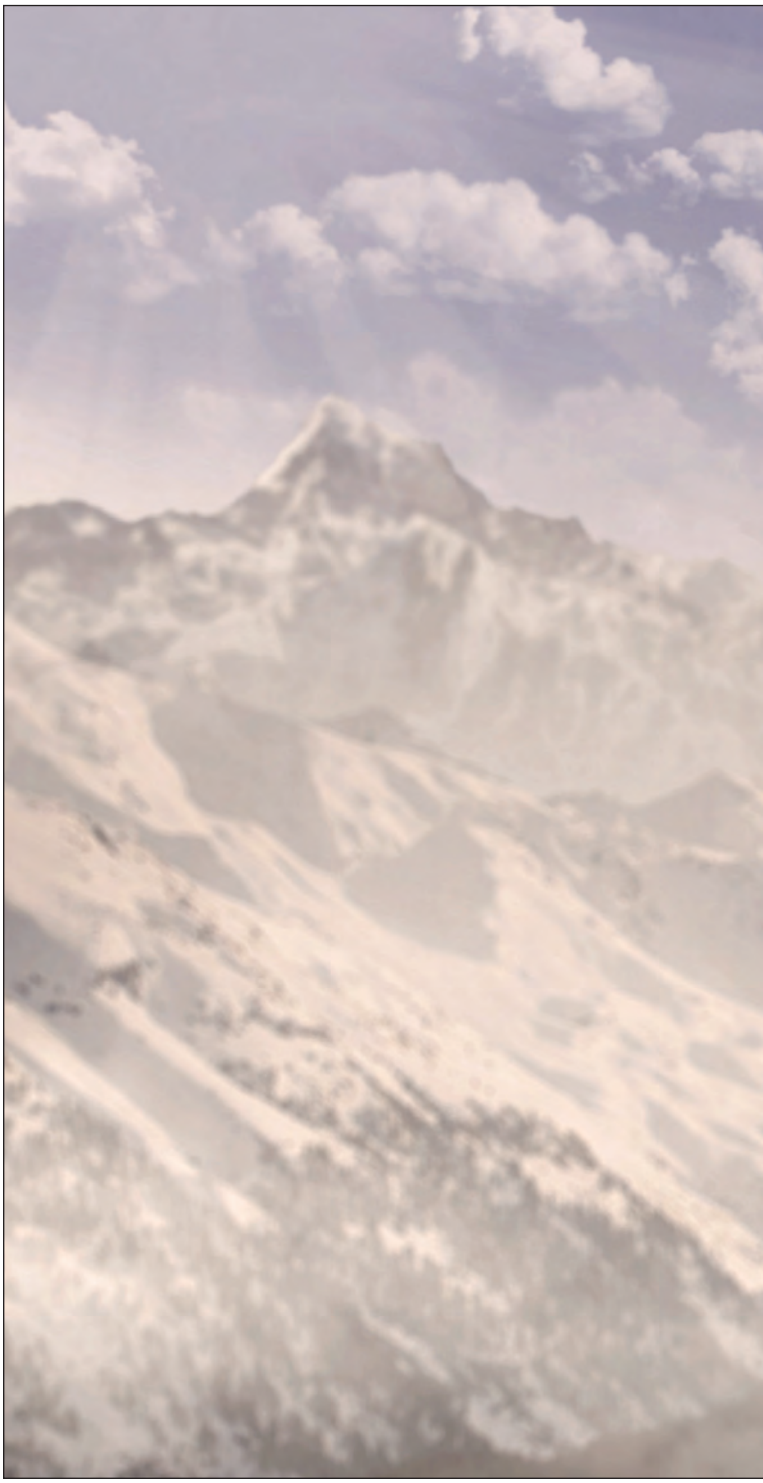
Meanwhile companies and countries try to contemplate the potential outcomes of all the trade investigations going on. Despite the number of such investigations, now spread to India and elsewhere, the actual industry will continue to grow. The most likely outcomes will be the quickening of the shake out of companies in a market with too many players. The companies who saved the most in the boom times and can carry the burden of tariffs are the ones most likely to survive.

There is no doubt the trade commissions will define the global industry for 2013 and years to come.

Overview impact on employment and value added including effects on supply side:

	Job losses		Losses of EU value added	
	1st year	3rd year	1st year	Over 3 years
Duty rate of 20%	- 115,600 jobs	- 175,500 jobs	€ 4.740 billion	€ 18.4 billion
Duty rate of 35%	- 199,700 jobs	- 244,100 jobs	€ 8.170 billion	€ 27.8 billion
Duty rate of 60%	- 193,700 jobs	- 242,000 jobs	€ 7.860 billion	€ 27.2 billion

Inverter market tipped to reach $71 billion by 2020



Yole Développement announced its Inverter market trends for 2013 – 2020 and technology changes report. The report provides a focus on the six most attractive applications (PV, wind turbines, EV/HEV, rail traction, motor drives and UPS) and a new analysis on power stack trend from the previous report. Also updated are the technology trends, market forecasts until 2020, supply chain analysis and regional player's strategies and comprehensive understanding of dynamics for passive components and semiconductor devices. There is significant growth in the inverter market, which reached $45 billion in 2012 for motion and conversion.

Energy related topics have become more and more important in 2012 – vehicle electrification, renewable energies, electricity transportation, – and as a direct result, the power electronics market has increased.

In this report, the analyst updates and presents market forecasts until 2020. "We estimate the inverter market to be $45 billion in 2012 and to reach $71 billion by 2020. A total of more than 28 million units were shipped in 2012 and we estimate that will grow to 80 million units in 2020," explains Brice Le Gouic, Activity Leader, Power Electronics at Yole Développement.

The main components of inverter, passive and semiconductor modules (that we will find in power stacks) represent enticing industries. The power module market was $1.9 billion in 2012 and passive components achieved a market size of more than $4 billion, including capacitors, resistors, connectors, busbars and - newly added in this updated report - magnetic components (inductors and transformers).

As expected, wide band gap semiconductor devices have also started to penetrate those high-end market segments: SiC is present in PV inverters – a total market size of $43 million primarily driven by diodes in micro-inverters, but also by JFETs – and GaN which should be introduced in 2013.

Yole Développement 2012 investigation confirmed that semiconductor improvements enabled more efficient conversion, lighter systems and more reliable end-products. IGBTs have improved (higher current density, thinner and faster), as have SiC and GaN-based devices. GaN could be delayed in its market introduction, but SiC is already here and several companies showed SiC power module capabilities all last year. In this report, Yole Développement updated its technology roadmaps for materials and devices.

The Power Stack is the custom design and manufacturing of an inverter's sub-unit which includes only the core components: power semiconductor module, cooling system, capacitors, resistors, current sensors, busbars and connectors.

Large firms such as Ingeteam, Semikron or ABB are now involved, but power stack also interests smaller players such as AgileSwitch – former IGBT driver manufacturer – who are part of

this about $500 million market. Power electronics often requires having several types of knowledge and experience gained know-how in mechanics, electronics, semiconductors, electrics, fluidics and hydraulics, and connectors. Therefore, research and development can be complicated and the final products can be more expensive.

As a consequence, Yole Développement analyst has observed and analyzed in this report two main trends coming out of the power electronics industry: Japanese and Chinese players, especially system makers, tend toward internal vertical integration and master the manufacturing processes of each sub-system and component. In the case of Japanese companies, this tendency is mostly driven by cost reduction and absorption of intermediary margins, whereas Chinese companies want to access the technology and show some proof of quality.

On the other hand, EU and US players are diversified and acquisition of new or complementary competencies (such as Mersen, Rogers or Power Integration) or high-end R&D and prototyping services (APEI, Primes, IMEC, GE Global Research) is becoming more common.

Industry grows but misses 30GW forecast

Solar PV demand for 2012 reached just 29.0 GW, an increase of only 5% year-over-year compared to 27.7 GW in 2011, according to findings within the upcoming NPD Solarbuzz Marketbuzz report that has recently been released.

This is the first time in a decade that year-over-year market growth in the PV industry has been less than 10% but needs to be put into contect with a challenging financial market and changing dynamics including government supports in the form of subsidies declining in light of an industry growing faster than market capacities.

“During most of 2012, and also at the start of 2013, many in the PV industry were hoping that final PV demand figures for 2012 would exceed the 30 GW level,” explained Michael Barker, Senior Analyst at NPD Solarbuzz. “Estimates during 2012 often exceeded 35 GW as PV companies looked for positive signs that the supply/demand imbalance was being corrected and profit levels would be restored quickly. Ultimately, PV demand during 2012 fell well short of the 30 GW mark.”

Despite an environment of declining incentives during 2012, Europe remained the largest regional market with 16.48 GW of PV demand, almost 60% of global demand last year, but less than 68% of the global demand in 2011 and 82% in 2010.

The second largest region for PV demand was Asia with 8.69 GW, stimulated by the growth of the Chinese end-market during the second half of 2012.

PV demand from the Americas is now segmented across North America (US and Canada), and the Latin America and Caribbean regions. The Americas provided 13% of global PV demand in 2012, or 3.68 GW. However, a large portion of PV demand from the Americas came exclusively from California, driven by Renewable Portfolio Standards and rebates. In fact, California provided more than one-third of all PV demand from the entire Americas region during 2012.

Despite falling short of the anticiapted 30 GW, PV demand during 2012 set another overall annual record for the industry.

Indeed, the 29.0 GW of demand added during 2012 is nearly 30% of all installed PV capacity at the end of 2012. However, the demand level of 29.0 GW in 2012 should be compared directly to the level of supply that upstream manufacturers were expecting during the year.

“For supply and demand to have been balanced during the year of 2012, end-market demand should have approached at least the 45 GW level,” added Barker. “This is 50% higher than actual PV demand in 2012, and reflects the lack of demand elasticity that characterizes the PV industry today. It also explains why even those companies that gained market-share throught the

year in 2012 have still ended up reporting significant operating losses in their balance sheets."

NPD Solarbuzz forecasts that the PV industry will see rapid globalization during 2013, incorporating growth from new regions including Latin America, the Middle East and Africa, and emerging Asian markets.

However, uncertainties still exist in many of these regions that will impact on the rate of adoption of renewables and exactly how much solar PV will be added during 2013.

"The role of emerging regions will be pivotal to PV industry supply and demand during 2013 and will offer a leading indicator for how quickly the industry can exceed the 30 GW annual run-rate level," concluded Barker.

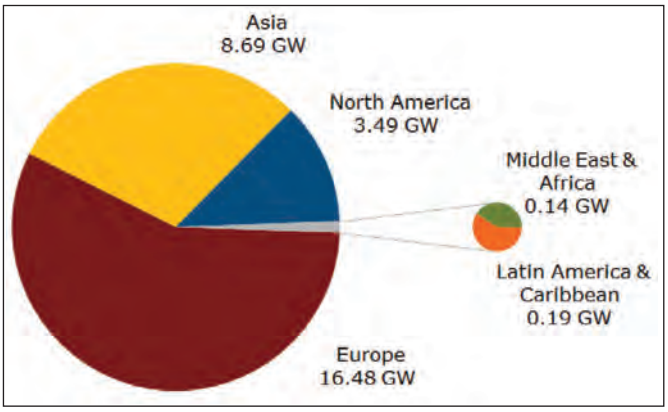


Figure 1: 2012 PV Demand by Region

Source: NPD Solarbuzz Marketbuzz report

The emerging trend for self-consumption

As the incentives that have helped make PV affordable in the first place taper off and electricity prices continue to rise over time, storage is becoming increasingly important for the PV industry's long term growth, with closer collaboration between PV companies and those supplying energy storage and management systems. Sara Ver-Bruggen looks at the companies driving the storage opportunities.

For off-grid electricity supply PV panels and battery generators are essential components, but these are not technologies that have been designed with each other in mind. Conventional lead-acid batteries, widely commercialised for automobile starting, lighting and ignition, are cheap but over the 20 year lifetime of a typical solar panel, they will need to be replaced several times. Efforts to commercialize storage technologies for stationary PV applications are gathering pace.

Electricity storage and management is a complex field and companies with understanding and knowledge of it are in a strong position to supply the emerging trend for PV self-consumption. Storage and management systems enable owners to use up to 60% of the energy their panel produces, significantly more than is possible with just a panel and no storage. According to Photon Consulting by 2016 as much as 15% of new PV installations worldwide will include storage. PV module makers, inverter companies and component and system suppliers are converging on the opportunities afforded by the grid-connected stationary storage market in the coming years.

One of these is Tenesol, which was set up over 15 years ago by the oil and gas company Total to manufacture solar panels before expanding into supplying and installing PV systems, specializing in off-grid. Tenesol's off-grid PV business spans energy, pumping and telecoms industries, private residential and regional authorities. Its off-grid markets include the French overseas territories, which are mainly made up of islands where the electricity grid infrastructure is non-existent or very basic, mobile telecoms providers across the African continent and the oil and gas sectors in the Middle East and North Africa. The company has built up extensive experience in supplying and installing off-grid PV systems. Earlier this year Total sold Tenesol to SunPower, in which it is also a shareholder.

About 10 years ago Tenesol began exploring a new kind of battery, based on lithium-ion technology. Collaborating with lithium-ion battery (LIB) producer Saft, Tenesol designed and studied a stationary system application and from the results the decision to go into the prototyping was made. To do this Tenesol established the Sol-ion project in 2008 with a consortium of French and German companies and research institutes to benefit from subsidies and support from both governments.

In the project 75 battery systems have been installed and field tested, with Tenesol coordinating installations in France and its overseas territories, including Guadeloupe, and inverter company Voltwerk coordinating trials in Germany. Based on the results of the field trials, in which the batteries reached 97% efficiency, Tenesol introduced a new PV energy conversion and storage system, called Sun Smart+ last year. The systems enable solar power to be time shifted, allowing grid connected PV households to consume the energy they produce as well as feeding excess into the grid. The system provides energy conversion and system management. The functions of Sun Smart + include multidirectional energy flows, self-consumption, grid support and back-up and can be retrofitted to residential and small commercial systems, accommodating PV energy production of up to 5 kWp for more than 20 years using LIBs rated from 8-13 kWh.

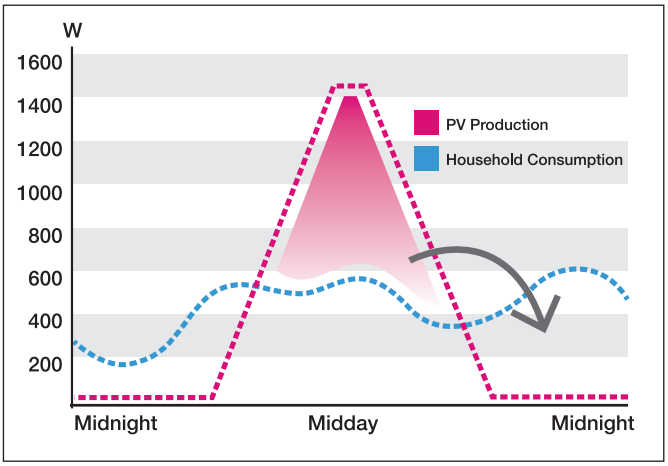
Jean-Christian Marcel, Tenesol's R&D projects coordinator, says: "I have been involved in the off-grid PV field for over 15 years and the weak point was always the battery, especially where it was difficult to understand the lifetime of conventional lead-acid batteries and the behaviour of the user. While Tenesol has carved out a profitable business in off-grid PV in the intervening years, he says, "As the smart grid model evolves there is a good chance that energy storage will come back in force and LIB will enable it, no question."

Products and partnerships

Through its acquisition of Sanyo in late 2009 Japan's Panasonic is one of the leading suppliers of batteries for electric and hybrid vehicle (e-mobility) market, with customers that include Tesla and Ford. LIBs for electric vehicles have high levels of energy density and high power-to-weight ratios, because smaller and lighter batteries reduce vehicle weight. Now Panasonic is investigating how it can adapt its mature LIB cell recipes and come up with designs more tailored for the stationary storage market, where cutting costs is the most important metric, over maximising power-to-weight ratios for stationary storage, particularly for community and large-scale storage applications.

Panasonic is also supplying its latest large-scale LIB battery packs for a storage system designed for the PV self-consumption market by German engineering firm E3/DC, a subsidiary of EWE AG. E3/DC's product, called S10, was field tested in Germany in 2011 and could be introduced for sale towards the end of 2012, or early 2013. The system has a nominal capacity of 1.35 kWh, which stores excess energy generated from the PV panel during daytime peak hours of sunlight and discharges the energy as needed. The battery has a life time of 5000 cycles, for long term operation that is on par with the PV panel lifetime, based on the conditions of about 80% depth of discharge and normal temperature. A battery management system designed to control charge and discharge of the battery is also included allowing users to remotely monitor the status of the system and battery.

Recently E3/DC announced it was working with Trina Solar to bring to market next-generation storage systems for homes and small businesses, for self-consumption. Products will be introduced in mid-2013 in Europe and parts of Asia.



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The self-consumption market is spurring partnerships and joint ventures between PV module producers and providers of storage and management technologies as PV companies look to enlarge their offerings in a market where panels have rapidly commoditised in the past few years. Through acquiring Sanyo, Panasonic has also gained access to high efficiency PV cell and module technology developed by Sanyo.

"Panasonic is now focused on how it can align its storage and solar businesses and take advantage of its PV and battery technologies, to provide integrated PV-storage systems. We are actively shifting our internal structures to take leverage these strengths," says Mark Waring, business strategy director at the Silicon Valley Technical Center of Panasonic North America.

A few months ago South Korean PV module producer Hanwha SolarOne made an $8 million investment in Silent Power, a Minnesota-based business. Silent Power developed energy storage and management systems for the off-grid market. With the investment by Hanwha SolarOne the company will focus on its self-contained grid-compatible storage management system OnDemand Energy Appliance. Hanwha Solar One plans to introduce a complete PV and storage packaged offering at Solar Power International. OnDemand is safe for home use (UL approved). OnDemand is designed to be battery agnostic and is compatible with LIB, lead-acid and advanced lead acid, depending on the user's budget and requirements and includes inverters and connections, such as DC-DC and AC-DC, control panel and interface, all housed in a cabinet.

"The system is software-intensive making it flexible to be configured for different markets," explains the company's senior vice president, John Frederick.

Axion Power International is breathing life into lead-acid technology for the US residential storage market. The company, which has rejuvenated the traditional lead-acid battery with the addition of carbon, is supplying Florida-based Rosewater Energy Group for the company's new product, the Residential Energy Storage Hub, being launched in September 2012. Joe Piccirilli, MD of Rosewater Energy Group, says the company is targeting high-end homes and residences with the system, where typically owners are prepared to spend a lot of income on electronic gadgets and home entertainment systems and expect a high quality power supply to serve their homes, whatever the source of electricity.

	Lead Battery	Li-Ion Battery
Provider	✔	✔✔
Lifetime		✔✔
Efficiency	✔	✔
Installation / Maintenance		✔✔
Price 2012	✔✔	
Potential Minimising Costs	✔	✔✔
Risk		✔
Customer Image		✔✔

The hub serves as an uninterruptible power supply (UPS) for the home and also conditions incoming utility and auxiliary power while allowing integration of solar energy. The hub acts as a surge protector and assures that, regardless of source, the connected circuits will always see pure sine waves at 110 volts and 60 cycles. It will also allow the user to participate in demand/response programmes from their local utilities and go off-grid, enabling power independence. Axion Power's lead-carbon battery used in the system ensures at least five times the cycle life of traditional lead acid batteries, is safe for home use (UL approved) and is over 99% recyclable. The Residential Energy Storage Hub uses 10 kW/12 kWh power quality conversion switchgear. This is able to correct many of the power quality problems that can occur with power from the grid, renewables and backup generators.

Piccirilli says the advanced lead-acid technology developed by Axion has additional advantages as it is able to leverage a very established manufacturing base, where lead acid factories initially built for the automotive sector can be upgraded, reducing capital expenditure on establishing new production lines and equipment necessitated by LIB.

Broader market drivers

According to the consultancy EuPD Research, in Germany, while the self-consumption storage market is likely to provide opportunities for cheaper battery technologies based on lead-acid in the near-term, the LIB stationary storage market will grow as products come down in cost with some analysts forecasting costs to come down by as much as two-thirds over the next 10 years. Three years ago, Dispatch Energy was set up in Germany to commercialise advance LIB technology to smooth the continued expansion of PV into the grid, initially developing products for the small scale/residential market. Dispatch Energy's LIB technology meets several criteria for the stationary storage market. These are high calendar lifetimes, intrinsic safety and full cycle activities including 100% depth of discharge, ideal for stationary storage. These advantages are due to the use of lithium titanate spinel as the anode material in place of more commonly used carbon, such as graphite.

Dispatch Energy has been developing the cell technology for commercial markets, scaling up production of the cells – based on technology developed within Fraunhofer Institute of Silicon Technology in Itzehoe – by working closely with equipment

What changes with a PV energy storage and management system?

According to partners on the Sol-ion project, a typical residential PV system with a panel size of 3 kW produces a daily average of 8.5 kWh throughout the year in northern Europe, ranging from 3 kWh in winter to a peak of 12 kWh in summer.

About 4.5 kWh of the PV energy will be used directly (self-consumed), as soon as it is produced. There is therefore an average excess of 4 kWh – with a seasonal range of 1 kWh to 6 kWh – that can then be stored until needed. So an energy storage system will need to 'time-shift' between 1 and 6 kWh per day – averaging 4 kWh.

On a yearly scale, the average direct self-consumption of a typical household is about 30%. With Energy Storage, it is possible to substantially increase this self-consumption. However, a very large battery size would be needed in order to achieve a full energy autonomy covering all kinds of PV production and energy consumption uncertainties.

Simulations in the Sol-ion programme show that an optimum of about 70% self-consumption vs. battery size is realistic.

provider Jonas & Redmann. The company has developed hardware and software to operate the cells and also makes modules as well as battery management technology for the modules. Dispatch Energy's intelligent battery systems can tell the inverter the stage of charging and how much the battery can give back to the utility.

"This is important because the storage system can be integrated into smart storage applications, so if the utility is overloaded then the system can take capacity from the grid. But to do this smart metering is required and Dispatch's system is prepared for this," explains founder Dietmar Gruidl.

Dispatch Energy is also getting requests for larger scale batteries for grid balancing, for 500 kWh transformer stations and also mid-size applications, where storage is taken out of the grid, for example for PV installations in a street. For these applications, the battery must be able to discharge and load quickly. The company is ramping up its production line and battery systems of 3.5 kWh and 5 kWh will go into production in Q4 of 2012. The fully automated line, supplied by Jonas & Redmann, at Itzehoe is equipped to produce 200,000 cells a year.

In mid-2012 Switzerland-based Leclanché completed its production line for making lithium titanate batteries. The line has an installed annual capacity of up to 76 MWh in cells. The company will sell its batteries through Talesun Solar Germany. The HS 3200 storage module achieves 15,000 charge and discharge cycles with an overall capacity of 3.2 kWh and 100% depth of discharge.

"Storage technologies are the key for the success of the energy change and provide interesting opportunities, especially for installers, for new business models," says Joachim Simonis, MD of Talesun's German business.

High-end stationary PV storage systems, based on technologies such as lithium titanate, are more expensive compared with lead-acid batteries or even some of the more conventional LIB technologies that use carbon-based LIB technologies adapted from EV applications. But in the case of lead acid batteries, as these will need replacing over the lifetime of a PV system, which is about 20 years, the total cost of investing in lead-acid technology can work out more expensive.

Batteries for stationary storage

While demand for renewables storage in Europe is being led by the emergence of the self-consumption PV model initially, in the US the electricity market is fragmented with different regulations and policies so it almost has to be dealt with at the individual state level. As well the residential and small-scale PV market, other applications include smoothing, to prevent the grid from destabilizing and can be problematic with PV when cloud cover clears and panel generation suddenly peaks. Smoothing applications can range from small-scale, right up to 0.5 MWh, for 1 MW sized PV or other renewable energy installations.

Smoothing is also going to be more common in eastern Europe and in parts of Asia, where the grid infrastructure is less well developed, says Waring. The other opportunity in the US, which Panasonic is also investigating, is the utility and direct wholesale electricity market to provide storage to stabilise the grid, working with third parties in the utility sector, because the US wholesale electricity market is more open to new entrants and competition than in Europe. Silent Power's OnDemand product is suited to areas where grid infrastructure is poor or underdeveloped as it is designed to continue working through rolling blackouts.

"Ultimately, when the user installs their own storage system, it will mean they always have electricity supply, than if it is installed further up the grid and something goes wrong," says Frederick.

And that could be a compelling reason for the growth of the small-scale stationary storage market in the coming years, putting consumers and homeowners firmly in control of their own energy supply and costs.

Cost implications

In Europe, particularly in Germany, where self-consumption is being incentivised the big challenge is making energy storage more affordable. PV and storage systems designed for typical domestic households can vary considerably. Take, for example the VS 5 Hybrid System, available from Voltwerk. The LIB-based system, with a storage capacity of 8.8 kWh, costs in the region of €20 000.

At the more affordable end, using lead-acid batteries, HaWi supplies a PV storage-management system with 5 kWh storage capacity, costing around €10 000. The different technologies and grades of sophistication make systems hard to compare. For a German consumer they can expect to pay for a PV and storage system from €18 000 up to €27 000.

Prices will come down, though according to Dr Armin Schmiegel, programme manager, smart grid and hybrid systems at Voltwerk, which is now owned by Bosch: "The key questions are whether battery costs are going to decrease this quickly and can the market actually support or afford this cost?"

There is more scope over the next decade to reduce LIB costs, further than lead-acid. By 2020, PV and LIB-based storage systems for a typical household could cost around €12,500, according to EuPD Research or even €5000, for a system with 5 kWh of storage, according to Schmiegel.

He adds: "Bosch has a lot of experience in how to reduce production costs and can leverage its experience and know-how from the other industries it supplies, such as automotive."

Gruidl says, "Those companies that develop and make machines for semiconductor, PV production are able to supply the battery industry – there are many processing and production steps to get involved in, such as mixing slurry, pasting on foil, calendaring, slitting, formation, degassing. There is a lot of manufacturing expertise opportunity. The research & development is done, but it is now time to ramp up. In Europe we need to hurry up."

This article first appeared in IPVEA's Energy Storage Journal and is reprinted with kind permission.

How Bosch is serving the PV self-consumption market

IN APRIL 2012 Germany's Bosch Group, which operates several businesses including Bosch Solar Energy, acquired Conergy's inverter business Voltwerk Electronics. As well as string and central inverters Voltwerk also supplies storage systems to increase solar energy self-consumption, which include inverters, lithium ion batteries (LIB), made by Saft, and software controls.

In 2008 Dr Armin Schmiegel, Voltwerk's programme manager, smart grid and hybrid systems, began work on the Sol-ion project, with partners including Saft and Tenesol.

Schmiegel explains: "At that time there was no self-consumption tariff so the idea of Sol-ion began with a focus on island off-grid applications. But then revisions to the Erneuerbare-Energien-Gesetz (EEG) – German Renewable Energy Act – introduced an incentive for self-consumption of PV generated electricity in 2009, which pays PV panel owners for consuming the electricity produced by their panels. Germany is the only country to incentivize self-consumption for solar PV." (These tariffs are applicable for installations commissioned until 2013 - source: Clean Horizon Consulting).

To date Voltwerk has installed 27 storage systems, 22 of which are in private households. The VS 5 Hybrid System was officially launched in summer 2012. The VS 5 Hybrid is a combination of a transformerless 5 kW inverter, a Saft lithium-ion battery with a capacity of 8.8 kWh and a management system with a colour touch screen display. If required, the battery capacity can be increased – the system cabinet is designed for 13.2 kWh.

Schmiegel states, "Today, We are starting to see a shift in motivation when it comes to buying PV systems. Up until now it has been an investment with the emphasis of selling electricity back to the grid. But now it is starting to be about self-sufficiency."

According to Schmiegel the supplier base for this market is growing, with over 100 companies at this year's Intersolar Europe event in Munich showing energy storage/management systems, suggesting that the future market for PV is going to be driven by the self-sufficiency model.

Energy storage products on the market encompass high-quality, high-performance systems, where high quality LIBs last 20 years (such as Voltwerk-Bosch Power Tec), which is about the same lifetime as a PV panel, to significantly cheaper systems, based on consumer LIB batteries or even lead-acid batteries, where the consumer will need to replace the battery up to four times during the life time of the PV system. The standard mode of operation for PV battery systems is to only inject PV power into the circuit when it is needed, and to inject the rest into the battery and any excess into the grid. The system is always calculating whether it is either more valuable to inject excess electricity into the battery or into the grid. This is going to be the story for the next 3 to 5 years, where the investment in a PV storage system is to reduce the electricity bill, says Schmiegel.

These feed-in tariffs are differentiated (meaning, the more the PV system owner consumes, the higher the tariffs) and are applicable for power ratings below 500 kW. In 2012, self-consumption tariffs can exceed €0.10/kWh. If the consumer injects PV electricity into the grid at the same time as using electrical power this can be measured by a production meter and an injection meter, which calculate that the consumer gets a lower tariff, but when this is added to the saved power from the grid then the payment is about €0.08-0.10/kWh.

Payback

Schmiegel says: "The end customer price for the VS 5 Hybrid System is in the region of €20,000. However in payback terms, which can only be exact with a detailed load profile of the customer, amortization is in the range of 10 years, give or take a couple of years. But you have also to take into account, that your electrical bill is reduced. In cash flow terms, after you have invested into such a system, the yields from the feed-in and self-consumption tariff are higher than the rest of the electrical power bought by the utility."

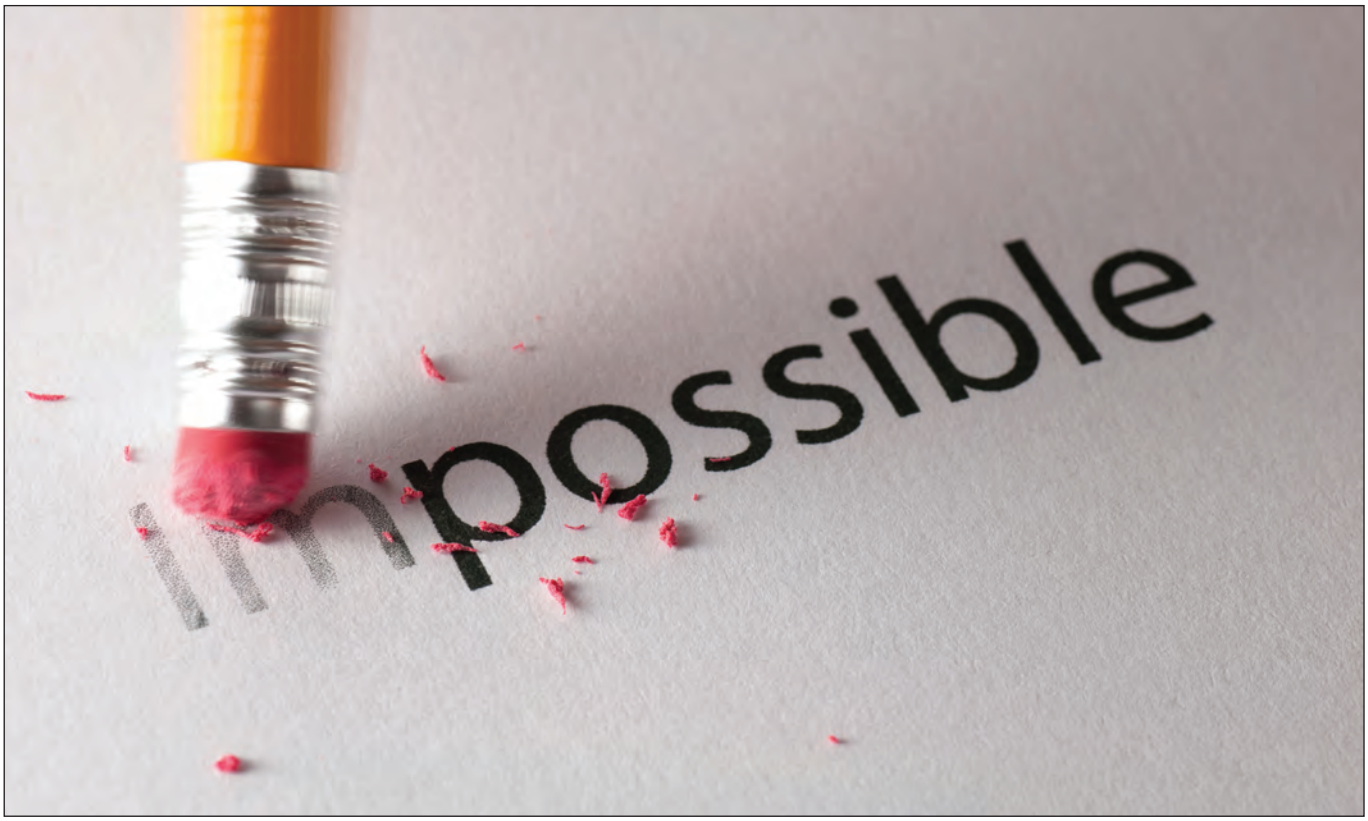
In the meantime costs of the battery are expected to reduce.

Global Solar PV tipped to triple by 2020

Constantly evolving and more efficient technology provided at lower prices, combined with a need for energy security and independence will ensure the continued rise of solar photovoltaic (PV) power across the world, states research and consulting firm GlobalData. The company's latest report forecasts global solar PV to continue its meteoric rise in the near future, with cumulative installed capacity climbing from 97 Gigawatts (GW) in 2012 to 330 GW by just 2020 – demonstrating a Compound Annual Growth Rate (CAGR) of 16.5%.

Germany is a major supporter of solar PV and is estimated to have accounted for around 32% of the global solar PV installed capacity in 2012. The country has proved its commitment to the renewable energy source through various policies and programs in recent years and maintained its position at the forefront of the market's development and technological progress.As a result, Germany's solar PV installed capacity has leaped from a relatively meagre 2.7 Gigawatts (GW) in 2006 to 30.1 GW just six years later in 2012. Continuing support though Feed-in-Tariffs (FITs) and other schemes will see this total reach 48 GW by the end of the decade, predicts GlobalData.

China remains the largest manufacturer of solar PV modules in the world and exports over 90% of its produce abroad. However, the Asian giant is also expected to significantly increase solar module installation at home in the near future, with GlobalData expecting a massive surge in installed capacity, from 7.6 GW in 2012 to 70 GW in 2020.



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Pressure sensitive adhesion for solar

Rob Thomaier, Senior Technologist at Nusil Technology discusses a novel adhesion method for solar cell assembly that uses a pressure sensitive adhesive and film providing greater control and reduced material use.

Traditionally, engineers and solar cell assemblers have used liquid silicone adhesives to bond solar cells to panel substrates such as satellites, and silicones with high light transmittance to bond cover glasses to cells. Using next generation silicone technology, low outgassing silicone pressure sensitive adhesives (PSA) and thin film sheeting can serve the same purpose as liquid adhesives but eliminate long wait times for room temperature cures or additional equipment, such as ovens, required to heat accelerate the cure process. Moreover, the processing these low outgassing materials undergo allows them to be used on extraterrestrial applications like satellites as mentioned above.

Through the thickness of a PSA or film, the bond line thickness between the cell and the cover glass can be controlled, facilitating solar cell assembly. Also, design engineers have the ability to rework panels where PSAs are applied – cutting cost for components and time. Low outgassing PSAs and film adhesives also have similar performance to liquid silicone adhesives, specifically good chemical stability, broad operating temperature ranges, low modulus during thermal cycling, and minimal or no mixing and de-airing. With dimethyl backbone chemistries similar to traditional adhesives, the clear PSAs and thin films are resistant to yellowing and have light transmittance greater than 97% at 400 nm.

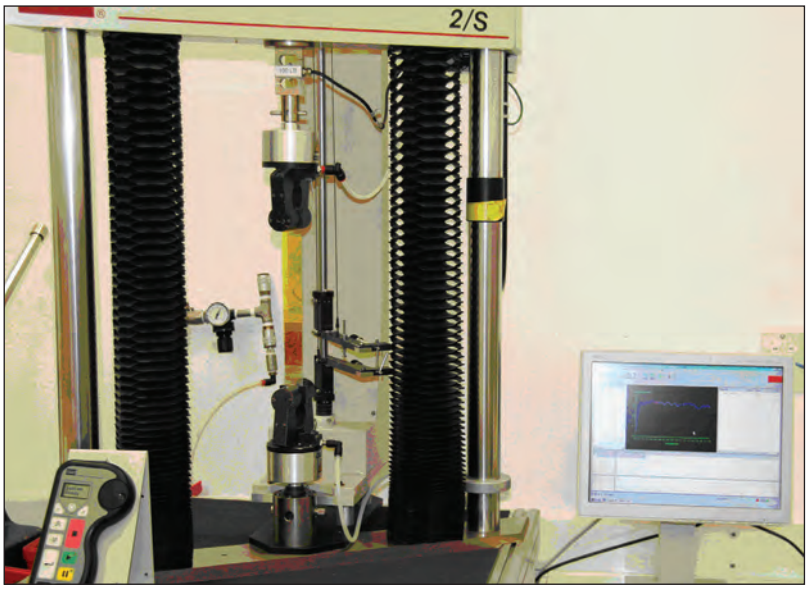


Figure 1: An 180° peel test of PSA coated onto Kapton then peeled off an aluminium panel

Pressure sensitive adhesive film

Two part, mixable silicone adhesives are widely used in the space power arrays as adhesives for cover glasses and bonding solar cells to substrates. A possible alternative for these adhesives may be space-grade pressure sensitive adhesives (PSA) films or, if a fully cross-linked adhesive with a very strong bond is necessary, a curable film adhesive. These materials can be handled as semi-cured films, offering quick adhesion with no mess, and can be die-cut to specific shapes prior to application. These are some of the advantages of PSAs and curable film adhesives over liquid adhesives.

Silicone PSAs are made by partially crosslinking a silicone polymer with a silicone resin, forming a loosely knit elastomer. The PSA adhesion works by hydrogen bonding to surfaces; hydrogen bonds are polar, intermolecular forces that although fairly weak can offer excellent adhesion in large quantities. The hydrogen bonding adhesion is typically low at initial contact but improves significantly as the PSA wets onto the substrate. The initial adhesion is called tack and is quantified as the force required to remove a probe quickly touched to the adhesive film.[1] The wetted-out adhesion is typically measured by a peel or lap shear test, usually after 24 hours.[2]

Controlled Volatility (CV) PSAs, suitable for use in

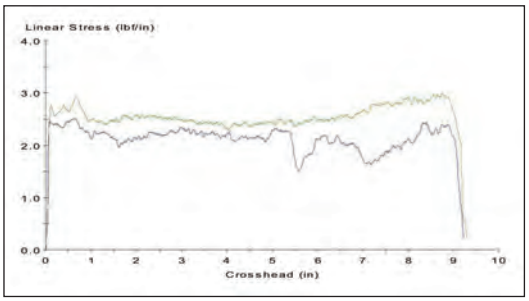


Figure 2: Graph of a peel test of a CV PSA

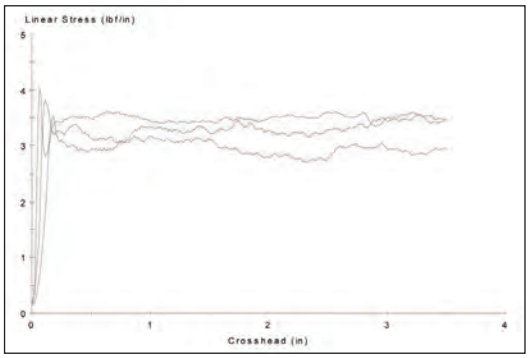


Figure 3: Stainless steel substrate peel results @ -55^{O}C: three samples

space environments, can be made by removing most of the low molecular weight species of a typical silicone PSA. The volatility can be lowered to surpass the ASTM E595 Controlled Volatility testing specification of 1.0% Total Mass Loss (TML) and 0.1% Controlled Volatility Condensable Material (CVCM). The PSA is initially in solvent and can be coated onto different substrates or can be delivered coated directly onto a release liner to make a free film. Silicone PSAs can be supplied at a thickness from 25 – 125 micron (1 mil to 5 mil) in sheet or roll form, and the films can be die-cut to shape and applied like an ordinary tape. These PSAs have bond strengths ranging from 0.17 - 3.5 N/cm (0.1- 2.0 lb./in), tested using a 180° peel test.[2]

For peel testing, a PSA film is bonded to a 2.5 mm wide by 20 cm long (1 in x 8 in) aluminium substrate. The aluminium substrate is lightly sanded with 400 mesh sandpaper, cleaned with isopropyl alcohol and permitted to dry 30 minutes. The release liner is removed from one side of the PSA and pressed down onto the aluminium substrate in an air-free manner. A 2.27 kg (5-lb) weight is rolled over the bonded PSA sample once and the sample is permitted to rest period at ambient temperature for 24 hours prior to testing.

Adhesion can develop in minutes; but, typically, adhesion improves over time as the adhesive wets over the surface. Adhesion can be formulated from low tack, or low adhesion, for temporary bonds that can later be easily removed, or from a higher tack PSA with good adhesion of approximately 3.5 N/cm (2 lb./in) for more permanent bonds.

Figure 1 shows a 180° peel test being performed. The PSA coated Kapton tape is held in the upper clamp of the MTS while the aluminium panel is held in the lower clamp. The crosshead moves up and peels the tape off of the aluminium panel.

Figure 2 illustrates the results of a typical peel test. The PSA coated Kapton tape is pulled off of the aluminium substrate and the force is recorded. In Figure 2, the y-axis is linear stress (lb./in), and crosshead travel is on the x-axis. A peel test consists of peeling a minimum of 20 cm (8 in) of the PSA off of the aluminium substrate, and then the average force between 2.5 cm (1 in) and 18 cm (7 in) of travel is reported for the peel.

Many PSAs have poor adhesion at extreme temperatures. At high temperatures, some PSAs will melt or soften, and the adhesive strength fails. A solution to this problem is to partially crosslink the PSA so it has good high-temperature adhesion. Silicone PSAs also offer advantages at low temperatures; their low glass transition temperatures (Tg) permit them to remain flexible at low temperatures.

CV PSA samples were prepared on aluminium and stainless steel panels and tested for peel strength at -55°C (-67°F) and 150°C (302°F). PSA coated Kapton tapes were bonded to the metal substrates, a 2.2 kg (5 lb.) weighted roller was rolled over the samples, and the samples were permitted to sit 24 hours at room temperature before 180° peel testing. The results are presented in Table 1. Figures 3 and 4 are the actual results of the stainless steel peel testing.

While most two-part, fully cross-linked silicone elastomers offer good adhesion at elevated temperature, many PSAs do not. A relatively simple pass/fail test to measure the heat resistance of the PSA bond is a static shear test. The test was designed to evaluate the shear strength of a PSA to support a mass at 175°C, 25°C hotter than the

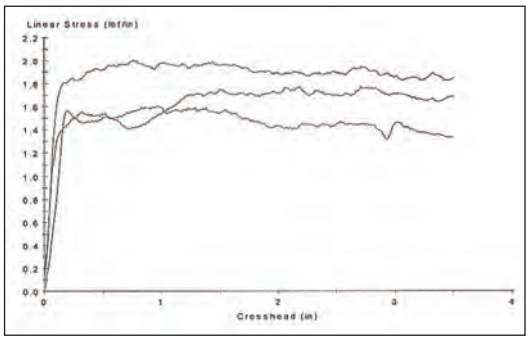


Figure 4: Stainless steel substrate peel results @ 150°C: three samples

Figure 5: Static Shear Test; PSA coated onto Kapton and bonded to aluminium panels

typical satellite bake-out temperature.

Figure 5 illustrates a static shear test. For the static shear test, a sample is prepared by bonding 6.5 sq. cm (1 sq. inch) of adhesive to an aluminium panel. The sample has a rest period of 24 hours. The panel is then suspended in an oven, and a 50 g weight is hung on the panel while the oven is heated to 175°C. The PSA is required to remain bonded to the aluminium panel for 24 hours without falling off the suspended aluminium panel.[3]

Silicones typically have a low glass transition temperature (Tg), the point at which a material goes from a rubbery elastomer to a glassy solid, and the CV PSA is similar in this respect. Below (Figure 6) is a graph of the modulus of the PSA as it is heated from -140ºC, using Dynamic Mechanical Analysis (DMA). The rate of heating was 5°C/min, the frequency was 1 Hz and the amplitude was 1 um. A film tensile clamp held the sample during testing. The PSA has peak tan delta of -116°C (-177°F), which is typically reported as the glass transition temperature. E' onset, the storage modulus, occurs around -125°C (-193°F) and is associated with mechanical failure. E" peak, the loss modulus, is recorded at -122°C (-198°F).

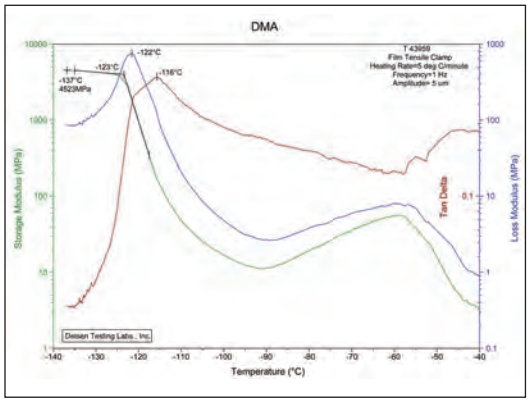


Figure 6: Graph of Storage and Loss modulus of a silicone CV PSA

These values are typical for a dimethyl silicone.

Many two-part curable silicone elastomers are used as cover glass adhesives. These adhesives are required to be very clear, with > 95% transmittance through the visible light region. These adhesives are typically two-part, low viscosity adhesives that require more than 8 hours to cure. The assembled part cannot be handled until the silicone has partially cured.

PSAs offer an alternative to these types of adhesives. The PSA offers instant tack, and the parts can be handled almost immediately after bonding. As a cover glass adhesive, the PSA offers good light transmittance from 375 nm to 1,100 nm. The PSA itself is very clear, wets out on practically any surface and offers good optical coupling between substrates. The refractive index of the PSA is 1.41.

Figure 7 is a UV/Vis graph of the transmittance of light through the PSA.[4] The PSA was sandwiched between two glass microscope slides, and a glass microscope slide was used as a blank.The PSA films can be die-cut to form shapes, or sheets of PSA can be cut to multiple shapes. These films can then be transferred to large areas and are then ready for the next substrate to be applied, e.g. cover glasses. One disadvantage of PSAs is the difficulty of handling such relatively thin films because they easily tear. Films, especially the thinner films, should be transferred from a release liner to a substrate and not handled as film. In addition, as the films are sticky, they are difficult to keep from adhering to themselves.

Also, the transfer from release liner to substrate is critical so no bubbles or flaws are introduced. Bonding two flat, rigid pieces can present some difficulties. While flexible pieces can be rolled down onto the PSA, minimizing bubble entrapment, rigid pieces almost always capture a bubble and must be vacuum-bagged for a period of time to remove the air bubbles. This sometimes introduces a wrinkle in the PSA film. Fortunately, all of these problems have been solved in production, for example, by automakers sandwiching a plastic liner between sheets of windshield glass.

PSAs are silicones so the Coefficient of Thermal Expansion (CTE) is relatively high at approximately 300 ppm/ºC but the modulus of the PSA film is quite low so the films have some "give" between substrates of different CTE during thermal cycling not unlike the typical liquid silicone adhesives currently in use.

CV grade film adhesive

Two-part curable films are different than PSAs. PSAs are pre-cured and offer moderate adhesion

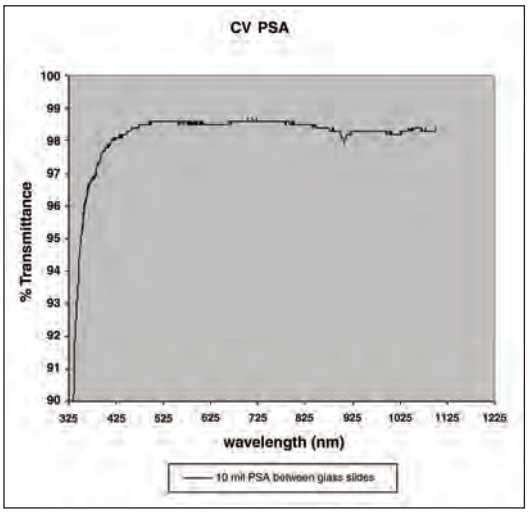


Figure 7: UV/vis spectrograph of PSAs

without any further cure. A two-part system is similar to the current liquid silicone adhesives except that Part A is a semi-solid film and Part B is a liquid activator similar to a primer. The adhesive is applied by wiping the liquid Part B onto a surface, permitting the solvent to evaporate for 15 minutes, applying the Part A film adhesive, and then pressing the two substrates to be bonded together. The adhesive can be heat accelerated at 60°C for 4 hours or permitted to cure for 24 hours at room temperature. Humidity is not a factor for the cure. Typically Part A, the film adhesive, is made in thicknesses ranging from 0.18 – 0.76 (7 mils to 30 mils). These films can be filled with thermally conductive fillers, electrically dissipative fillers, or both.

The films come on release liners and can be handled as free film transferred from the release liner to a substrate and then bonded to a catalysed substrate. If uncatalyzed, they have practically unlimited shelf life and will cure after catalyzation at room temperature in 24 hours or can be heat-

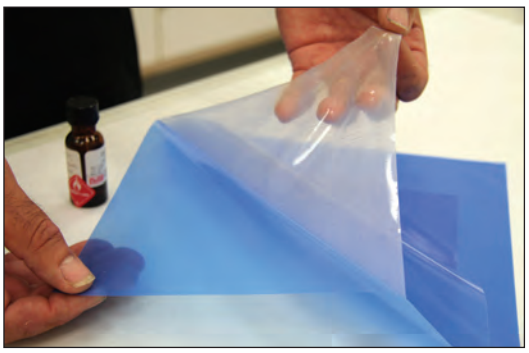


Figure 8: Photo of a CV film adhesive, a high consistency silicone calendered out to 0.012" with fiberglass scrim reinforcement embedded. Also, small bottle of Part B Activator

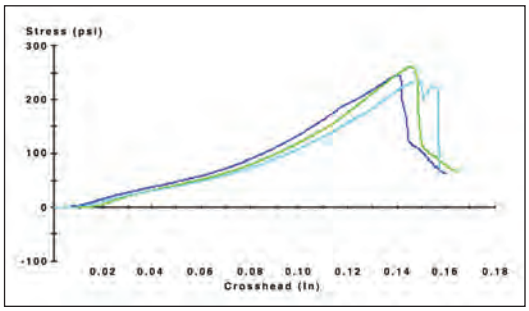


Figure 9: Graph of a lap shear test of unfilled film adhesive. Crosshead moves at 0.25 mm/min (0.1in/min)

accelerated. The film is a firm, uncured silicone that can be handled, die-cut, or pressed onto substrates and still maintain its dimensions. When cured, it is a fully cured silicone elastomer with adhesion properties similar to liquid adhesives.

Some disadvantages of the low viscosity adhesives typically used to bond solar cells are carefully mixing, de-airing, and applying a measured film of the adhesive onto a substrate to which the solar cells are bonded. The film adhesive offers a controlled bondline, the adhesive requires no mixing, and the film adhesive offers enough tack so the substrates can be handled immediately after bonding.

A typical test for a solar cell adhesive is a lap shear, meaning the adhesive is cured between two panels, and the panels are then pulled apart on a tensile tester to measure the force required to pull the two panels apart.[5] A 2.5 cm square portion of the lap shear panel is covered with adhesive and another panel is laid on the adhesive with the unbonded portions facing away from each other.

The film adhesives are tested for lap shear strength. The films are bonded at 6.5 cm^2 (1 in^2), cured at 60°C and pulled apart at 0.02cm/min (0.05"/min) on a tensile tester. The resulting lap shear should be greater than 1.4 mPa (200 psi). Figure 9 depicts a typical test result for a two-part, unfilled film adhesive.

Another bonding difficulty on solar cell assemblies is bonding the through-wires on the back of a solar panel. The electricity from the solar cells is collected and eventually the wires need to go through the array substrate; all the individual wires are combined and then combined again into a large cable. All the individual wires are tacked

Sample	Results N/cm (lb/in)
Stainless steel sample @ - 55°C	5.7 (3.2)
Aluminum sample @ -55°C	7.0 (3.9)
Stainless steel sample @ 150°C	3.0 (1.7)
Aluminum sample @ 150°C	3.0 (1.7)

Table 1: Results of 180o peel testing at different temperatures

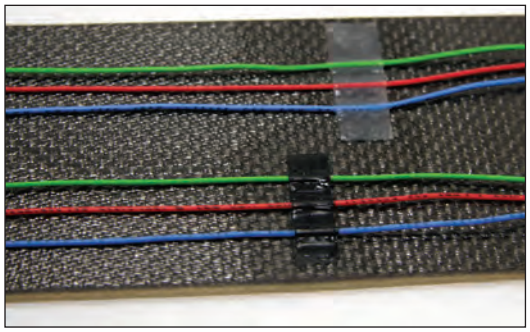


Figure 10: Cured film adhesives tacking wires down on a composite board

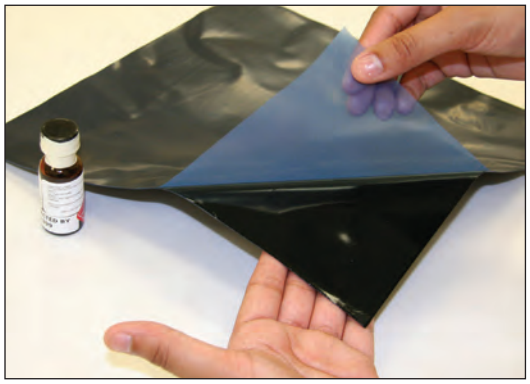


Figure 11: 300 micron (12 mil) thick electrically conductive Part A film adhesive with a blue release liner and Part B liquid activator

down on the back of the solar array substrate. Currently, a two-part, mixable silicone is used. The area around the wirers is masked to prevent any contamination, the wires are held in place, and the adhesive is applied. The adhesive may need to be applied two times to build up enough thickness to hold the wire. The wires still need to be held in place while the silicone cures. Calendered films can be cut into tapes suitable for tacking wires down, the activator is wiped on the solar array substrate permitted to dry; then the film adhesive is pressed down over the wires, and in 8 hours the adhesive is cured.

Figure 10 illustrates how cured film adhesives can be used to tack down wires on a composite board. The Part B activator was applied to the board (the slightly dark areas around the adhesive strips). The film adhesive was pressed down through the wire and, again, the Part B activator was applied to the surface of the film adhesive. The adhesive was cured in approximately 8 hours. The translucent adhesive is an unfilled CV silicone reinforced with fiberglass scrim. The black tape is an electrically dissipative material. Fillers can be added to the Part A films for different properties such as thermal conductivity. They can be filled with non-electrically conducting ceramic fillers like aluminium oxide or zinc oxide and have thermal conductivities of up to 1 W/mK. These films are white and are similar to the unfilled films.

In addition, carbon black can be added to the silicone films to offer electrical conductivity. The electrically dissipative films can have resistivities from 10^8 ohm-cm to 400 ohm-cm.[6] Films can be developed with other fillers to tailor properties as desired.

Conclusions

Silicone PSAs are different from curable film adhesives; PSAs are semi-cured films that provide adhesion through hydrogen bonding and have immediate tack while adhesion builds up over a longer time, around 24 hours. The adhesion is typically from 1.0 - 3.5 N/cm (1 - 2 lb./in) for peel testing. PSA film thickness usually runs from 25 – 75 microns (0.001" to 0.003"). PSAs are optically clear.

Silicone film adhesives offer an alternative to two-part, mixable silicone elastomeric adhesives. Curable film adhesives are two-part systems that include a calendared sheet of Part A, typically 175 - 750 microns (0.007" to 0.030"). The Part B is applied as a liquid and evaporates in 15 minutes, and then the Part A film is applied. The silicone cures in 8 hours at room temperature. Both adhesives offer short cure times and pre-cut peel-and-stick operations for quick manufacture of parts with little to no wait time for the cure. The PSA bonds quickly enough to be handled immediately. Film adhesives offer permanent adhesion to a variety of substrates in a pre-formed, controlled thickness format. Both materials provide additional options for adhesive bonding in the manufacture of solar arrays.

In summary, new options are available as adhesives for spacecraft: silicone PSAs and two-part curable films. These films offer manufacturers increased flexibility and improved turnover rates with faster cure and ease of handling.

References

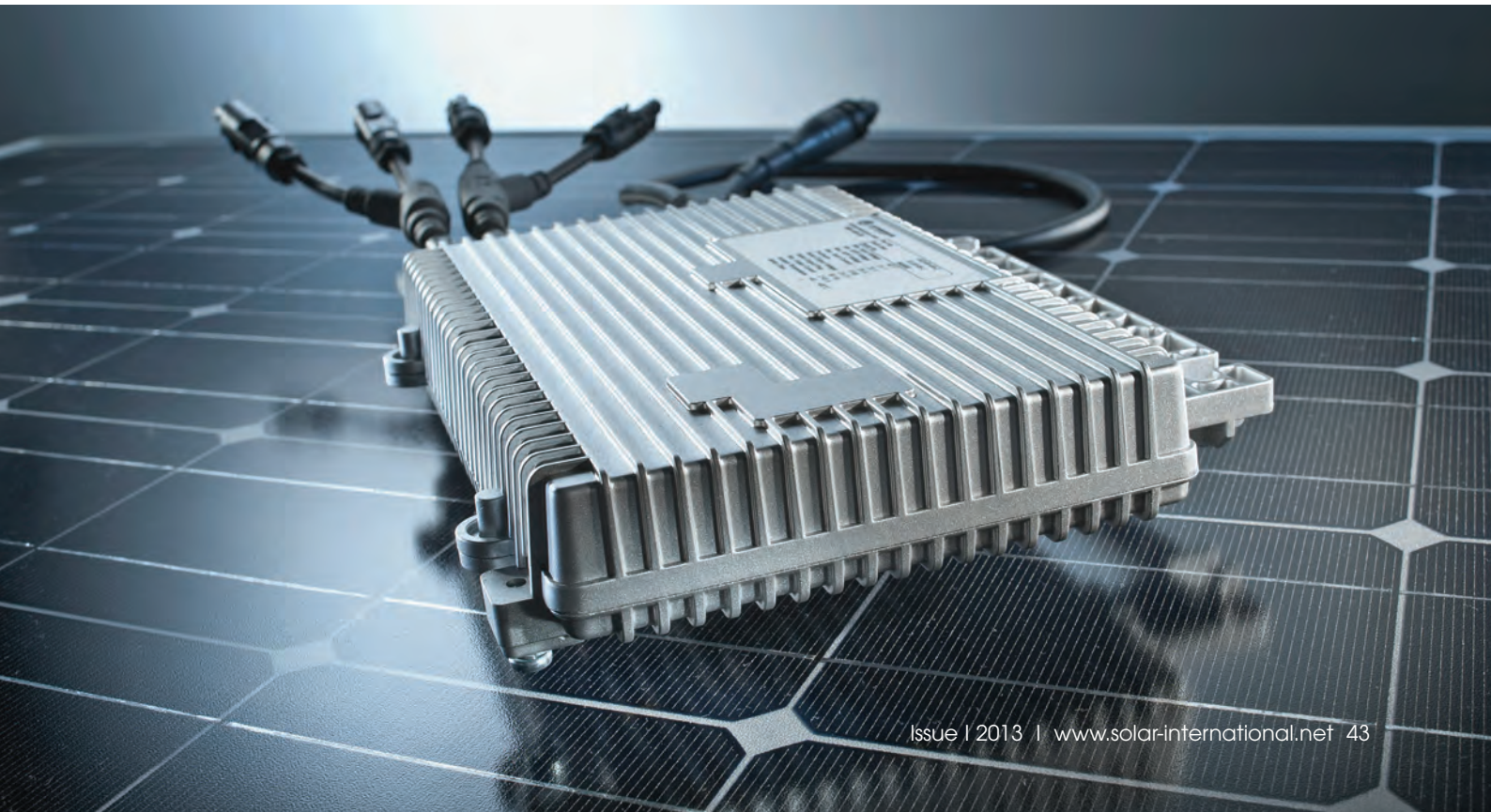
1) Nusil Test Method TM122 PSA Blunt Probe Tack Test, based on ASTM D2979
2) Nusil Test Method TM163 180° Peel Strength of PSA Sheeting, based on ASTM D903
3) Nusil Test Method TM152 PSA Static Shear Test
4) Nusil Test Method TM100 UV/visible Spectrophotometry, based on ASTM E275
5) Nusil Test Method TM010 Lap Shear Strength of a Cured Silicone, based on ASTM D1002
6) Nusil Test Method TM040 Volume Resistivity of a Cured Silicone, based on ASTM D257 and D4496

Energy improvement through innovation

The solar industry has been on a mission to reduce the cost of PV generated energy to equal or less than traditional methods. To this end there is constant innovation to achieve these goals and continuously improve the customer experience. A key area of concern is energy harvesting for customer use as well as energy put into the grid for financial returns. Sulaiman Ahmad, VP European Project Business at Enecsys discusses how increasing energy harvesting is occurring through evolving PV solar architectures.

As demand for renewable energy grows, photovoltaic (PV) modules, or panels, are being deployed in various types of solar PV installations. However, the most popular use of these modules is in grid-connected applications, where the output of the solar PV system must be 50 or 60 Hz AC power that can be fed into the main power grid. Such systems provide end users with clean energy to power their appliances during daylight hours, while also allowing them to sell any excess energy they generate back to the power utility. Equally important, is the fact that users can still receive power from the grid, when solar power is unavailable during overcast conditions or at night.

Nevertheless, grid-connect solar PV systems impose certain requirements. For example, PV modules produce DC power at peak levels up to 250 W. So in most installations, multiple panels will need to be connected in series to generate sufficient power levels for the home or business being powered. The output of those multiple panels will then need to be converted from DC to grid-compatible AC power. That requires additional



electronic equipment in the form of a solar power inverter. Those are the most basic needs for grid-connected solar PV systems. The design of these systems is heavily influenced by the end user's requirements for economy and reliability. Because of these demands, the design of solar PV systems is evolving from an architecture that relies on a single power inverter in each system to one that employs multiple micro inverters.
The adoption of the micro inverter based solar PV architecture promises to reduce the cost per watt of the solar PV system over its operating lifetime, while increasing the amount of energy harvested. However, as such systems are relatively new the issue of micro inverter reliability must be addressed.

Traditional Solar PV Architecture

In a conventional, grid-connected solar PV installation, the modules are connected in series, or daisy chained, to form a "string". The output of this string is fed to a central inverter (also referred to as a "string inverter"), which converts the high DC voltage generated by the string into AC that can be fed into the grid.

In this type of solar PV system, installation is complex and expensive. Special skills are required to ensure the system is setup for optimum performance and to ensure that the necessary safety procedures are followed. The safety requirements are dictated by the presence of high and potentially lethal DC voltages and currents in the system. The voltage produced by the string can be as much as 900 V at 5 A. This is sufficient to cause a fatality should someone touch a live connection. At the same time, systems based on DC strings are very sensitive to how the components are selected and configured during installation. Maximum energy harvesting can only be achieved if every module is matched exactly for performance and then installed so that the same level of solar radiation reaches each solar cell in every module. These requirements are difficult to meet under real-world conditions. Consequently, many solar PV systems do not perform up to their potential, often falling well short of their energy-harvesting capability. This lack of performance can be caused by any object that blocks a module's view of the sun. In some cases, shading from tree branches is the problem. But even objects as small as an antenna or vent pipe can dramatically lower the energy produced by a string.

While some obstacles may be accounted for during installation, some cannot. Over time, dust and dirt can build up unevenly on the modules causing some modules or even a few cells within the modules to receive less solar energy than other modules. Unfortunately, because the modules are connected in series, the poorest-performing module will determine the overall performance of the entire system. Just one shadowed module significantly limits the energy generated by the system as a whole and the higher potential energy of the un-shadowed modules is wasted.

Often a system with relatively few obstructed solar cells won't even produce half of its peak power capability. And in those cases where shadowing affects several modules, the system may not generate any power output. Since the weakest modules have such impact on the efficiency of the solar PV system, the individual modules must be pre-selected prior to installation to ensure their uniform performance. Meeting this requirement

adds to the cost of manufacturing the modules and to the cost of installing them.

A more complete solution

There is another, more complete solution – a micro-inverter based architecture. In this environment, a micro inverter is either built into, or attached to, each PV module. A micro inverter converts the DC produced by each module to AC that can be fed directly to the grid. With this arrangement, each module becomes a standalone solar PV system with its own optimised energy production output.

By replacing the large, central inverter with many smaller micro inverters, the micro inverter architecture eliminates the single point of failure that makes conventional solar PV systems vulnerable. Installation of the systems also becomes safer, easier and faster with micro inverters. Instead of dealing with high-voltage DC circuits that require special wiring, installers work with lower-voltage DC and standard AC line voltages and cabling. Wiring up of the system is greatly simplified since the micro inverters are essentially plug-and-play units. This change can reduce installation time and cost by 15% to 25% versus installation of a conventional solar PV system. The micro inverter architecture is also flexible and scalable. Modules can be positioned on any plane, or on multiple planes within a single system.

For the end customers who purchase solar PV systems, micro inverters offer several benefits. The systems are inherently safer than the conventional solar PV systems, generate more power, and save money in the long run. By optimising the energy harvested from each module, micro inverters can extract 5% to 20% more power from the installation than would be possible with a central inverter. Although the up-front cost of the system can be higher with micro inverters, the added cost of putting a micro inverter at every module can be offset in time by the savings accrued from not having to replace the central string inverter, one or more times. That said, for installations of 2KW or less, a solar architecture using micro inverters is usually around the same cost as one using a central inverter.

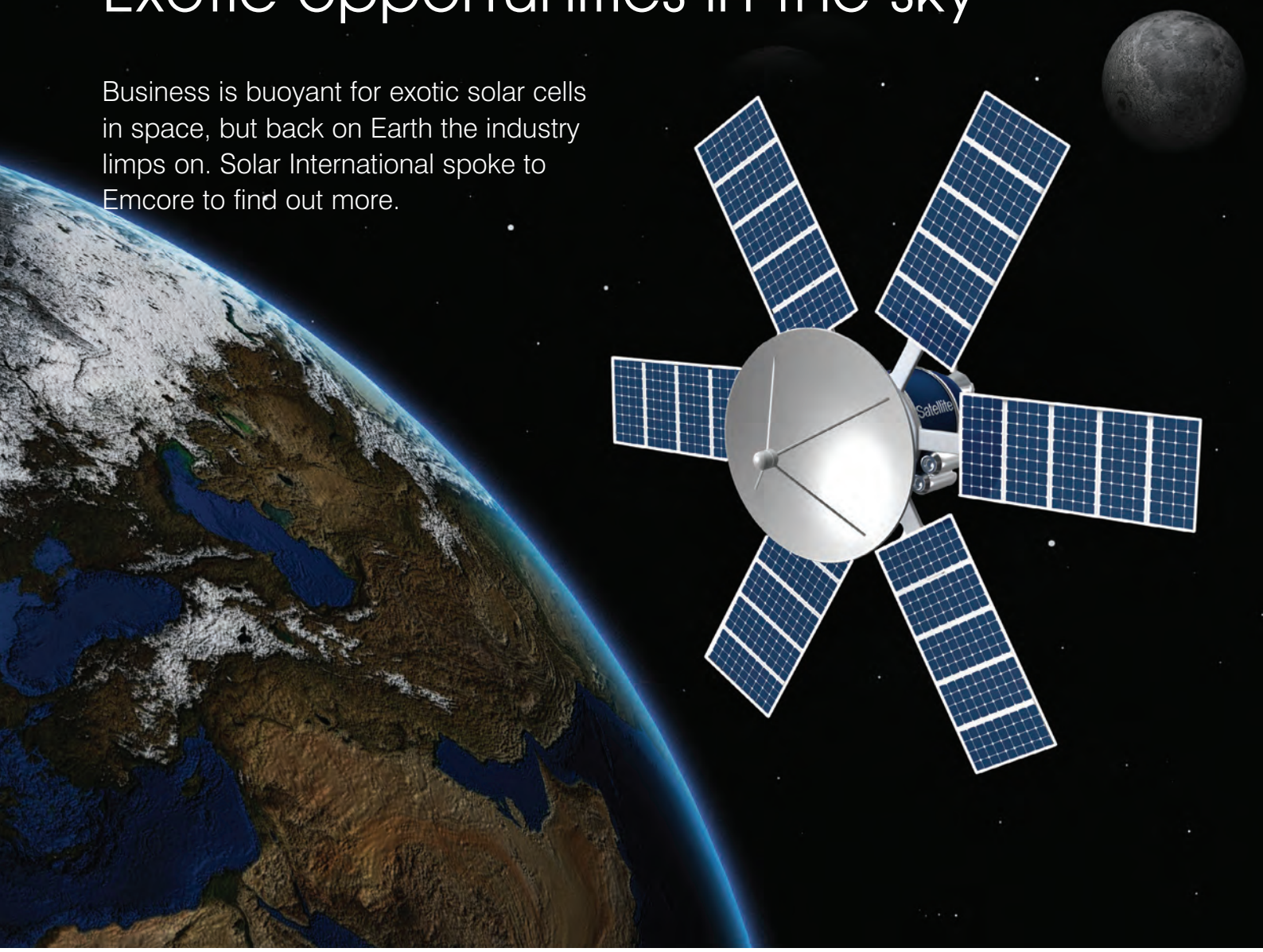
Evolving benefits

It's becoming increasingly clear throughout the solar energy industry that conventional DC string architectures have limitations in rooftop PV solar installations for both domestic and commercial premises. The discrepancy between the energy they could potentially harvest and what they actually harvest is significant. This lack of system efficiency in the real world is hampering adoption of solar-electric technology.

Micro inverter based systems will address both energy harvesting performance and cost issues. As a further advancement, we can expect many PV module manufacturers to build micro inverters into their products. The resulting AC modules, which will be solar modules with grid-ready AC output, will become industry-standard products. This standardisation will dramatically reduce the PV system installation time, complexity and cost. Equally important will be the benefits to PV system users, who will harvest more electricity from their systems and see their investments in solar energy paid back over much shorter periods of time.

Exotic opportunities in the sky

Business is buoyant for exotic solar cells in space, but back on Earth the industry limps on. Solar International spoke to Emcore to find out more.

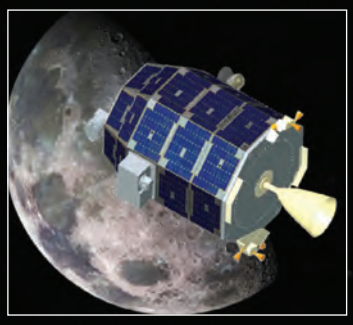


In late January, this year, US-based Emcore, delivered its one millionth multi-junction solar cell to US satellite maker, SSL, previously known as Space Systems/Loral, representing more than a megawatt of power delivered into space. This landmark figure followed its Summer 2012 milestone, which saw the 100th spacecraft powered by its solar equipment launched.

As chief operating officer, Christopher Larocca, said at the time: "We have a total of 120 more satellites under contract to be launched and powered by our solar equipment over the next several years."

But while the solar power and fibre-optics manufacturer's III-V systems continue to find favour in space, the story at ground level is quite different.

In August 2010, Emcore joined forces with San'an Optoelectronics, China, to launch joint venture Suncore Photovoltaics. Together the businesses were to develop and manufacture CPV modules and systems, for terrestrial applications, that would produce electricity by focusing sunlight onto Emcore's multi-junction solar cell. In March 2012, manufacture at Suncore's 200MW Huainan facility started,



An artist's concept of NASA's Lunar Atmosphere and Dust Environmental Explorer (LADEE): Emcore is to provide solar panels for this and many more space contracts

including the supply of 50MW to a utility-scale CPV farm in Golmud, one of the sunniest locations in China. And then six months later, Emcore sold its share of Suncore to a US Suncore subsidiary.

This time, Larocca said: "This will allow us to focus efforts on our core competency of multi-junction solar cell technology for both space and terrestrial power applications."

But without a doubt, the lion's share of Emcore's solar business lies in space.

As vice president of business development, Navid Fatemi, puts it: "The [terrestrial CPV] market has been either flat or declining since 2008, and Emcore was in the systems business all this time. There is 15MW [of capacity] installed at the Golmud power plant, but we haven't seen much growth anywhere else other than China... so we divested the CPV systems business with Suncore."

According to Fatemi, the company is still supplying its terrestrial cells to a few domestic customers - "in small quantities relatively speaking" - and sending the bulk of this business to China. But as he highlights, space is where the big wins are for Emcore, now the company has stepped back from the uncertainties of the CPV solar industry.

"Space is the completely dominant market for us," he says. "We have more than 50% of the US space market and around 40% of the global market, so our outlook [especially] in the States, depends on the satellite industry."

And the company's latest financial results reflect this move. Revenue for the photovoltaics business was up 13% to $2.2 million, which chief executive Hong Hou, attributed to strong demand in space programs. Meanwhile, margins leapt 8% to 30.5%, following the sale of the lower-margin terrestrial systems lines.

And thanks to a steady stream of satellite-related projects, Hou and colleagues now expect the solar business to generate a "nice" operating profit, with revenues remaining flat, but at the current high level.

So what of the future?

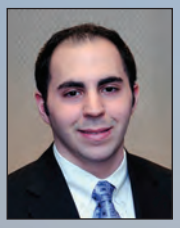
Fatemi will not be drawn on details, saying: "We expect slight growth for the next year. I've been in this business for many years and every time experts predict a downturn or up-tick, it hasn't, in my view, been very accurate."

Still, with the company's third generation, triple junction, 29.5% efficient solar cell well established - the company recently announced a $5 million contract with ATK to power the AMOS-6 telecoms satellite - attention surely turns to the much-awaited inverted metamorphic (IMM) solar cell.

As early as 2007, Compound Semiconductor reported company executives flaunting the new architecture, promising at least 33% efficiency and delivery by 2010. Clearly, this hasn't happened, but today, Emcore predicts the cell will ship come 2016.

"We hold the world record for space solar cell efficiency with this cell and are still very much focused on this architecture," says Fatemi. "We believe we are ahead of world competition with development of the IMM cell, and our belief is we should have qualified products by 2015, and with today's plan, these will be in production by 2016."

China, India emerge as most promising high-growth markets for solar



Japan, U.K., France, and South Korea also offer attractive landscape and large addressable markets, according to Lux Research's, Matt Feinstein, analysis of policy and market drivers.

As the economic crisis settled in, European legislatures in 2012 made significant cuts to solar installation incentives, which were previously the major support mechanism for solar deployment worldwide – and though often designed to fall in kind with equipment costs, became too costly themselves. In its recent World Energy Outlook 2012 fact sheet, the International Energy Agency (IEA) cited major growth in emerging economies' energy markets – including a 60% rise in demand in China, more than 100% in India, and major growth in the Middle East by 2035.

Worldwide economic conditions, concerns about climate change and a push for increased energy security have led to new legislation and revisions of existing laws to encourage (or discourage) solar deployment. In some cases – like those of the U.S. and the EU – broad policies like net metering or renewable portfolio standards (RPSs) are established on a national/union level, assigning responsibility to localities for determining and implementing program specifics. Ontario and European nations flourished with feed-in tariffs, but stumbled upon significant problems in 2012. Those markets are tasked with confronting tariff deficits or ballooning premiums to ratepayers that fund feed-in tariff programs, as well as pending grid infrastructure problems. Continued rapid growth could require promotion of energy storage or broader grid upgrades.

U.S. state markets are reliant on the federal Investment Tax Credit (ITC) and state-specific RPSs and net metering. A carbon tax and national RPS have some potential for passage – though are far from probable – for implementation during President Obama's second term. On a national level, U.S. market participants are more likely to benefit from tax regulators enabling innovative, new financing vehicles to finance projects, as well as executive orders and tighter standards from the Environmental Protection Agency (EPA).

Asian nations like India and China have recently debuted layered programs that combine monetary incentives with broader standards. China recently expanded its installation target to 35 GW (cumulative) by 2015, and it stands a far greater chance of achieving that target than any other country with an aggressive target.

Stakeholders must commit

Policymakers and regulators have begun to alter net metering policies as they prepare for high deployment, as well as reduce bottlenecks in system costs outside of the direct equipment – namely, financing and interconnection permitting, as well as broader environmental reform, like pricing GHG emissions. To better determine target market strategy according to policy, we combined several quantitative and qualitative factors related to solar deployment policy and general market outlook. We rated markets based on their overall 'risk' and 'reward', for every major region, in both distributed generation and utility scale solar.

Conventionally strong, established markets remain fruitful for distributed generation (see Figure). These include markets in Europe, like Germany and Italy, which have expressed a strong preference for rooftop systems and have strong existing channels to market. While they are also large energy markets, solar installations are rising faster than electricity demand, eroding the total addressable market. To that end, betting on distributed generation also requires betting on infrastructure upgrades or a rise in energy storage adoption, in order to continue solar's rapid growth.

(The figure shows Europe, Middle East, and African markets' prospects in distributed generation; each is rated from 1-5 on reward – with 1 being low system profitability, and 5 being high system profitability – and risk – with 1 being high-risk, and 5 being low-risk.) Utility-scale generation favors the bold, as high-growth emerging markets are crucial. Specifically, large markets with growing overall electricity demand will be hotbeds. India, China, South Africa, and Saudi Arabia are just a few of the markets set to become solar powers. Despite the various risks that accompany new market entry, the nature of the industry is forcing utility-scale players to tap these countries for long-term success whether they like it or not. Though some markets stand above the others in each region and application segment, the key lesson from experiences in Spain, Germany, and Italy is that too high a stake in few key markets can leave business stakeholders scrambling as policy changes. Those looking to win in distributed generation must broaden their technology scope, and those in utility-scale development must broaden their geographic scope.

Emerging markets with growing electricity demand are bringing new programs online, and now is the time for stakeholders to expand. Successful players will anchor business in key developed regions like the U.S., Europe, Japan, and China, and place informed bets in markets like South/Central America, the Middle East, and Africa, through new offices or partnerships.

EU told to crack down on governmental changes

Solar energy was a buzz-word for governments around the world and many were keen to show their environmental credentials by supporting a local PV industry with subsidies and tariffs. The explosive rate of PV growth meant many countries backtracked on their promises leaving many companies out of pocket. Now the EPIA has called on the EU to take action.

More than 70 companies and associations in the solar photovoltaic (PV) electricity sector have co-signed a letter to European Energy Commissioner Gunther Oettinger, calling on the EU to take action against Member States that are enacting retroactive measures or moratoria on support schemes for renewables. The letter, sent by the European Photovoltaic Industry Association (EPIA), makes reference to recent or imminent action in several countries – including Belgium, France, Czech Republic, Italy, Spain, Bulgaria and Greece.

"Such measures seriously damage the investment climate in general and for renewables in particular, not only in the countries where they occur, but also throughout Europe," the letter states. "We therefore call on you to react strongly to these decisions and use, where appropriate, all the legal means the European Commission has to stop this trend, which threatens the climate of confidence needed in Europe to attract further investors."

The signatories also point out that these actions can "heighten the perceived risk in investments in renewables, and PV in particular, thus unnecessarily increasing the cost of capital for private operators. In the transition to a power sector that will require more CAPEX-intensive investments, retroactive measures will seriously endanger the achievement of 2020 targets."

The changes in the FiT schemes and subsidies across Europe have changed the way the industry functions and has made it nearly impossible for the industry to effectively plan and manage capacities to the detriment of all.

Bulgaria

Measure n°1: Retroactive measure

The State Commission on Energy and Water Regulation (SCEWR) implemented grid access payments for all renewable installations, commissioned after 04.2010. The 'grid access payment' (GAP) is structured and functions as an additional fee.

The GAP is based on applications from the operators of the Transmission and Distribution grids, who had informed SCEWR about 'increased costs for management and dispatching of the grids due to the large amount of renewable energy electricity generators'. The determined GAP are not based on calculations of the real costs for management of the energy system, but as a share of the price for purchasing the electricity from RES. In addition, the GAP are discriminatory.

Impact on the Sector

The decision is making it impossible for PV producers to pay their bank loans. Most affected by the GAP are small and medium PV producers with installations commissioned in H1 of 2012, who have to pay 39% of their income and directly face bankruptcy.

Measure n°2: Moratorium

No grid connection procedure for renewable energy sources (RES).

1) The Renewable Energy Act (RESA), adopted on May 3rd 2011, implemented a moratorium on new grid connected RES. RESA provided no procedure for grid connection until July 2012, when SCEWR determined annual maximum admissible grid capacity for new RES initiatives. By Decision EM-01/29.06.2012 SCEWR determined 0 (zero) MWp capacity for RES for the regulatory period (07.2012-06.2013).

Impact on the Sector

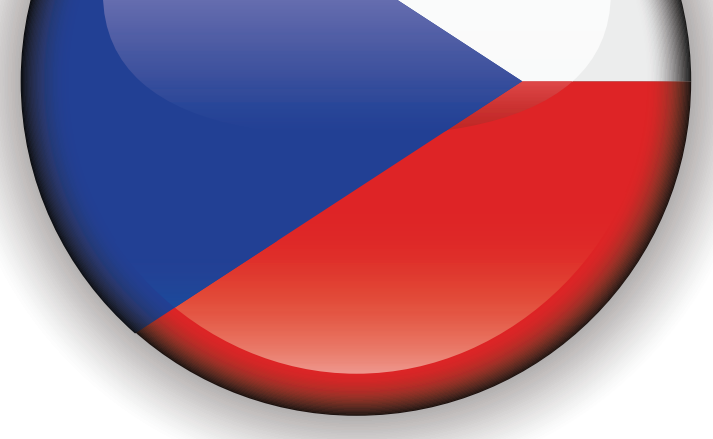
The only RES projects that can be developed are rooftop and façade PV installations on residential (up to 30kWp) and industrial buildings (up to 200kWp). Grid operators wrongly interpret the notification of NEC as relevant to such projects and therefore send letters to the producers with proposal for postponement of the grid connection after 2016. Large investments in PV projects, modules and equipment are stopped or nullified by these provisions.

Measure n°3: Cancellation of support

Ban on the construction of PV installations on agricultural lands from 1st to 4th category. The ban affects only PV installations, not other RES technology, nor conventional energy generators, buildings, etc. The ban was implemented as amendment to the Act for Protection of Agricultural Lands (APAL).

Impact on the Sector

Agricultural lands with category 1-4 represent more than 40% of the agricultural lands in Bulgaria. According to



calculations of BPVA, not more than 0.5% of the agricultural lands in Bulgaria could be used for building of 1500MWp of PV.

Measure n°4: Unplanned support reduction

SCEWR is allowed to determine FiTs more than once per year, but based on unclear conditions and without transparent methodology. By an amendment to RESA, adopted on July 17th 2012, SCEWR can determine the price for purchasing electricity from RES more than once per year. The only necesary condition, which enables this right of SCEWR, is more than a 10% decrease in the value of a price-forming element that should be observed since the moment of the last determination of FiTs.

According to this provision, SCEWR determined new purchasing prices for RES at the end of July 2012 with a more than 54% cut (annual adaptation) and proposed another change of the prices only for PV - just three weeks after that - on July 21st 2012 (decreasing PV FiTs with other 39%). New FiTs for PV only were determined by SCEWR from September 1st 2012.

The SCEWR motivated this second determination of FiTs on a single website of a German installer company with two completed projects, which gives a chart with the evolution of the PV module prices weekly. BPVA analysis of the website shows that there was no statistic proof of a change in the price-forming components with more than 10%.

Impact on the Sector

No bank would agree to finance PV or RES investment, because with SCEWR can change the FiT unpredictably; there is no minimum period for which a price change could not occur and there is no clear interval for price decrease.

Belgium - Flanders

Measure n°1: Retroactive measure

New grid fee in Flemish region for PV 10 kW for the partial compensation of missed distribution fee caused by net metering allowed for this category of small PV systems.

Details:

- A fixed 53 euro per year per kW installed or
- An injection-based fee measured through of a smart meter able to measure injected and withdrawn electricity to/from the grid. The smart meter will have to be paid by the PV owner
- Proposal from distribution grid operators, to be approved by the national regulator CREG
- Decision applicable to all existing and new PV systems from 1 January 2013

Impact on the Sector

The grid fee will be over 55% of the new support by green certificates as from January 2013

Measure n°2: Unplanned support reduction

Drastic cut in green certificate support mechanism.

- decrease announced on May 25th, going into effect on August 1st (two months later), without consultation of the PV sector in advance
- reduction of guaranteed price for PV green certificates from 210 euro/MWh over 20 years to 90 euro/MWh over 10 years (= reduction of total support per kWp PV from 4200 euro to 900 euro = minus 79%).

Impact on the Sector

PV market has been moribund since August 1st, 2012: only 493 kW has been installed in comparison to 230 MW in the first 6 months. Uncertainty about the new green certificate price valid from January 2013 will last till beginning of December, leading to a serious market decrease and PV companies going broke or shrinking.

Czech Republic

Type of Measure: Retroactive measure

Many retroactive legislative measures have been introduced since 2011: abolition of tax holidays, changes in depreciation, abolition of contribution on decentralized production, obligation to equip PV installations with facilities for remote power control, recycling fees.

The largest impact has been a so called solar tax which decreased retroactively the FiT by 26% and green bonuses by 28%. The tax hasn´t been implemented in the frame of the tax legislation but within the Amendment to the Act on RES 180/2005 Coll.

The tax has been implemented for a three-year period (2011-2013). The tax on PV investments together with the gift tax on

carbon credits and an increased fee for usage of an agricultural land for construction of the PV power plant have been adopted in order to decrease impact of the RES on the price of electricity.

Impact on the Sector

The result of all these steps is that the payback period for PV installations has been pushed 15 years beyond what was guaranteed by the law (the lifetime is 20 years) in many cases. Photovoltaic power plants are operating at a loss. Many of them have negative cash flow, the operational costs are higher than revenues after the solar tax. The Czech PV Association keeps track of several forced sales when entrepreneurs were unable to repay bank loans.

France

Measure n°1: Moratorium

On 9 December 2010, the Decree n° 2010-1510 the Government decided to suspend, for 3 months, the purchase obligation which applies to photovoltaic installations above 3 kWp.

Under specific criteria, PV projects which have accepted the quote for grid connection before the 2nd December 2010 have to be grid connected and commissioned within 18 months beginning from the quote acceptation, or 9 months if the quote has been accepted more than 9 months before the decree publication. The moratorium ended on 4 March 2011 with the publication of a new Feed-in tariff decree, which applies to all PV systems up to 12 MWp.

Impact on the Sector

The measure has led to the cancellation of many PV projects above 3 kWp. For a period of 3 months, many solar companies were unable to launch new projects due to the suspension of the purchase obligation.

Measure n°2: Retroactive measure

A decree project on the Feed-in tariff level has been under discussion since October 2012; it foresees a 20% decrease of the FiT applicable to all installations above 100 kWp, or without specific integration, or ground mounted.

This decrease will be applied to all projects which have asked for grid connection starting from 1 October 2012.

Impact on the Sector

This will lead to a low FiT for specific installations, with a retroactive effect.

Greece

Measure n°1: Retroactive measure

New tax on revenue generated by renewable energy systems as part of new austerity measures. The tax on existing solar power plants will be between 25% and 30%, and is aimed at helping the country reduce its deficit.

More specifically:

- PV systems installed before 2012 have been assigned a tax of 25%
- PV systems built from Jan. 1, 2012 that receive a FiT calculated according to the law 3734/09, article 27A between February and August 2012 onward will be taxed at 27%.
- PV systems built from Jan. 1, 2012 that receive a FiT calculated according to the law 3734/09, article 27A before February 2012 will be taxed at 30%.
- Revenue generated by other types of renewable energy systems, including wind, biomass and hydroelectric, will be taxed at 10%.

YPEKA (Ministry of Environment, Energy and Climate Change) could decide to extend the retroactive tax by one year.

The tax excludes rooftop systems with a capacity <10 kWp, as well as PV systems built from Jan. 1, 2012, that receive a FiT calculate according to the law 3734/09, article 27A.

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Impact on the Sector
The measures will drive many small- and mid-size solar companies out of business because they will not be able to repay bank loans.

Solar plants were already charged with tax of 40% on profits; the new measure brings the overall taxation unrealistically high and makes unsustainable many investments.

Measure n°2: Suspension of authorization procedures for new PV projects

In August 2012, the Greek Ministry of Environment, Energy and Climate Change put on hold authorization procedures for new PV projects. This decision has affected over 7.5 GWp of PV projects which had initiated such procedures. The only category not affected by the decision is the residential sector (PV systems <10 kWp). The reasoning for this suspension of authorization is the large number of applications overriding the indicative PV national target for 2020.

However, this target (2.2 GWp) is only indicative and according to existing legislation can be revised every two years. The Greek PV industry is asking for such a revision and a considerable increase of the target for PV (up to 6 GWp) until 2020.

Country: Italy

Measure n°1: Unplanned support reduction

Sudden stop of III Conto Energia (DM 6/08/2010): application to pv plants entering into operation from 01.01.2011 to 31.12.2013. However, due to the so-called “Salva Alcoa” arrangement (which allowed plants built by 31/12/2010 to accede incentives of II energy bill up to 30/06/2011), lasted only five months. Then the IV Conto Energia entered into force.

Impact on the Sector
In less than two years Italy has had three different incentive systems. These sudden changes of legislation have generated many uncertainties on the part of operators and in some cases limited access to credit

Measure n°2

Unplanned support reduction

IV Conto Energia (DM 5/05/2011): introduction of limits on access to incentives, such as the “register” for so-called “big plants” , rapid and sudden decrease of incentives, excessive bureaucracy

Impact on the Sector
The three different incentive systems in less than two years continues to impact the Italian system. These sudden changes have generated uncertainties on the part of operators and in some cases limited access to credit

Measure n°3: Unplanned support reduction

Revision of minimum guaranteed prices for the dedicated withdrawal

Impact on the Sector
Yet another change of a regulatory framework a few weeks after the publication of the IV Conto Energia. It created further uncertainty in the sector.

Measure n°4: Unplanned support reduction

V Conto Energia (DM 05/07/2012): Anticipation of the transition from Feed-in premium to Feed-in tariff (net metering and dedicated withdrawal alternative incentives) - new tariff and premium for self-consumption. Tariff decrease of 50-75% over those of IV Conto Energia, limited budget of 0,7 billion euros divided in the 5 semesters; lack of protection of investments in progress; in order to access to the incentive system, PV plants must be included in a register drawn up on the basis of suitable criteria (exclusion: all PV systems up to 12 kW and PV system up to 50 kW with asbestos removal that directly access to FiT)

Impact on the Sector
Once again the three dramatic changes to the Italian system have led to a situation of uncertainty for operators leading to restrictions of credit and uncertain conditions in the market.

Measure n°5: Cancellation of support

Restricts access to the incentive for photovoltaic systems installed in agricultural areas. Since its entry into force ground-mounted PV plants in agricultural areas no longer get incentives.

Impact on the Sector
Uncertainty again due to the sudden changes over two years. No market can tolerate three major and rapid unannounced tariff changes with leading to uncertainty and difficulty in credit acceptance from the banking sector.

Measure n°6: Cancellation of support

Prohibits the construction of photovoltaic systems on the ground in industrial areas - introduction of a register for PV plants (12 kW and above) installed on buildings and priority criteria for

'access to the registry completely different compared to the criteria valid for the IV Conto Energia

Impact on the Sector
Limits the installation of residential PV systems. Consequent suffering of the sector.

Measure n°7: Retroactive measure

Introduction of the contribution of 0.05 cents € for each kilowatt-hour of energy self-produced and incentivised in 2013 and retroactive for all PV systems incentivised according to the 4 previous Conto Energia. This is to cover the GSE costs of managing, monitoring and control.

Impact on the Sector
It is an addition operational cost for the management of the systems (OPEX) not budgeted

Measure n°8: Other

Consultation paper of Italian TSO (Terna) published at the end of July 2012. It established, with effect from 1 August 2012, in case of emergency situations (probably in the peak of PV production during summer), a reduction of the production plants of Distributed Generation connected to the medium voltage. In particular this referred to non-programmable solar/wind systems up to 100 kW.

Impact on the Sector
Although, there hasn't been any detachment, the lack of a clearly defined procedure of this measure has created much confusion among operators. In addition, we highlight two problems: firstly the lack of any compensation for the failure to produce photovoltaic energy (as is the case for wind power) and secondly the lack of a time limit of application of the measure (and so, in this way seems already applicable today)

Measure n°9: Other

All PV systems with an installed capacity over 50 kW and connected to Medium Voltage grid by March 31, 2012 must carry out retrofits to be completed by March 31, 2013 whereby plants are brought into conformity with Chapters 5 (broadening of the thresholds of frequency and voltage) and 8 (protection of interface function to release voltmeter) of Appendix A70 of the network code of Terna.

Impact on the Sector
Great demand for systems interface protection of medium voltage in accordance with Annex A70 during summer 2012, since this included incentives until 31 October 2012. For several weeks the market for interface protection of medium voltage was saturated because of the great demand. Risk of suspension of incentives for plants not adapted by March 31, 2013

Measure n°10: Other

The AEEG Resolution 84/12 has set the date of entry into force of the CEI 0-21 July 1, 2012 (ahead of the demands made by the manufacturers of inverter and interface protection LV).

Impact on the Sector
This date did not allow, especially for manufacturers of LV protection interface, to have the physical time for the design, proper engineering and marketing of their products. Especially in the months of July and August, this has made it very difficult for market participants to implement protection systems on the market that comply with LV interface CEI 0-21, since there were very few manufacturers able to provide products complying with the timing dictated by the AEEG.

Measure n°11: Other

Consortia for the disposal of the PV modules at the end of life: all the requirements that must be met from 1 January 2013 are not yet defined, thus affecting eligibility for incentives by the GSE. Furthermore, the definition of "PV module producer" is not in line with the one defined in the WEEE Directive that has to be changed in Italy until 1 February, 2014

Impact on the Sector
Uncertainty and confusion. Lack of clear regulations.

Measure n°12: Other

From January 1, 2013 the cost of imbalance will be borne by producers of energy from renewable sources.

Impact on the Sector
Scenario of economic uncertainty

Country: Slovakia

Measure n°1: Unplanned support reduction

The change of FiT (decrease of 38,77%) in the middle of regulatory period 2012 contrary to law, the change was announced 1 month before. Cumulative decrease of FiT from 2011 is of 54%.

Impact on the Sector
The regulator announced new FiT 1 month before the new FiT was launched, no option to finalize running installation processes within old FIT conditions etc.

Measure n°2:
Non-transparent calculations and set-up of FiT, impossible to control the regulatory office or to claim.

Impact on the Sector
PV development is no longer attractive because of the low return on investment or the length of time of economic return

Measure n°3: Cancellation of support
The maximum limit of the capacity per installation is 100kWp only at the rooftop or facade since 2011, no matter the consumption of the owner. Ground mounted plants restricted also at the brownfields.

Impact on the Sector
The SMEs with high consumption are not motivated to act green

Country: Spain

Measure n°1: Unplanned support reduction

Sudden change of support framework: caps introduction, 30% FiT reduction

Impact on the Sector
- One year market paralysis
- Employment destruction
- Lack of confidence / Unreliable framework

Measure n°2: Unplanned support reduction
Sudden FiT reduction of 25% for rooftop PV systems and 45% for ground mounted PV systems

Impact on the Sector
- Losses of expected revenues
- Lack of confidence from the market and unrelieble framework.

Measure n°3: Retroactive measure
Hourly production limits to FiT, which means:
- 30% FiT reduction for 80% of current PV power plants in 2011, 2012 and 2013, and 10% FiT reduction for next 25 years (For PV systems under Royal Decree 661/2007)
- 10% FiT reduction for 10% of current PV power plants for next 25 years (For PV systems under Royal Decree 1578/2008)

Impact on the Sector
- Losses of expected revenues
- Lack of confidence / Unreliable framework
- Companies bankrupcty

Measure n°4: Moratorium
Sudden stop to FiT programs without deadline

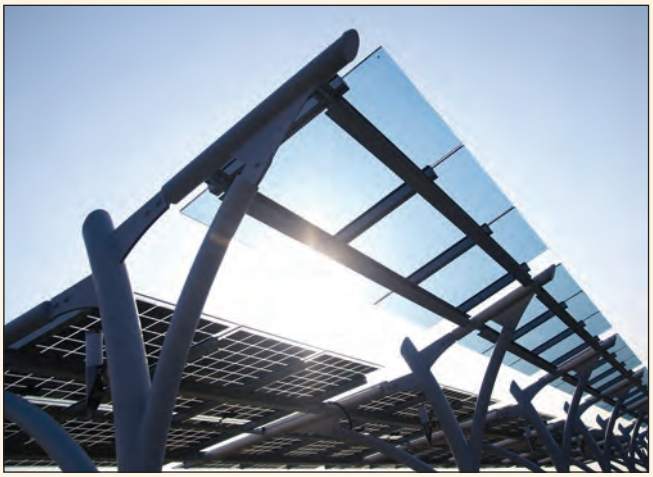
Impact on the Sector
Employment destruction (from 60.000 jobs in 2008 to 7.000 - 5.000 now. Loss of investments done. Lack of confidence and Unreliable framework.
Company bankruptcies.

Measure n°5: Other

New tax on all energy systems production of 7%

Impact on the Sector
- Losses of expected revenues
- Lack of confidence / Unreliable framework
- Companies bankrupcty

The Open letter to the EU Commissioner



Dear Commissioner Oettinger,

We are writing you to express the photovoltaic industry's great concern about the growing number of countries that are adopting retroactive measures affecting the economics of existing PV installations. Such measures seriously damage the investment climate in general and for renewables in particular, not only in the countries where they occur, but also throughout Europe. Even beyond Europe there could evolve a general bad feeling about the reliability of European political decisions happening in various member states. This lack of confidence in the support measures heightens the perceived risk in investments in renewables, and PV in particular, thus unnecessarily increasing the cost of capital for private operators. In the transition to a power sector that will require more CAPEX-intensive investments, retroactive measures will seriously endanger the achievement of 2020 targets.

The following retroactive measures affecting PV investments have recently been enacted:

- Czech Republic, end 2010, adoption of a 26% or 28% retroactive tax on PV investments realised between 2009 and 2010
- Spain, end 2010, adoption of a retroactive measure on all existing PV investments, limiting the number of hours they could operate to receive the Feed-in Tariff
- Bulgaria, September 2012, adoption of a discriminatory, abusive and retroactive grid access fee for systems commissioned since April 2010
- Greece, 7 November 2012, adoption of an up to 30% tax on revenues of PV systems already installed or to be installed in the future
- Flanders, Belgium, 6 December 2012, adoption of a retroactive grid access tariff for the use of the grid for PV systems benefiting from net-metering (<10 kVA).

The following retroactive measures are being considered:

- Czech Republic, October 2012, official declaration of the Minister of Industry concerning his intention to prolongate and increase the tax on the PV investments
- Spain, October 2012, proposal for the adoption of a 7% tax on revenues for electricity producers, discriminating against renewable energy producers and in favour of conventional players
- France, November 2012, proposal to adopt a retroactive measure on the tariff level for large scale systems.

The above lists refer only to retroactive measures that are already affecting or could soon affect the security of existing PV investments. This is not to mention the series of moratoria that have been in place in several countries, such as Spain and Portugal currently or France in the past.

You will find enclosed a description of the series of negative measures that have been taken in the last two years; we are convinced you will see the full seriousness of the situation the whole PV and Renewable sector faces today in Europe. We therefore call on you to react strongly to these decisions and use, where appropriate, all the legal means the European Commission has to stop this trend, which threatens the climate of confidence needed in Europe to attract further investors. Once again, we call on the EC to forcefully discourage this kind of practice in the future — in particular through the upcoming guidance on national support schemes.

Yours sincerely,

Dr. Winfried Hoffmann
President

Reinhold Buttgereit
Secretary General

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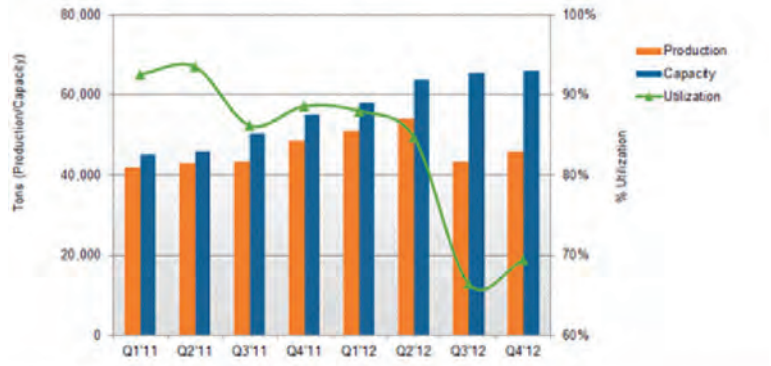
Tier 1 polysilicon producers rationalize supply to PV

Polysilicon suppliers to the solar photovoltaic (PV) industry have been significantly lowering plant utilization rates during the past six months, with average quarterly utilization rates falling below 70%, says the latest NPD Solarbuzz Q4'12 Polysilicon and Wafer Supply Chain Quarterly Report.

This contrasts with historic plant utilization rates at above 90% typically provided by the leading polysilicon suppliers to the solar PV industry. Even when polysilicon spot prices declined 70% between Q1'11 and Q2'12, Tier 1 polysilicon suppliers maintained these high utilization rates.

"Polysilicon makers strive to run plants at optimal capacity levels, where maximizing production offers the lowest cost structures by spreading depreciation costs over a larger volume. This often results in the highest yields, avoids shutdown/start-up costs, and enables volume purchases of raw materials," stated Charles Annis, Vice President at NPD Solarbuzz.

Figure 1: Tier 1 Polysilicon Maker Plant Utilization



Source: NPD Solarbuzz Q4'12 *Polysilicon and Wafer Supply Chain Quarterly Report*

Accordingly, polysilicon suppliers maintained high utilization rates while prices remained above cash costs. When average spot prices fell below $20/Kg in Q3'12, and continued down to $16/Kg in Q4'12, even Tier 1 makers with best-of-class cost structures were forced to adjust production levels. China, the world's largest end-market, consumed approximately 188,000 tons of polysilicon for PV applications between Q1'11 and Q3'12. However, during the same time period, 262,000 tons of materials were provided to the Chinese market from a combination of domestic production and foreign imports.

In particular, foreign imports grew to record highs during most of 2012. As a result, the 74,000 tons of excess supply contributed to a strong inventory buildup and, combined with weaker than hoped end-market PV demand during 2H'12, ultimately led to the recent utilization corrections. The reduced utilization rates have also had a profound impact on the previously aggressive capacity expansion plans of PV polysilicon suppliers. In fact, several Tier 1 polysilicon manufacturers, including Wacker, Hemlock, OCI, and Tokuyama, have now decided to delay ramping up and building new polysilicon plants.

"The rationalization of supply finally started stabilizing polysilicon prices towards the end of Q4'12, and this trend continues into early Q1'13," added Annis. "Even so, price pressure is expected to remain strong with polysilicon makers hoping to increase utilization rates as early as possible. Moreover, several polysilicon plants are still currently scheduled for completion, but this new capacity is likely to remain idle until end-market PV demand increases."

Solar powered coffee business

Solar Roast Coffee was started in 2004 by brothers Michael and David Hartkop. At the time, Michael was an apprenticed coffee roast master, and David was a special effects artist with an interest in alternative energy. So that they could move out of their parents' house in Oregon, they decided to combine their talents and go into business together. The idea to build a solar coffee roaster from scratch came out of the necessity to build a coffee roaster for low cost, and the desire to create a practical demonstration of concentrated solar energy.

They constructed their first solar coffee roaster from an old satellite dish in their backyard. It used 100 plastic mirrors to focus sunlight to create heat, and a broccoli strainer, which served as the roasting drum. Dubbed the Helios 1, the roaster could produce one pound of coffee at a time. When Michael and David tried the coffee they had made, the realized that it was not only excellent in flavour, but possibly the most eco-friendly coffee ever created. Michael and David began business as an online venture.

During the summer of 2005, the brothers constructed a new solar coffee roaster, the Helios 2, using glass mirrors and an improved balanced design. The new roaster could roast over 2 pounds of coffee at a time, and took just under 20 minutes per batch. They attended several festivals and events with coffee they had produced, and generated some local news interest.

Sustainable business

In 2006, David and Michael realized they had to make a change if they wished to stay in business: Oregon afforded only about 3 months of sunny weather, and it was nearly impossible to sustain a solar powered roasting business during the winter months. They constructed a third roaster that was built onto a trailer that could be moved with them. The Helios 3 mobile solar roaster could roast up to 5 pounds of coffee at a time, and easily folded up for travel. They attended several events, and made visits to Arizona, California, Nevada, New Mexico, and Colorado, looking for a new home for Solar Roast Coffee.

In 2007, Michael and David made the decision to move their business to Pueblo, Colorado. There they opened their first retail coffee shop, aptly named Solar Roast Coffee. Pueblo was their final choice because of its small to medium size, it's affordability, its excellent solar exposure, and the fact that it has its own university. Their parents were their first investors, believing in the business enough to help them secure the resources to start the business in earnest.

The Helios 4 used a mirrored solar concentrator measuring 35 feet across. It could rotate and elevate to track the sun, and provided around 20KW of heat energy to the roaster in the container behind. Despite many challenges in creating this new solar coffee roasting system, the new roaster went into operation in the first quarter of 2008. It was capable of producing up to 30 pounds of coffee at a time, with a batch taking around 20 minutes. This enormous roaster uses a movable wall of mirrors to focus sunlight onto a receiver box, which heats air to several hundred degrees. This heated air is then ducted into the solar roaster. In addition, the new roaster is outfitted with a conventional propane heat source to assist when needed, particularly on cloudy or extremely cold days.

In 2010, Solar Roast Coffee received a business development grant from the city of Pueblo through the Pueblo Economic Development Corporation (PEDCO.) The grant was slated to be used by Solar Roast Coffee LLC to create a new generation of solar coffee roaster, the Helios 5. The new system is designed to be a downtown attraction, located on the premises of the solar roast coffee shop. Moving the roaster from Pueblo County into town also has great time benefits, streamlining the coffee roasting & shipping process.

The brothers have now completed the Helios 5 solar coffee roasting system. This new solar powered coffee roaster was first begun in 2010 with an initial investment from the Pueblo Economic Development Corporation (PEDCO). As of July 2012, they have demonstrated the full functionality of the Helios 5 solar electric roasting system, which draws electrical current from a PV fed grid-tie in order to power large electric heater. This system is used in conjunction with a standard natural-gas heater, making the system a 'solar-electric-gas hybrid' system. Further refinements are yet to be made, but the new system means that Solar Roast Coffee finally has its sales, production, and shipping departments under one roof for the first time!

Solar Roast Coffee is working in collaboration with fellow Coloradans Nathan Stern and Chris Bass in Denver. Their spin-off business, Solar Roast Coffee: On The Road, is a fully functioning cafe on wheels. Together, they exclusively serve Solar Roast Coffee to the Denver area along a constantly updated route.

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Angel Business Communications Ltd (Coventry)
Registration Number: 1972952

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Solar International is published six times a year on a controlled circulation basis. Non-qualifying individuals can subscribe at: £110.00 (UK & Europe), $140 pa (USA). Cover price £5.50.
 Printed by: Pensord Press Ltd. ISSN (Print) 2040-8714 (Online) 2040-8722. © 2013.

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