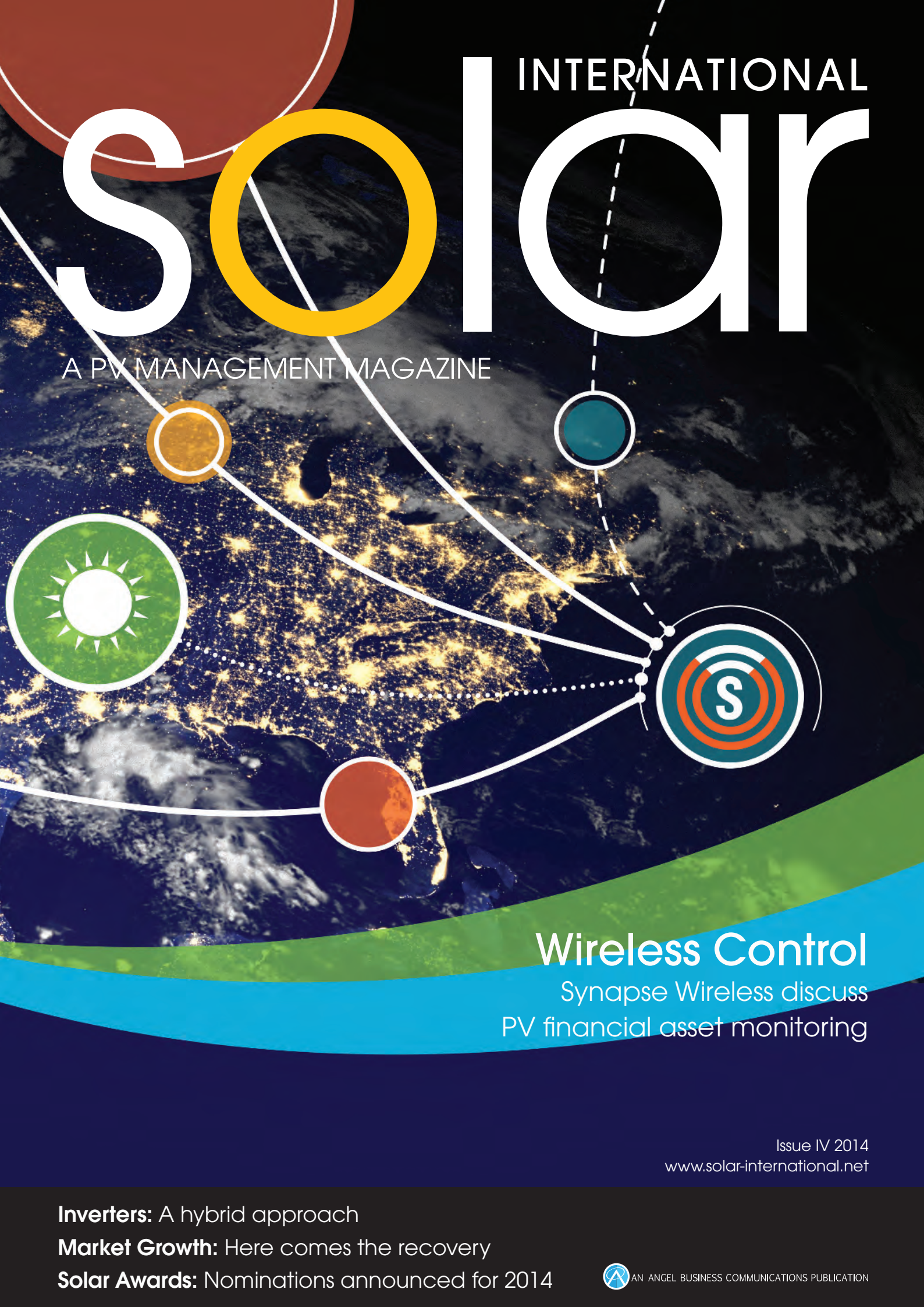

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editor's view

By david ridsdale, editor-in-chief

Has PV success pushed renewables too fast?

A PUSH FOR RENEWABLE ENERGY SOURCES is not a new quest for our species but the speed of change in the last decade or so seems to have caught the traditional energy suppliers off guard and around the world we are seeing changes that suggest there is a bit of a backlash to renewable energy sources, and in particular, solar energy.

Of course such changes on a global scale are not easy to define and it would be difficult to show any links to some of the changes and the companies that most benefit from the changes. On a local scale it would seem obvious that some regions are reacting to such growth but in others the backlash is more subtle.

We are seeing CEOs of major solar companies telling the world of the naivety of believing solar could ever surpass the knowledgeable and incumbent energy giants' ability to manage national grids. Or, heaven forbid, ever replace the need for nationally controlled energy sources.

We are seeing many regions changing or cutting financial support to renewable energy expansion with costs cited as the primary reason. While it is true that PV costs have dramatically reduced over time, the subsidy reviews often contain subtle changes that impact the industry. In the UK for example, the government has ensured PV must now compete with other renewable sources for state supports, conveniently reducing the overall pot at the same time.

Meanwhile China continues to grow in a manner that still seems to surprise traditional money markets. Analysts are predicting the country to hit 100GW in a couple of years and this year China expanded its GDP while reducing the amount of coal used, demonstrating its renewable commitment. In a global enery market these positive energy figures have a ripple effect that can impact on other regions.

Australia has been moving towards becoming a global leader in renewable capacity with over 2 million homes covered and some regions passing 50% in renewable generation. The new governement decided to review the country's much-lauded Renewable Energy Target (RET) policy from the previous government.

They decide to put a traditional energy man in charge of the review and suddenly China's impact became obvious in a country which is a huge resource exporter with China the biggest coal customer. To the surprise of many in the energy sector the review directed Australia to cut the RET and to increase the purchase of coal. The government is seriously considering this option.

Despite the idealistic beginnings of the industry that solar would provide free energy to the world the truth is that energy is big business nowadays. Solar has grown faster than expected and pushed renewable options to the forefront of the business sector which will look at ways to integrate the changes into their own battle plans.

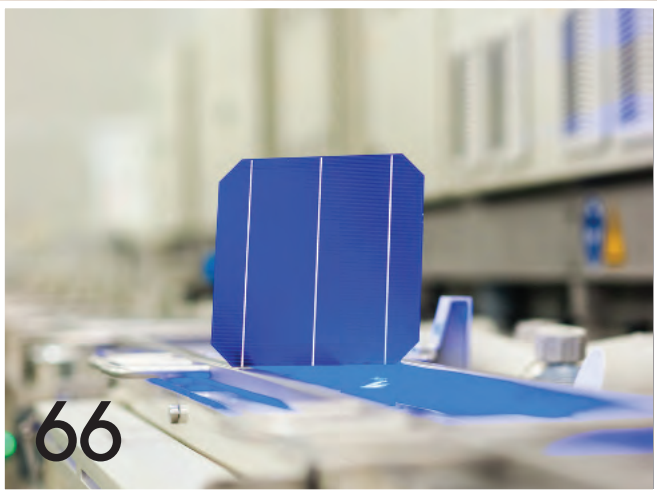
With the financial markets controlling more of the renewable sector, financial returns will be more important than social energy goals and ideals. If the foundation that companies and individuals began with is ever to continue then stake holders in renewable energy will need to be more involved in the broader energy discussion or face being lost in the bigger picture.

Issue IV 2014

what's inside

news


60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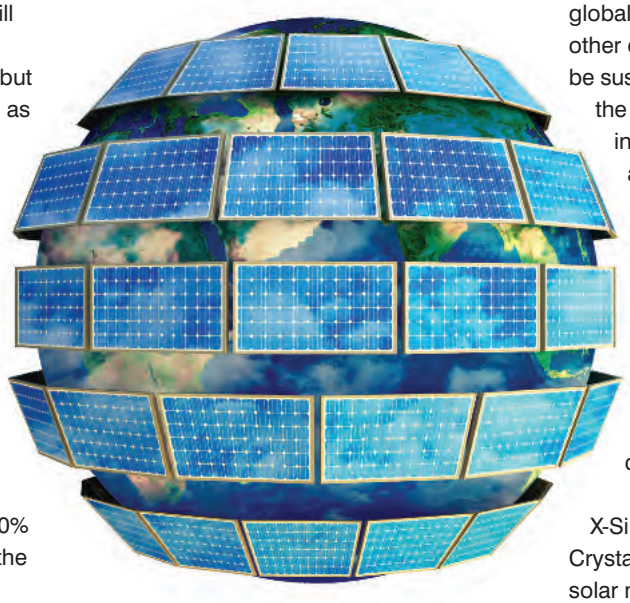
Lux Research tips 65.6GW globally by 2019

LED BY CHINA, the solar industry will grow at a CAGR of 8.3%, from 37.5 GWp in 2013 to 65.6 GWp in 2019, but emerging trade disputes it, as much as global policies, cast a shadow over short-term prospects, according to Lux Research.



China became the biggest solar market in the world with 11.8 GWp installations in 2013, and has been key to faster-than-expected global recovery. Since the competitive bankruptcy-ridden cost environment of 2012, module supplier margins have increased, with most Tier-1 suppliers topping 10% toward the end of 2013 and 15% in the first quarter of 2014.

"With solar now fairly common in most parts of the world, it reaps the rewards of direct incentives but also faces uncertainty due to pressure on trade activity with China," said Matthew Feinstein, Lux Research Senior Analyst and the lead author of the report titled, "Solar Market Size Update 2014: Reform for the Long Haul."

"Furthermore, as an increasingly commonplace electricity source, most major markets are dealing with some combination of these dynamics, complicating the status of policy globally," he added. Lux Research analysts evaluated the growth trajectory of the solar industry, besides weighing policy and other challenges.

Growth is fastest in the Americas. At a CAGR of 16.3%, the Americas will be the fastest-growing region in the world as its new installations market nearly triples from 5.3 GWp in 2013 to 15.4 GWp in 2019. The U.S. will pace the rest of the Americas, growing from 4.7 GWp to 11.7 GWp but South America will grow 10-fold to 2.5 GWp in 2019. The Asia-Pacific region will grow at a lower 8.2% CAGR but will account for over 50% of global demand, led by China, Japan and other emerging markets. Cost cuts will be sustained. With cost cuts critical to the sustained growth of the industry, incremental increases in efficiency are on course from technologies such as passivated emitter rear contact (PERC), heterojunction with intrinsic layer (HIT) and selective emitter (SE). System costs will drop by between $0.36/Wp for utility-scale and $0.60/Wp for residential by 2019. This will translate to a 20% cut in system costs.

X-Si remains technology of choice. Crystalline silicon (x-Si) will dominate the solar market through 2019 even though other module technologies such as copper iridium gallium diselenide (CIGS), copper zinc tinc sulfide (CZTS), cadmium telluride (CdTe) and thin, flexible, epitaxial silicon (epi-Si) have the potential to become major threats in the future. X-Si, with an 84.6% market share, will grow from 31.6 GWp in 2013 to 55.7 GWp in 2019, growing at a CAGR of 8.45%. CdTe and CIGS will be a distant second – growing to 4.8 GWp and 4.2 GWp, respectively, in 2019.

The report, titled "Solar Market Size Update 2014: Reform for the Long Haul," is part of the Lux Research Solar Intelligence service.

EIA says solar energy doubled in the US in 1H 2014

ACCORDING TO the U.S. Energy Information Administration (EIA)'s latest "Electric Power Monthly" report, with data for the first six months of 2014, renewable energy sources (i.e., biomass, geothermal, hydropower, solar, wind) provided 14.3% of net U.S. electrical generation. Conventional hydropower accounted for 7.0% while non-hydro renewables provided an even larger share of 7.3%.

Overall, electrical generation from non-hydro renewable energy sources (i.e., biomass, geothermal, solar, wind) expanded by 10.4% compared to the first half of 2013.

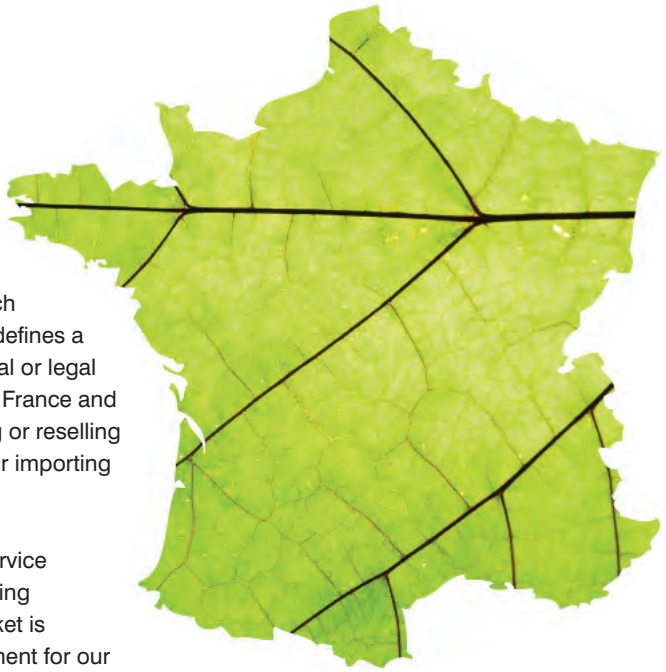
Solar-generated electricity more than doubled (growing by 115.7%) and wind power increased by 9.0% compared to last year. Biomass also grew by 4.0%. However, geothermal power dipped by 1.5% and conventional hydropower declined by 4.2%.

Even with the lower output from hydropower and geothermal, net U.S. electrical generation from all renewable sources combined grew by 2.73%.

By comparison, net electrical generation from all energy sources - renewables, fossil fuels and nuclear power - grew by 2.59%.

"Not long ago, EIA was forecasting that renewables would not reach 14% of U.S. electrical generation until the year 2040," noted Ken Bossong, Executive Director of the SUN DAY Campaign. "And even the current 14.3% figure undoubtedly understates the real contribution from renewables inasmuch as EIA's data does not fully reflect distributed and off-grid generation."

PV recycle becomes mandatory in France



THE FRENCH WEEE Decree 2014-928 in the Official Journal brings PV modules within the scope of greater producer responsibility. With effect August 23rd 2014, PV companies established in France must finance and ensure the waste treatment of the PV modules they sell and import.

Extending WEEE (Waste Electrical and Electronic Equipment Directive) to photovoltaic (PV) modules results in a legal obligation for France-based companies to organize the take-back and recycling of their discarded products returned to them by consumers and professionals.

"As far as the major PV module manufacturers are concerned, they anticipated the regulatory changes betimes, already integrating WEEE-compliance in their processes," said Jan Clyncke, President at PV CYCLE France and head of Europe's first PV-focused take-back and recycling scheme. "WEEE, however, not only concerns large manufacturing companies but the many small and medium-sized enterprises today active in France." Article R543-174 of the French Environmental Code defines a "Producer" as a natural or legal person established in France and manufacturing, selling or reselling under its own brand or importing PV modules.

"Offering a tailored service and good understanding of the French PV market is therefore a vital argument for our industry-managed waste treatment and compliance services", said Nicolas Defrenne, Country Manager in France. Founded by leading actors of the French PV market, PV CYCLE France manages the WEEE-compliance for Producers and Importers and represents the industry towards the WEEE authorities.

"As the French regulations do not provide for any transitional period, it is important to comply immediately," he stressed the impact of WEEE in France. Additionally, PV modules are considered to be household equipment under French WEEE law, for which end-of-life treatment and financing must be provided in a global approach. "Classifying PV modules as household equipment results in charging a visible fee on every newly sold equipment to set aside the mandatory funds for future waste management," explained Mr Defrenne further.

China power does JV deal for domestic growth

JINZHOU YANGGUANG ENERGY has entered into a processing contract with CPI Solar Power, a subsidiary of China Power Investment Corporation (CPI). The deal will see Jinzhou, a subsidiary of Solargiga, provide processing services to CPI in respect of 73 MW solar modules before the end of 2014.

The Processing Contract enables the Company to expand its business cooperation with CPI, one of the five state-owned power generation companies in China. CPI will become the Group's second largest client in terms of total sales volume after Sharp Corporation.

The Chinese government actively promotes the domestic photovoltaic application market demands. As one of the five state-owned power generation groups in China, CPI is strong on the development and construction of domestic new energy and plays an important role in the PV market in particular.

The Group has maintained stable partnership with CPI in the area of PV ingot and wafer businesses with stable increase shipment volume. The Processing Contract expands and deepens the cooperation scope between the Group and CPI and boosts the shipment volume of various products. Therefore, based on the 2014 total shipment volume of the Group covering the entire PV industry chain, CPI will become the Group's second largest client after Sharp.

It is noteworthy that upon the Processing Contract being entered into, CPI is starting to widely adopt new high-end monocrystalline silicon wafer products which is developed by the Group recently for producing monocrystalline silicon cells. Highly cost-competitive 280W modules can be produced by using new high-end monocrystalline silicon wafer products. Therefore, construction cost of PV system will be reduced and investment return rate of PV power generation will be improved.

Could solar be the key to greater European growth and success?

THE EU Commission is loking to expand Germany's energy transition (Energiewende) Europe-wide. A move that could help crisis-ridden Southern Europe. In those countries, this would involve the introduction of simplified approval processes, work skills training as well as lower grid connection costs, while the core European countries such as Germany would have to contribute with targeted investments in the order of 1 to 3 billion euros annually. Countries such as Greece could then expect an additional economic growth of about 0.5 to 1.0 percent. These are the results of a new study led by researchers from the Mercator Research Institute on Global Commons and Climate Change (MCC) and other renowned research institutes and published in the journal Renewable and Sustainable Energy Reviews.

Based on meteorological data and the evaluation of scenarios for a cost-efficient energy transition in Europe, the researchers come to the conclusion that countries such as Greece, Portugal, Italy and Spain could move from being electricity importers to exporters in particular through the expansion of photovoltaics. However, realizing this potential would require the legislative harmonization of energy policies through the EU in close coordination with its Member States. More specifically, the scientists are proposing that the feed-in tariff for renewables be uniform, or as uniform as possible, across Europe.

"The energy transition should be understood as a joint European project that provides prospects especially for disadvantaged countries," says Felix Creutzig, head of the study and of the MCC working group Land Use, Infrastructures and Transport. "Germany's Energiewende alone cannot do the job. Instead, Germany needs partners in Southern Europe." This is true also in light of the fact that the impact of wind and clouds on the energy yield of renewables is better compensated across a larger geographical area.

However, Europe's Mediterranean countries are only able to take on the bureaucratic and financial hurdles facing a large-scale implementation of photovoltaic systems with aid from the North. A possible source of funding in this endeavor could be the revenues generated by a reformed European emissions trading system. This type of EU investment in which Germany and other countries finance the renewables infrastructure of Southern Europe could also offset the collapse of private investment in those countries with no additional burden to their budgets.

The researchers estimate that the union of the European Economic Area provided economic benefits primarily to Europe's core countries, being Germany and the Benelux countries, and that it weakened the productive base of its Mediterranean member states.

Dupont chase SunEdison over tellurium patents

DUPONT has filed a patent infringement lawsuit against SunEdison and its affiliate NVT LLC in the U.S. District Court for the District of Delaware.

In its complaint, DuPont (DFT) alleges that by sourcing and using photovoltaic cells and solar modules containing Samsung SDI Co., Ltd. (into which the former Cheil Industries Inc. merged) front side metallization paste, SunEdison infringes DuPont's patented tellurium paste technology.

The complaint also identifies Neo Solar Power of Taiwan as the cell manufacturer and Flextronics as SunEdison's contract manufacturer.

"DuPont will enforce its patent rights to protect our substantial investment in innovation to improve solar energy efficiency," said Peter Brenner, global photovoltaic business marketing manager, Microcircuit Materials, DuPont Electronics & Communications.

"Installers and module makers like SunEdison are responsible for ensuring that their products do not use infringing cells or pastes. Our patented tellurium technology is available only from DuPont; no other photovoltaic paste manufacturer has a license to use our patented technology."

As a supplier of materials to the photovoltaic industry, DuPont hasdeveloped innovations such as Solamet photovoltaic metallization paste products.

DuPont has been able to deliver innovations to the solar industry as a result of investing heavily in research and development and the company intends to protect its investment when required or necessary.

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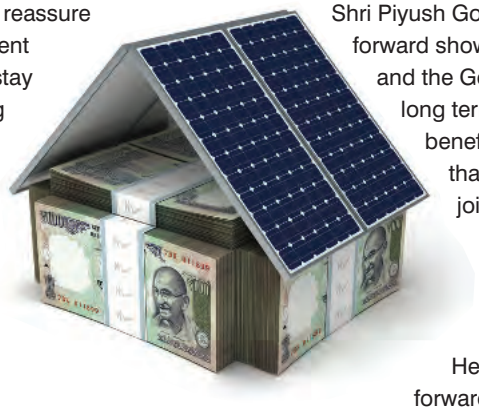
Indian government confirms solar commitment

THE GOVERNMENT OF INDIA has moved to reassure the solar and PV industries that the Government policies supporting solar growth are here to stay and investors can plan accordingly. Speaking at a meeting of interested parties and stakeholders Shri Piyush Goyal Minister of State (I/C) of Power, Coal & New & Renewable Energy said that Government is open to provide all support which is required to develop a robust ecosystem which is efficient & sustainable to provide a fillip to the renewable energy sector .



Pointing out that the Government is committed to strengthen the domestic manufacturing in solar sector, Shri Piyush Goyal urged all stakeholders to to align with the Prime Minister's vision of providing electricity to all households .

Shri Goyal said that while large projects are being planned for feeding power into the grid , it is also proposed to set up small solar based systems to provide energy in decentralized manner to remote areas. He said Government realizes that the domestic manufacturers need support in order to sustain. NTPC is therefore coming up with a tender for setting up of 1000 MW of solar power projects in EPC mode by using cells and modules made in India. He said that the large PSUs would provide the necessary financial strength and confidence for the developers by procuring power and then selling to the DISCOMS. He also talked about companies generating conventional power coming in a big way in solar development and generating at least the percentage of their energy through renewables.

Shri Piyush Goyal said that more states are coming forward showing interest in setting up Green Corridor and the Government has suggested taking land on long term lease so that the land owner will also benefit on sustainable basis. He also disclosed that Ministries of Agriculture and MNRE are jointly framing a comprehensive Scheme proposing therein solar water pumps coupled with drip irrigation and water reservoir.

He said that several States have come forward to identify land for setting up of large solar capacities and Government of India is working on a new scheme to set up solar parks and ultra mega solar power projects as announced by the Hon'ble Finance Minister in the budget speech. He said that solar pumping along with drip irrigation and water harvesting would be taken up in a big way in the country.

Rooftop solar is a priority of the Government and correctly policies would be put in place for supporting this sector. He said that Government is very much concerned about the large number of households who do not have access to modern sources of energy and, therefore, adequate attention would be paid to providing power to the left out households by deploying renewables in a big way.

Renewable power is the future of the country and would be supported fully so that India can add capacities in this sector at par with the leading countries in the world and become a leader.

SolarWorld recalls over 1.5 million units in US and Canada

SOLAR WORLD has announced it is recalling solar systems with copper grounding due to electrocution and fire hazard. The company urges customers to stop using the product immediately and get in touch with the company. Installers and distributors have been reminded it is illegal to sell or resell a recalled consumer product..

The product us SolarWorld Solar Systems which is installed with bare-copper grounding lugs that can corrode which could result in a faulty ground circuit, posing an electric shock, electrocution or fire hazard.

The recall effects about 1.3 million units in the U.S. and 210,000 in Canada. The company has given no indication of the cost of the recall but the situation is likely to further reduce their yearly accounts. They had already revised estimations downward.

This recall includes SolarWorld solar systems installed with bare-copper grounding lugs installed after June 1, 2010. These solar systems use energy from the sun to generate electricity within a system circuit. The installation instructions for SolarWorld solar systems sold after June 1, 2010 called for the use of GBL-4DB lugs for grounding. SolarWorld has revised these installation instructions to explicitly call for tin-coated lugs, specifically Ilsco part number GBL-4DBT. "T" is for tin-coated and indicated by the silver color of the lug.

The firm has received one report of corrosion related to the bare copper lugs. No injuries have been reported.

Customers may be able to identify from the ground whether a tin-coated lug (silver) or a bare-copper lug (brown) has been used on their solar panels. Consumers who can identify the improper lugs should contact SolarWorld for replacement. If customers cannot determine which grounding lugs were used, they should contact SolarWorld to have an authorized SolarWorld agent inspect the installation and replace the lugs with tin-coated grounding lugs or equally safe alternative remedy at no cost to consumers. SolarWorld is requesting that distributors and others remove SolarWorld's installation instructions dated before June 2014 from their websites or other commercial information sources.

IEA suggests renewables need policy certainty

THE EXPANSION OF RENEWABLE ENERGY will slow over the next five years unless policy uncertainty is diminished, the International Energy Agency (IEA) said in its third annual Medium-Term Renewable Energy Market Report.

According to the report, power generation from renewable sources such as wind, solar and hydro grew strongly in 2013, reaching almost 22% of global generation, and was on par with electricity from gas, whose generation remained relatively stable. Global renewable generation is seen rising by 45% and making up nearly 26% of global electricity generation by 2020. Yet annual growth in new renewable power is seen slowing and stabilising after 2014, putting renewables at risk of falling short of the absolute generation levels needed to meet global climate change objectives.

Non-OECD markets, spurred by diversification needs in many countries and increasing air quality concerns in China, in particular, comprise almost 70% of the growth. Renewables are seen as the largest new source of non-OECD generation through 2020. Yet they meet only 35% of fast-growing electricity needs there, illustrating the still-large role of fossil fuels and the potential for further renewable growth. Renewables account for 80% of new power generation in the OECD, but with more limited upside due to sluggish demand and growing policy risks in key markets.

“Renewables are a necessary part of energy security. However, just when they are becoming a cost-competitive option in an increasing number of cases, policy and regulatory uncertainty is rising in some key markets. This stems from concerns about the costs of deploying renewables,” said IEA Executive Director Maria van der Hoeven.

“Governments must distinguish clearly between the past, present and future, as costs are falling,” she added. “Many renewables no longer need high incentive levels. This calls for a serious reflection on market design needed to achieve a more sustainable world energy mix.”

The report noted that policy and market risks threaten to slow deployment momentum. For example, in many non-OECD markets including China, constraints include non-economic barriers, an absence of needed grid integration measures, and the cost and availability of financing. In the European Union (EU), uncertainties remain over the precise nature of the post-2020 renewable policy framework and the build-out of a pan-European grid to facilitate the integration of variable renewables.

For the first time, the annual report provides a renewable power investment outlook. Through 2020, investment in new renewable power capacity is seen averaging over USD 230 billion annually. That is lower than the around USD 250 billion invested in 2013.

The decline is due to expectations that both unit investment costs for some technologies will fall and that global capacity growth will slow. With decreasing costs, competitive opportunities are expanding for some renewables under some country-specific conditions and policy frameworks. For example, in Brazil, with good resources and financing conditions, onshore wind has outbid new-build natural gas plants in auctions. In northern Chile, high wholesale electricity prices and high irradiation levels have opened a new unsubsidised solar market.

The roles of biofuels for transport and renewable heat are also increasing, though at slower rates than renewable electricity. Uncertainty over policy support for biofuels is rising in the EU and the United States, slowing expectations for production growth and threatening the development of the advanced biofuels industry at a time when the first commercial plants are just coming online.

The annual report highlights the potential energy security implications of energy use for heat, which accounts for more than half of world final energy consumption and is dominated by fossil fuels. But the contribution of renewables to meet heating and cooling needs remains underdeveloped, with more limited policy frameworks compared with the electricity and transport sectors. Although modern renewable energy sources are expected to grow by almost 25% to 2020, their share in energy use for heat rises to only 9%, up from 8% in 2013.

Environmental goods talks kick off in Geneva

OFFICIALS FROM 14 governments meeting in Geneva today announced the launch of international negotiations that will aim to eliminate tariffs on "environmental goods".

Products like wind turbines, solar water heaters, filters for wastewater treatment, and photovoltaic panels.

The governments involved in the talks represent Australia, Canada, China, Costa Rica, the EU, Hong Kong, Japan, Korea, New Zealand, Norway, Singapore, Switzerland, Taiwan, and the US.

In a joint statement, the governments noted that "urgent action" is needed to address challenges such as environmental protection and climate change.

"We will now engage in intensive negotiations, meeting regularly in Geneva, to discuss the substance of the agreement, including product coverage," the joint statement said. "We are committed to work towards the timely and successful conclusion of the agreement."

The statement added that an environmental goods deal could be extended to all members of the WTO if a "critical mass" of the organization's members agrees to participate.

The first stage of the talks, which officials say they aim to conclude by the end of 2015, will focus on eliminating tariffs on environmental goods.

To that end, the negotiations will build on a list of 54 environmental goods that was agreed by the Asia-Pacific Economic Cooperation (APEC) forum in 2012.

Subsequent negotiating rounds may tackle more complicated topics like environmental services, non-tariff barriers, and government procurement.

"By eliminating tariffs on the technologies we all need to protect our environment, we can make environmental goods cheaper and more accessible for everyone, making essential progress toward our environmental protection and trade policy goals," said Peter Froman, the US Trade Representative.

Peter C. Brun, Managing Director of the SETI Alliance, also welcomed the announcement., "A breakthrough in trade negotiations on environmental goods would be an important signal to the world to remove unnecessary barriers to trade in technologies that are meant to deliver affordable climate change solutions."

Scatec strikes Norweigan deal to finance expansion

SCATEC SOLAR has signed a partnership agreement with Norfund, the Norwegian Investment Fund for Developing Countries, to jointly invest in solar power projects to be developed in all countries within Norfund's mandate.

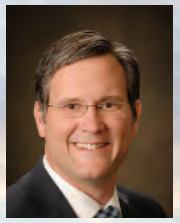
Scatec Solar and Norfund have been partners in the realization of four solar PV projects in Africa totaling 200 MW (three in South Africa and one in Rwanda) and the agreement signed is a formal confirmation of an existing, fruitful partnership. The partnership will provide a framework for project development and joint investment and under the agreement Norfund and Scatec Solar will jointly realize projects in all countries within Norfund's mandate.

"We enter the partnership with Norfund with great expectations," Raymond Carlsen, CEO of Scatec Solar, said. "Our common objective is to contribute to the increased implementation of renewable energy in Sub-Saharan Africa, and the project- to-project cooperation we have had so far has proved very successful. Long term financing is the key enabler to any solar project and will reduce the risk in all phases of the project execution. When Norfund invests in our projects, their backing from the Norwegian Government combined with the company's excellent standing in the market will attract other investors as well. With the combined efforts of our two companies, we expect to realize more projects and a faster execution of each."

Norfund has extensive experience from successful investments in developing countries and will provide long term capital, an extensive network in the Sub-Sahara regions as well as experience and competence from investing in this region, while Scatec Solar with its proven track record in the execution and management of solar PV projects, will provide world class solar PV competence, project development and executions skills.
" We are very pleased with the cooperation we have had with Scatec Solar in the realization of four solar power plants, and this new agreement provides a solid foundation for more such projects in the future," Kjell Roland, CEO of Norfund said. "Norfund needs strong industrial partners like Scatec Solar in order to contribute to a sustainable development in poor countries. Our objective is to increase our investments and this type of long-term cooperation is a prerequisite for us to do so in a good and effective way."

Scatec Solar will hold 70 % of the joint investment company and Norfund the remaining 30 %. Investments will be made on a consensus basis in projects the partners develop together and which meets the required return on capital employed.

The wireless advantage



Solar technology cannot afford to stand still as the industry moves closer to a subsidy free and competitive global market. PV installations are financial assets and monitoring installations are expected to do more than fault detection. Craig Goodwin, Senior Product Marketing Manager at Synapse Wireless discusses how innovations in monitoring are meeting the need for insight and efficiency.

EVEN AS TOTAL SOLAR GENERATION moves toward a projected 75GW in North America alone by 2015, market realities are forcing operators to redouble their efforts to create new efficiencies in their technology and processes. As subsidies decline, renewables portfolio standards-driven demand weakens in areas, and customers negotiate lower power purchasing agreements, the solar industry is looking for opportunities to reduce operations and maintenance (O&M) costs and, where possible, extend the life of plant assets.

For most operators, smarter O&M starts with continuous system monitoring, with real-time data driving critical decision-making and analytics. While new plants are monitored from day one, there has also been an increase in retrofits of older plants, both to comply with new regulations or to get one or more data streams flowing to developers, operators, and investors.

Traditionally, operators relied on wired monitoring systems installed during construction. These systems require infrastructure (cabling and power) and, like all other assets, create their own O&M challenges. As plants get both larger and more distributed, the cost of this monitoring becomes a larger and larger cost centre.

The wireless advantage

As a pioneer in M2M connectivity, Synapse Wireless was able to approach PV monitoring differently from the start, building a wireless monitoring solution based on our SNAP technology. The lessons we learned in solve solar operator challenges would also inform the meaningful M2M innovation we were also bringing to global leaders in manufacturing, lighting, healthcare, and other verticals.

The autonomous mesh network design of the SNAP OS, combined with the long range and low power requirements of the SNAP modules, made it an ideal choice for a PV monitoring solution. Working with Shoals Technologies, Synapse began to build a portfolio of specialized SNAP solutions targeted directly at the needs of PV operators, owners, and EPC partners.

Synapse leveraged expertise gained through experience in diversified market verticals to develop solutions that optimize operations costs and performance by providing real-time performance information to the owner, EPC, or O&M manager. Synapse products are uniquely suited to provide life cycle management capabilities for managing solar assets from construction to cash flow, delivering key benefits during install and going forward.

Smarter, faster commissioning

The renewed focus on efficiency makes it increasingly important to optimize all aspects of the solar plant lifecycle. Real-time granular data provided to the developer and EPC drives faster time to resolution of critical issues discovered during site commissioning. Solving problems quickly reduces operational and contingency costs, and real-time data acquisition improves project oversight and ensures efficient use of construction and commissioning hours to maximize the velocity to revenue.

Simpler, more reliable support

Once sites have been commissioned, Synapse solutions provide O&M and asset management teams with the information needed to make intelligent decisions that optimize allocation of repair and maintenance hours, ensuring peak production of the solar asset. Intelligent management of the velocity of installation and operational efficiency helps create sustainable margins as the market matures and energy pricing competition increases.

Longer distances, lower costs

Wireless monitoring also helps reduce the cost of managing the commission of large plants as well as the trend towards smaller distributed sites located strategically closer to customers or to lessen environmental impact, making a powerful stream of 24/7 data easier to build and cheaper to maintain.

Lower costs and disruptions

The cabling and trenching required to install traditional wired monitoring is no small expense. Eliminating the time and labor required to get this monitoring up before and during commissioning, simplifies processes, and lets you focus closely on the task at hand: careful, precise, efficient commissioning and operations.

SNAPshot partnership

Synapse's solar solutions include SNAPshot, a velocity monitoring tool that can be used during commissioning to provide early warning on faults and errors. Developed in partnership with Shoals Technologies, SNAPshot is installed with Shoals Smart Combiner and Recombiner boxes.

The choice of Shoals Technologies as a strategic partner was important for both Synapse and Shoals Technologies, giving operators and EPC instant access to critical real-time data and the advantages it brings.

"Snapshot's Velocity Monitoring tool is connected from the initial order of solar field installation. SNAPshot enables the Shoals optimized field layout to upload information to a software package so that, from the first day of construction until the solar field is complete, we have the ability to monitor the velocity of the installation. From there SNAPshot becomes an OEM tool." Dean Solon, CEO of Shoals Technologies.

Synapse Wireless is an exclusive technology partner with Shoals Technologies balance of systems (BOS) solutions, working with leading solar developers and EPC organizations to understand their business and technical challenges and creating solutions that match. The SNAPshot solution represents an important step forward for both companies and the industry, making the Internet of Things a very real advantage for solar stakeholders.

SNAP-built solar innovation

Built on the SNAP operating system, the SNAPshot monitoring system is designed for scalability and range, bringing M2M communication and real-time data from the string level up. The bus-powered solution provides data from the time PV is turned on through final installation and configuration.

The system delivers up to 1200V capability and up toto 30 amps per string. Powered directly from the DC busbar it also supports external plug-ins for additional features. SNAPshot is FCC certified on all 16 channels with maximum ranges exceeding 3 miles. The system has instant-on capacity, self-detecting and self healing capability.

SNAPshot is also recognized for its best-in-class accuracy, delivering information that is 98% accurate in real-time. This information allows customers to generate faster, more informed decisions and take more responsive action in real-time.

The Synapse SNAPshot Arc Fault solution provides early detection and interruption of arcing faults, reducing the damage to plant assets and power generating capacity while ensuring compliance with regulations like NEC 690.11.

Installation opportunities

In addition to the benefits of cable and trench-free installation, both SNAP OS and SNAPshot are built to integrate with existing infrastructure, across a wide range of communication protocols, and plugs easily into existing SCADA solutions.

In addition to the monitoring solution, the Synapse SNAPshot installation tool provides an immediate link to the SNAPshot system for installers in the field. Like the rest of the SNAPshot solution, information can be shared onsite or around the world when paired with Internet or cloud gateway. The system only requires 30MB of HD space and 25MB of RAM and can tracks assets by ID number, cross-checking with a MAC address.

Real-time insight and intelligence

SNAPshot insight and efficiency has distinct advantages for all PV stakeholders. Synapse and Shoals worked to ensure that the tool was reliable and easy to use, producing relevant data in real-time. “Using the SNAPshot system we are able to analyze and predict, real time, string-by-string fields as they go live. The system provides the ability to watch the performance of the strings before they’ve been commissioned and then monitor the speed at which the contractors are getting work done. Each contractor, crew, and person can be monitored for their performance as they install the field.

So, while SNAPshot is an EPC tool, it is primarily a field owner’s tool that will provide independent data that can be used to track the progress of field installation. This benefit keeps everyone honest through the construction phase. Ultimately, SNAPshot adds value through operational efficiency which benefits everyone because efficiency drives ROI,” said Dean Solon, CEO Shoals Technologies.

Cloud-powered velocity monitoring

Synapse and Shoals have recently taken wireless monitoring to its next and logical conclusion, offering a cloud-based monitoring solution built on the SNAPshot platform. In addition to monitoring output from the string level up, the cloud platform makes accessing this critical information easier and provides easy backup and recovery, robust analytics, lifetime traceability, and integrated work order management. The tool’s intuitive GUI is optimized for easy usability across multiple devices, including smart phones. This means that no matter where you are or what device you’re using, you get fast access to the information and answers you need about plant efficiency and output.

Success stories

Based on its proven success helping reduce commissioning and O&M costs, SNAPshot continues to find customers and advocates across the industry, anxious for proven methods for reducing the time to commission while improving long-term O&M. As of August 2014, the product has provided over 1.5 gigawatts of energy monitoring for customers worldwide, with more installs planned throughout the year.

“With access to cost-effective string-level information, this technology has major implications for improving efficiency and ultimately, return on investment. We’re looking forward to working with Shoals and Synapse to push the boundaries of solar innovation,” remarked Nick de Vries, VP Plan Operations and Engineering, Phoenix Solar

Ready today, ready for tomorrow

As the solar market matures, protecting revenue and market share will become critical to the success of operators and developers, and it starts with faster, more efficient commissioning and more effective, data-driven O&M decisions.

Synapse SNAPshot provides a future-ready platform for simple, robust management, maintenance, and analytics that transform the Internet of Things from big idea to even bigger business advantage.

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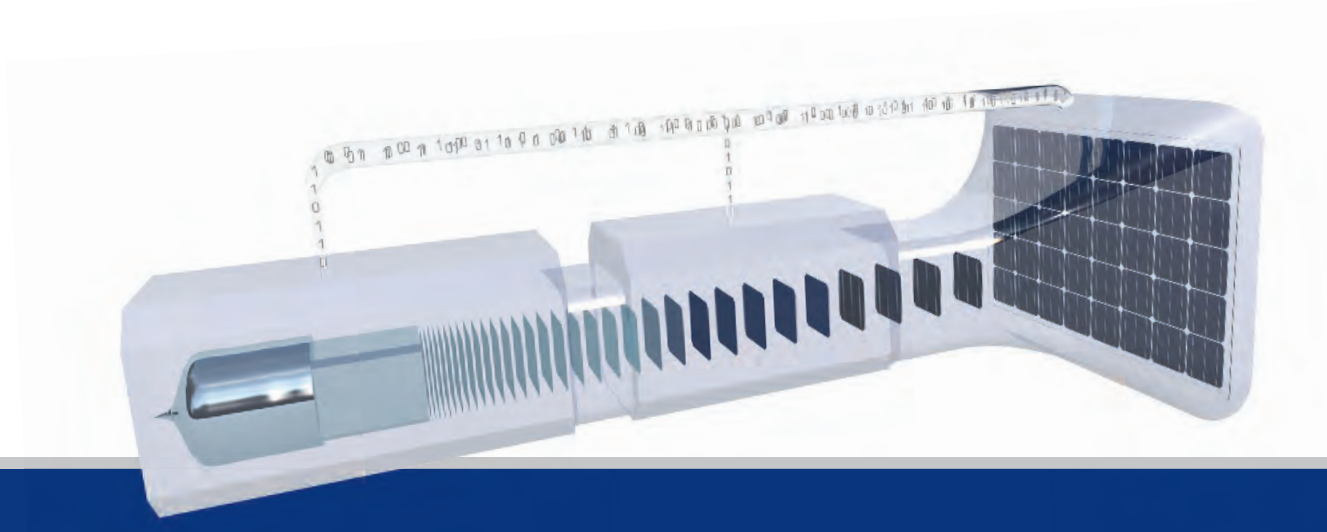
Processes and systems from the Meyer Burger Group play a vital role in increasing overall performance and efficiency throughout the photovoltaic value chain. We enhance the crucial key factors for all manufacturing processes - for optimum yield, lowest possible costs and maximum availability.



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A hybrid approach to inverters

Inverters are now recognised as a key technology for solar and PV and are a focus for companies seeking continual improvements. Dr. Georges Tchouangue, Chief Engineer for Power Semiconductors at Toshiba Electronics Europe discusses a SiC hybrid approach to inverter technology.

SILICON CARBIDE (SiC) devices have the potential to unlock performance and efficiency improvements in applications ranging from rail traction to renewable energy generation. Now, the introduction of hybrid technologies that combine these performance and efficiency advantages with the high-power handling capabilities of silicon injection-enhanced gate transistors (IEGTs) is providing engineers with an effective way of significantly reducing losses while minimizing equipment size.

Improving the efficiency of motor drives, even by only a small percentage, can save a significant quantity of energy normally wasted as heat. This can translate into positive benefits for business operating costs, equipment design and performance, and carbon footprint. High-power semiconductors have made tremendous advances in recent years, as new device architectures, fabrication processes and technologies have helped to improve both switching and conduction efficiency.

In order to meet wider system requirements such as reliability and overall cost, designers of high-power controllers such as choppers and inverters are typically faced with a choice of a thyristor or Insulated Gate Bipolar Transistor (IGBT) as the

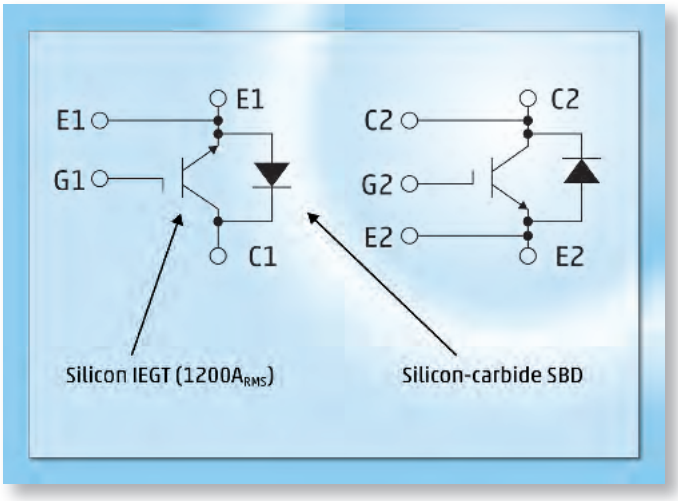

Figure 1. Latest hybrid silicon-IEGT/SiC-SBD half-bridge module.

main switching element. Both device types have strengths and weaknesses, which force designers to make a selection that will deliver the best compromise in relation to a given application.

Power switch performance

Generally, thyristors have a low forward voltage, resulting in low conduction losses, but can require more complicated commutation circuitry to turn the device off. The Gate Turn Off (GTO) thyristor overcomes this reliance on commutation circuitry, although switching efficiency remains lower than that of an IGBT.

The IGBT combines the advantage of a voltage-controlled Metal-Oxide Semiconductor (MOS) gate, which allows relatively simple gate-drive circuitry, with the low saturation voltage of a bipolar transistor. Its ability to support high switching frequencies allows the use of smaller capacitive and inductive components. The IGBT also has a large Safe Operating Area (SOA), which helps enhance safety and reliability. The one drawback of the IGBT is its relatively high saturation voltage, compared to the thyristor's low forward voltage, resulting in higher conduction losses which can impair overall energy efficiency.

Injection enhancement gate transistors

In recent years we have seen the development of the Injection Enhancement Gate Transistor (IEGT). These combine the ease of use, support for high switching speeds, and large SOA of the IGBT with high conduction efficiency normally associated with a thyristor–based design.

The IEGT is a high-power trench MOS gate device that behaves in the same way as an IGBT, yet has a low saturation voltage comparable to the forward voltage of a thyristor. The thyristor's low forward voltage is the product of high carrier concentration resulting from the injection of electrons at both the anode and the cathode. In contrast, the conduction performance of a conventional IGBT is governed by the movement of holes from the collector to the emitter resulting in a relatively low carrier concentration at the emitter side.

The IEGT process, combined with an optimised gate structure and distance between electrodes, overcomes this limitation of the IGBT by creating a high carrier concentration similar to that of a thyristor, allowing the saturation voltage to be much lower than a conventional IGBT and comparable to the forward voltage of the thyristor. The blocking voltage is also higher than that of an IGBT, and similar to that of a thyristor.

Diode reverse recovery

In power-conversion applications where anti-parallel diodes are connected to conduct freewheel currents, the reverse-recovery characteristic of the diode has an important effect on the operating efficiency of the circuit. When conducting freewheeling current, the diode stores charge as minority carriers that contribute to minimising the diode forward voltage. When the diode is commutated, this stored charge must be neutralised by recombination and reverse-current flow before the diode can behave as if turned off. This process of reverse recovery contributes a proportion of system energy losses.

To minimise these losses, equipment designers have typically used ultrafast or hyperfast silicon Fast-Recovery Diodes (FRDs)

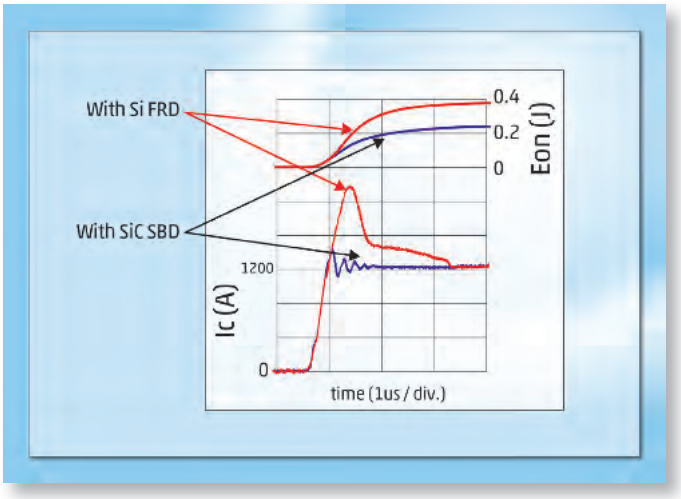

Figure 2a. Module turn-on energy and reverse-recovery current with FRD and SiC SBD.

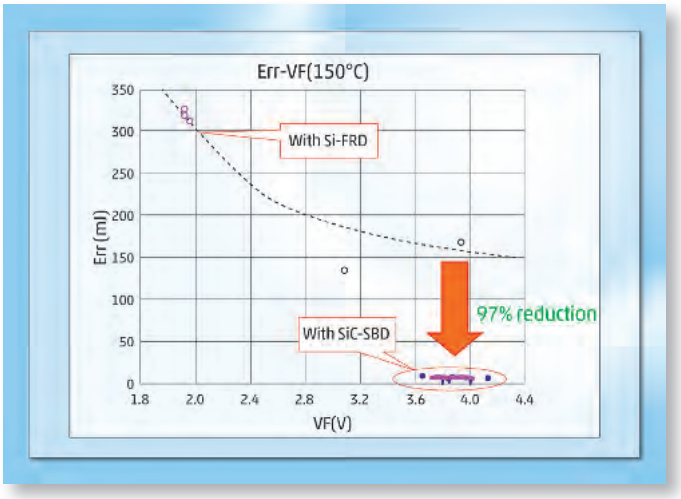

Figure 2b. Comparison of module reverse-recovery losses with silicon and silicon-carbide diodes.

that have the shortest possible recovery time. In many cases these FRDs are integrated within the power module.

Next-Generation IEGT/SiC power module

To further enhance the efficiency of high-power IEGT modules, Toshiba has introduced its latest-generation IEGT modules with integrated Silicon carbide (SiC) Schottky Barrier Diodes (SBDs). Figure 1 shows the connections and internal circuit of the module. As a wide bandgap semiconductor technology, SiC allows greater efficiency and reliability than conventional silicon devices such as fast-recovery diodes. So far, a relatively small number of manufacturers, including Toshiba, have successfully brought SiC products to market. SiC SBDs are effective replacements for silicon diodes for power conversion and switching across a wide range of power ratings and commercial applications. They can offer up to 50% greater efficiency than conventional silicon diodes, and also offer improved stability up to high voltages and currents owing to reduced heat generation.

Solar thermal management

Offering a valuable increase in efficiency as well as thermal management, SiC technology is desirable in applications such as solar inverters. High-power string inverters are currently the most attractive target for SiC diodes and transistors, while cost-sensitive microinverters are expected to combine silicon transistors with SiC diodes.

Toshiba's latest hybrid module combines 1700V/1200A silicon IEGTs in a half-bridge connection, with anti-parallel SiC SBDs, in the 130mm x 140mm x 38mm module size. The IEGT has been shown to have saturation voltage of less than 3.0V when conducting 1200A at an applied voltage of 850V. It can turn off a high current quickly and has low switching losses, since the turn-off energy (Eoff) can be as much as 30% less than that of a conventional device. In addition, the module provides guaranteed operation up to 150°C. The co-packaged SiC SBD has forward current rating of 600A with low forward voltage of 2.8V, and is highly suited to traction inverter applications. The leakage current of the SiC SBD is less than 10μA.

With its improved reverse-recovery characteristic the SiC SBD effectively reduces both turn-on loss and reverse-recovery loss. In fact, the reverse recovery loss is less than one tenth of the loss when using a conventional silicon diode. Figures 2a and 2b illustrate the influence of the SiC diode in reducing module reverse-recovery losses and turn-on losses. The lower waveforms shown in figure 2a illustrate the significant reduction of reverse-recovery current leading to the 97% saving in reverse-recovery energy losses illustrated in figure 2b. The upper waveform of figure 2a shows how using a SiC SBD also yields a valuable saving in turn-on energy.

With its improved reverse-recovery characteristic the SiC SBD effectively reduces both turn-on loss and reverse-recovery loss. In fact, the reverse recovery loss is less than one tenth of the loss when using a conventional silicon diode

The plastic module package is designed to provide high reliability and low thermal resistance. Internally the module features an aluminium silicon-carbide (Al-SiC) Metal Matrix Composite (MMC) baseplate material, which has extremely low thermal resistance and a low Coefficient of Thermal Expansion (CTE) allowing the internal structure to be optimised for excellent lifetime characteristics with low thermal fatigue and the ability to withstand a high number of thermal cycles. The construction of the module features materials displaying high Comparative Tracking Index (CTI), and allows a high insulation-withstand voltage.

Module performance analysis

Figure 3 compares the loss performance of a half-bridge inverter using the latest 1700V/1200A hybrid IEGT/SiC-SBD module and a previous-generation device featuring conventional silicon Fast-Recovery Diodes (FRDs). The diagram shows that the total hybrid module energy loss is as much as 30% lower than the losses of the earlier module.

The significant improvement in efficiency delivers further advantages by allowing the size of any cooling systems and other motor-control components to be reduced. Overall, this can allow the size of the inverter to be reduced by as much as 40%.

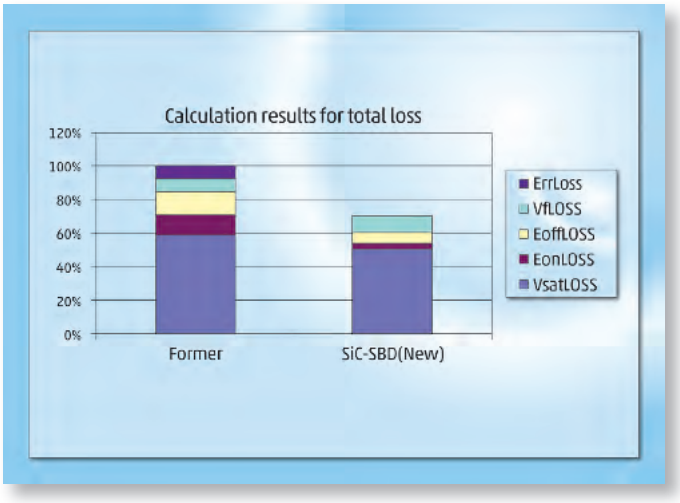

Figure 3. The hybrid IEGT/SiC-SBD module has lower energy losses compared to the previous generation.

Uniform thermal control

Continual improvement is the usual mantra for technology manufacturing and PV is no different. Dr. Hans Bell , Milo Gaggioli and Manuel Schwarzenbolz of Rehm Thermal Systems, along with Dr. Kay Reuter, Mathias Ribke, Dr. Norbert Müller, Christian Arndt and Dr. Armin Froitzheim of Bosch Solar Energy come together to reveal recent results for machine capability of firing systems.

FIRING IS A PRODUCTION PROCESS during which the contacts of a crystalline solar cell are conclusively formed. It's a thermal process that takes place in a tunnel oven, in which the solar wafers are exposed to a defined temperature profile. The tolerance width and the reproducibility of this thermal process are essential criteria for assuring uniform quality of the manufactured solar cells. The temperature profile (see figure 1) is subdivided into several zones.

The solar wafers, which are printed with a thick-layer paste, are heated up to a temperature of approximately 500 to 600° C in the burnout zone. The goal of this process step is to drive out the nonvolatile organic constituents which remain in the paste after the upstream drying process. The solar pastes are sintered in the firing zone (approx. 900° C), where the electrical contact is generated. The firing process is especially decisive for the quality of the solar cells. The purpose of the cooling zone is to cool the solar cells down to room temperature.

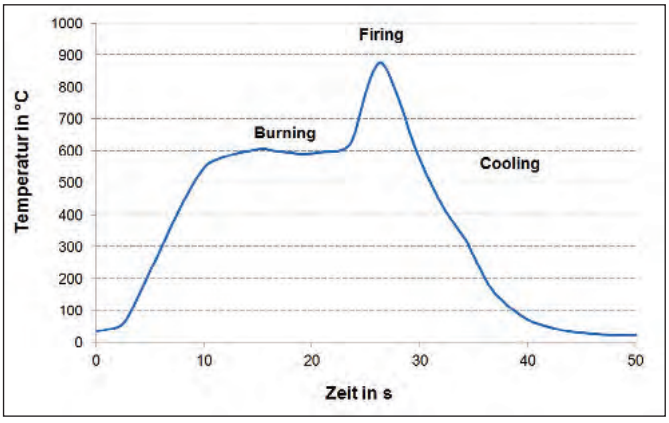

Figure 1: Temperature profile of a firing oven

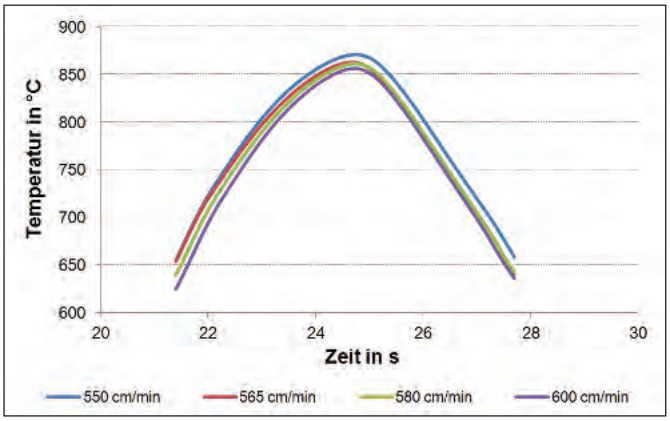

Figure 2: Influence of conveyor speed in the peak zone

A complex relationship exists between the utilized solar pastes, the temperature gradients, the absolute temperatures, the wafer material and, in particular, the quality of the solar cell coating system. A great deal of experience and process knowledge is necessary in order to define the temperature profile that results in the greatest degree of efficiency for the manufactured solar cells. Measurement of temperature profiles presents a number of challenges in this respect. Amongst other factors, this has to do with the relatively high temperatures in the firing zone, as well as the very steep temperature gradients that occur from segment to segment within the temperature profile.

A further problem results from the relatively minimal thermal mass of a solar cell as compared with the measuring equipment. Even a slightly altered thermal mass at the measuring point (caused for example by unsuitable mounting of a thermocouple) can influence the measured temperature. Limit deviation,

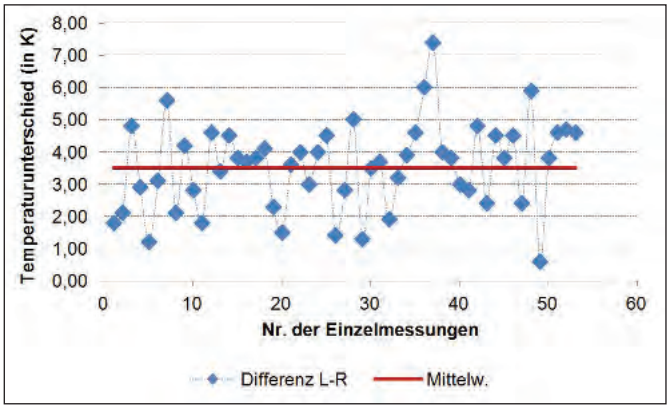

Figure 3: Calculation of temperature difference on the solar cell

calibration and the ageing characteristics of the thermocouples, as well as test setup and execution, must also be taken into consideration.

On the one hand, this article discusses the measurement of temperature profiles, and it specifically addresses the question of which acquired temperature data are stable enough for the calculation of machine capability coefficients. In addition to theoretical observations, results are also presented which have been obtained during close collaboration between Bosch Solar Energy AG and Rehm Thermal Systems GmbH.

Machine capability

Process capability is defined by DIN ISO 21747:2006 [1] as a statistical estimate of the consequence of a characteristic of a process which is verifiably kept under control, wherein the estimated value describes the capability of the process to affect the characteristic such that it fulfills its respective requirement. Sauer [2] goes into the subject of the quality capability of processes in great detail. Process capability and machine capability describe the potential capability of a process (a machine) to produce a certain characteristic in a constant fashion within specified tolerance limits. Capable machines are

Process capability, machine capability

$$C_p ; C_m = \frac{T_o - T_u}{6\sigma}$$

Critical process capability, machine capability

$$C_{pk} ; C_{mk} = Min\left\{\frac{\overline{T} - T_u}{3\sigma} ; \frac{T_o - \overline{T}}{3\sigma}\right\}$$

a prerequisite for capable processes. Machine capability only takes the capability of the machine into consideration [2]. The capability of a process/machine can be numerically described through the use of generally accepted capability coefficients.

Due to the fact that process capability depends upon the capability of the utilized production machines, higher numeric requirements are specified for machine capability. Sauer [2] indicates that in general, a capability value of Cmk > 1.67 is required for machines. Wohlrabe[4] describes the fundamental procedure used for capability analysis. Generally speaking, atleast 50 individual measurements are required.

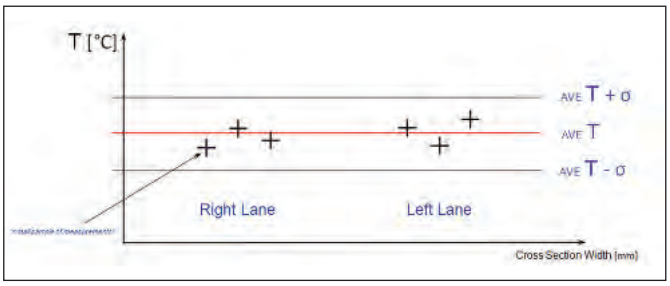

Figure 4: Calculation of standard deviation in dual lane systems

Problems become plainly apparent right from the start when attempting to ascertain capability coefficients for the firing process used for crystalline solar cells. Which measurable characteristics can be defined? The quality of the manufactured solar cells depends upon a great variety of influencing factors (e.g. wafer quality, POCl3 process, solar paste combination etc.), and the impact of the machine (firing system) accounts for only a small portion of overall influence. Consequently, cell parameters are unsuitable as a measurable characteristic of machine capability.

Temperature, conveyor speed and, if applicable, temperature differences are all possible candidates as measurable characteristics.

Conveyor speed is generally not used for the ascertainment of machine capability data. To some extent this is due to the knowledge that minimal variation in conveyor speed has nearly no significant effect on cell parameters. At the relatively high speeds typical of the firing process (5.5 to 6.0 meters per minute), the amount of heat absorbed by the individual wafers is nearly identical when the usual conveyor speed tolerances are taken into account (< 0.5%, ~ ± 3.5 cm/min.). A comparison of the temperature profiles for various conveyor speeds differing by ± 25 cm/min. (550 to 600 cm/min.) is shown in figure 2. The heat equivalent absorbed by the solar wafer in the peak zone deviates by no more than ± 4.5% of the mean value, although

	Temperature Difference (L-R)	Absolute Temperature (R)
Mean value	5.5	771.8
Standard deviation	2.0	1.7
Machine capability Cm	1.72	1.18

Table 1: Statistical Values Associated with Figure 3

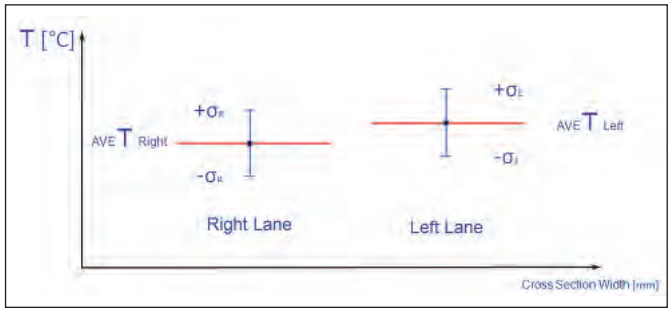

Figure 5: Calculation of the mean value in dual lane systems

the difference between maximum temperatures is 14.5° C. We take a critical view of acquiring temperature differences for the purpose of calculating machine capability coefficients. This is discussed briefly below. The temperature difference between two measuring points, as shown in figure 3 is noteworthy.

As a prerequisite, the wafer must be very well prepared with several thermocouples. Differences in thermocouple mounting result in changes to the thermal mass at the measuring point, which has a critical influence on data acquisition. The position of the test wafer on the conveyor belt influences thermal mass as well.

Furthermore, the results only reflect the temperature difference on a single wafer (e.g. ôL-Rô), which depends more upon wafer preparation than on interaction with the firing systems temperature profile. Table 1 lists the statistical values associated with figure 3. The requirement for a capability coefficient of Cm > 1.67 for a tolerance width of ± 7 K is fulfilled using temperature difference on the wafer as a characteristic, although this is not the case when absolute temperature on the same test wafer is used as the characteristic.

For this reason, we haven't made use of this temperature difference for the capability analysis. The acquisition of temperature differences between lanes is used for dual and multi-lane systems

Standard deviation of all measuring points on the test board for both the right and left-hand lanes is used as a basis for calculation in figure 4. Heat transfer tolerance over the entire width of the profile is ascertained in this way. Due to the fact that only one test board is available as a rule, the lanes have to be measured one after the other with the same board. This, too, is not in the spirit of the capability analysis. The calculation based on the procedure depicted in figure 5 provides us with the mean temperature difference between the lanes. In this case as well, two test boards which run through the oven simultaneously are really required.

In our opinion, measurement of absolute temperatures makes more sense for the ascertainment of machine capability coefficients. A firing system offers numerous options for acquiring temperatures. Figure 6 depict the temperature curves generated by temperature measuring systems integrated into the machine.

The thermocouples designated as controllers are incorporated into the firing system's temperature control loop, whereas the so-called watchdog thermocouples measure temperature in proximity to the conveyor belt independent of the control system. Table 2 lists the corresponding statistical values. Machine capability Cm is calculated here with a tolerance width of ± 5 K.

If a controller thermocouple is used to determine machine capability coefficients, the required value of Cm > 1.67 is easily complied with, whereas a dramatically worse value results from the data supplied by the watchdog thermocouple. This comparison demonstrates that it makes little sense to use data from thermocouples which are integrated into the firing system in order to calculate machine capability coefficients.

Measuring equipment and tolerance width

For this reason, it's advisable to ascertain absolute temperatures on standardized test boards, which are independent of the firing system, when determining machine capability coefficients. These can be either calibrated test setups on specified solar wafers (as shown in figure 7a) or standardized measuring devices consisting of, for example, defined metal sheets to which thermocouples are attached (see figure 7b). The latter have the advantage of being significantly more rugged, and are thus able to withstand the procedure which involves multiple repeat measurements.

As opposed to mechanical systems, the fact that there's direct interaction between the firing system and the measuring device (test board) must be taken into consideration in the real thermodynamic world. Fundamentally, firing systems are radiation systems, i.e. heat transfer is subject to the conditions set forth in the Stefan-Boltzmann law. Emittance specifies the amount of radiated power emitted/absorbed by the respective body. Actual emittance depends to a great extent on the respective material (color and finishing quality of the surface), and usually lies within a range of 0.012 to 0.98.

$$P = \varepsilon(T) \cdot \sigma \cdot T^4$$

P	Radiated power
ε	Emittance
σ	Boltzmann's constant $5{,}67 \cdot 10^{-8}\ W/m^2K^2$
T	Temperature

	Controller	Watchdog
Mean value	905.4	886.6
Standard deviation	0.9	9.8
Machine capability Cm	1.78	0.17

Table 2: Statistical Values (peak zone Tmax) Associated with Figure 6

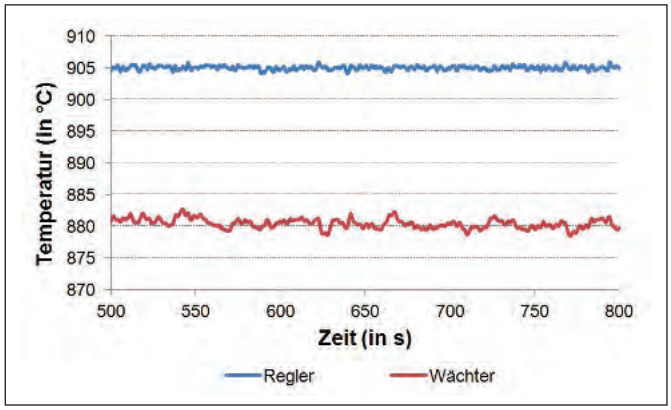

Figure 6: Peak (zone) Temperature Acquired by the Firing System's Internal Thermocouples

Figure 8 depicts measurements conducted by Vogg [3] on various solar wafers. Settings used at the radiation system were identical for all of the measurements. The significantly varying temperature-time curves make is plainly apparent that not just any crystalline solar wafers with various surfaces are suitable as measuring devices.

The next difficulty arises in establishing tolerance limits To and Tu. All too frequently, experience from the field of mechanical engineering is used to this end, and excessively tight tolerance limits are specified which cannot be adhered to in light of the thermodynamic circumstances which prevail in an inline system operated at roughly 1000° C. Consequently, table 3 below should be used as a basis for discussing which elements will determine overall tolerance width To - Tu.

Temperatures are determined by means of a test board to which type K thermocouples with a limit deviation of ± 4.0 K (± 0.004×T) are attached in accordance with DIN EN 60584-2. Data are recorded to a data logger during the measurement procedure with a measuring accuracy of ± 0.5 K. The test board and the firing system interact with each other, which means that the repetition accuracy of the firing system must also be taken into consideration.

The controllers for the individual heat zones have an accuracy of ± 0.5 K. Finally, in the case of multi-lane systems, heat transfer homogeneity must also be taken into account, which is represented by the numeric value of cross profile dTw (also known as the width profile). In actual manufacturing practice it

Test Board	**[K]**
Thermocouple on the test board	± 4.0
Data logger	± 0.5
Firing System	
Thermocouples in the control loop	± 4.0
Controller per heat zone	± 0.5
Cross profile (dTw)	± 2.0
Tolerance Width	**± 11.0**

Table 3: Tolerances

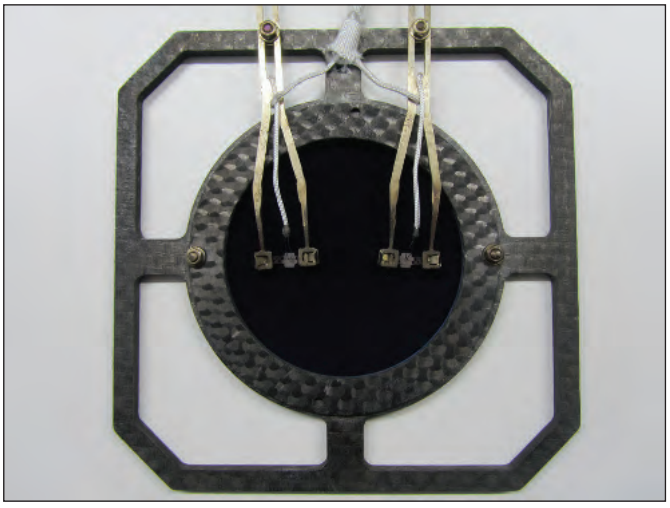

Figure 7a: Test board with solar wafer and 2 thermocouples

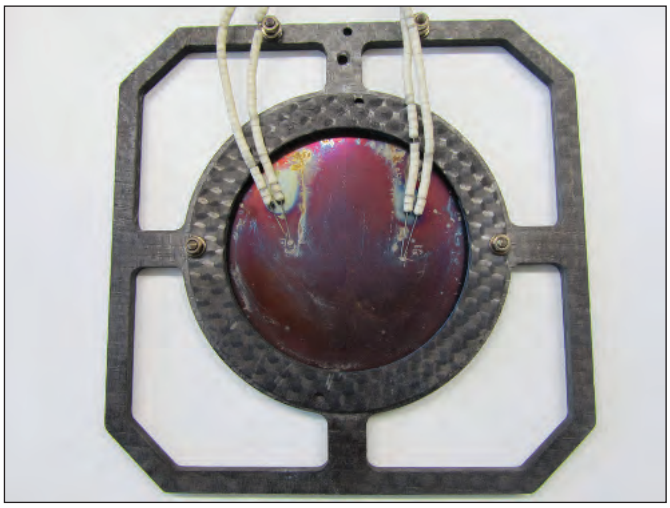

Figure 7b: Test board made of specified metal sheet

has to be irrelevant in which lane the solar cells are produced, and uniform quality should be expected in any case. Cross profile dTw is typically ± 2.5 K.

Figure 9 shows the characteristic time curves for temperatures in the peak zone for two lanes of a firing system, which have been ascertained with Rehm's Cross-Profiler measuring system. The Cross-Profiler makes it possible to perform measurements over a lengthy period of time at the same place within the firing system's peak zone.

Under certain circumstances it may be important to always record a full revolution of the conveyor belt, because the belt itself has significant influence on the measured temperature curve. Table 4 lists the corresponding data. Maximum standard deviation (rounded off) has been taken into consideration for the cross profile.

All in all, this often results in a tolerance width which is quite large in comparison with mechanical systems. In actual practice, however, this type of procedure has turned out to be a solid basis for ascertaining capability values for the firing process.

	Min Temp. in K	Max Temp. in K	Mean Value in K	Standard Deviation in K
Lane 1	921.3	928.1	925.1	1.4
Lane 2	918.0	926.0	922.0	1.8

Table 4: Cross Profile

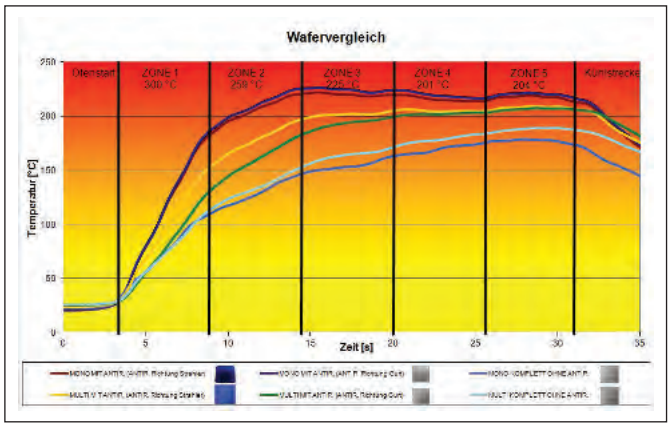

Figure 8: Comparison of heat absorption at various solar wafers

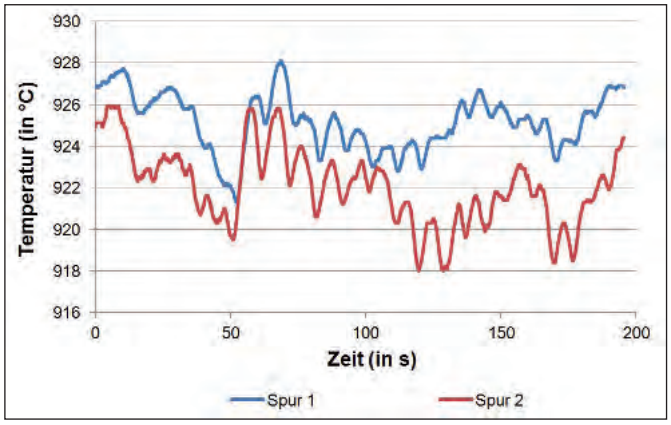

Figure 9: Cross profile of a dual lane firing system

Field results

Machine capability analyses were conducted on an RFS-D-250 single-lane firing oven manufactured by Rehm Thermal Systems GmbH with unchanging oven settings (temperature, conveyor speed, exhaust air, supply air). A calibrated test board was used to this end consisting of a defined metal sheet (see figure 7b) with 2 type K thermocouples. A Datapaq Q18 data logger was used to record absolute temperature data. 50 oven temperature profiles were recorded for each of the following three loading statuses with this test setup. Maximum

absolute temperature Tmax in the firing zone was determined with the help of Datapaq InsightSolar Tracker software.

Cmk >1.67 for	Left Thermocouple	Right Thermocouple
Empty oven	± 8.5 K	± 8.5 K
Partially loaded oven	± 7.5 K	± 9.5 K
Fully loaded oven	± 8.5 K	± 7.5 K

Table 5: Ascertained tolerance widths

1 Empty oven
2 Partially loaded oven
3 Fully loaded oven

These three load variants are intended to reflect various possible production statuses in the field of solar cell manufacturing. Empty means that the oven was not loaded with cells for a period of 10 minutes, after which it was profiled. Partial loading of the oven occurs during the production process when continuous loading of the oven cannot be assured due to the upstream silk-screening process (e.g. due to removal of broken cells).

This status was simulated by not loading the oven for a period of 8 minutes and then releasing 50 wafers into the oven. 30 seconds after the last wafer entered the oven, the oven was profiled with the help of the test setup. In order to record the temperature profile in the fully loaded state, the oven was loaded with 50 cells and the test setup was transported into the oven immediately thereafter. 50 more cells were fed to the oven directly after the test board.

Evaluation of the resulting data reveals that maximum temperature in the peak zone can be assumed to be nearly normally distributed for each loading status. Figure 10 shows the probability grid of the left-hand thermocouple in the fully loaded state as an example.

Under these conditions, it's possible to calculate as of which tolerance width a machine capability of Cmk > 1.67 can be achieved for the various loading statuses. The overview in table 5 shows the calculated tolerance widths of the thermocouples for the various loading statuses.

It was possible to substantiate that the firing system fulfills

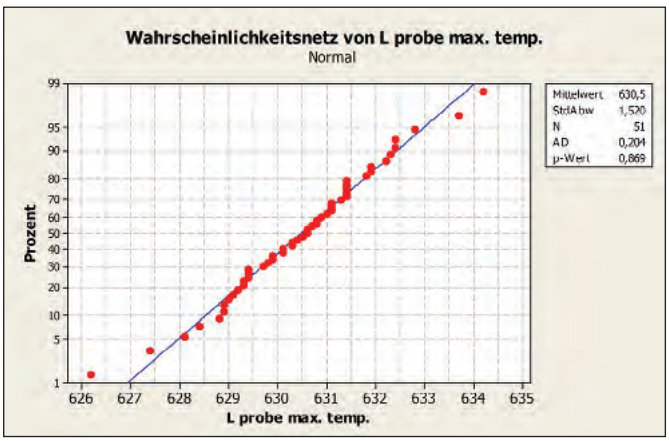

Figure 10: Probability grid for temperature measured at the left thermocouple

machine capability requirements for an overall tolerance width of ± 7.5 to ± 9.5 K. The discussion in section 3 demonstrates that deviations of ± 9 K can be expected for the utilized single-lane fast firing oven due to the utilized measuring device and its interaction with the firing system. This indicates that the tolerance width determined by means of the machine capability analysis lies within the tolerances of the test setup.

From a process engineering standpoint, it makes good sense to conduct machine capability analyses on the basis of parameters whose tolerances lead us to expect large fluctuations of the solar cells' characteristic electrical values. From our point of view, maximum temperature in the firing zone is best suited for this purpose. The characteristic electrical values are decisively determined by the attributes of the semiconductor-metal contact.

Contact formation is influenced by complex cause-and-effect relationships between the cell material (paste selection, passivation layers etc.) and the firing system (firing profile, conveyor speed etc.) [6, 7]. The firing profile is characterized in turn by maximum temperature in the firing zone [8].

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Here comes the recovery

After a turbulent couple of years for the solar industry is set to have a few seasons of more stable growth. With a promising outlook for PV and solar suppliers, Glasstec points out that the recovery for the global PV market is on the horizon.

THE CRISIS OF THE PHOTOVOLTAIC INDUSTRY is drawing to a close. While it is true demand for solar modules is dropping in Europe, demand in many other regions is rising rapidly. Even the producers of thin-layer modules which we had been almost "written off" are investing in new factories again. This is good news for the producers of solar glass and production equipment.

The solar industry has changed. As little as five years ago the manufacturers of solar modules were still announcing huge Gigawatt factories while research institutes were outdoing each other with ever new efficiency records. Thanks to abundant subsidies in many European states the total installed PV in Europe quadrupled to 70 GWh between 2008 and 2011. This huge demand made the sector brim with self-confidence.

Changing landscape

Today, scarce evidence of this boom can be seen anymore. Many countries with feed-in tariffs for solar power have drastically curtailed subsidy tariffs due to the rapidly rising green energy subsidy costs involved. As a result, the build-up in Europe dropped by almost 40% last year. Subsequently, nearly half the European cell and module manufacturers disappeared from the market and production equipment suppliers started posting losses while solar glass producers and processors lost an important source of income.

However, those keeping their heads above water can now finally hope for better days. This holds particularly true for companies that are already multi-national players. "While Germany runs the risk of a further shrinking market, other countries are increasingly relying on the power of sunlight to make their energy supply safer and more eco-friendly," says Carsten Körnig, General Manager of the German Solar Industry Association (Bundesverband Solarwirtschaft).

And statistics support Körnig's view. In Japan and China demand for modules tripled last year and even in the USA it was up by 40%. China has announced it once again plans to considerably increase its targets for solar power build-up – by 2017 the total solar power output installed in the country is to more than triple. On a global scale demand for modules is expected to rise by at least 20% in 2014.

At the same time, China continues to expand its market leadership in module production. According to a study by consulting firm Global Data, modules with a total of 40 Gigawatt will be manufactured in the Asia-Pacific region this year and of these 30 Gigawatt will be produced in China alone. As Global Data Analyst Ankit Methur explains, this means Asia now accounts for 90% of global production.

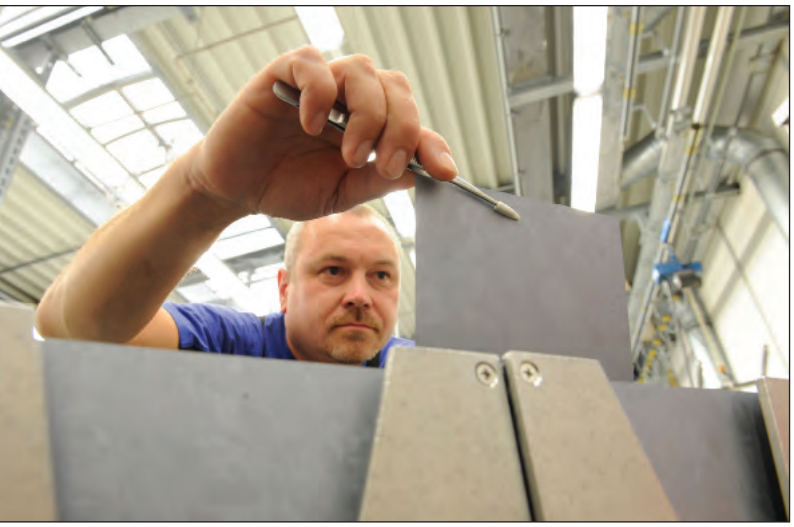
Thin-layer in rows: solar project developer Belectric has built Europe's biggest photovoltaics power plant in Eastern Europe using cadmium-telluride modules by First Solar.
Photo: BELECTRIC Solarkraftwerke GmbH

Growing opportunities

This development should play into the hands of solar suppliers. Many of them owe their economic success to the Chinese solar groups ordering equipment worth many billions of Euros for their huge factories in the boom years 2009 to 2011. Back then the export of cell and module manufacturing lines for the Far East accounted for some 80% of sales posted, for firms like Centrotherm and the Schmid Group. As the new capex cycle starts in Asia these companies could see a silver lining on the horizon.

At Centrotherm there are already clear indications of an upswing. After the company was forced to file for insolvency due to poor order levels at the end of 2012, it is now hoping to return into the black again in the current year thanks to new orders from China and Taiwan. Florian Wessendorf, Managing Director of the Association Photovoltaic Production Equipment in the German Engineering Association VDMA, sees a similar development for the other suppliers. "The outlook has clearly improved." The expert thinks that German firms have clear advantages when it comes to automation and coating technologies. "In these high-tech areas plants made in Germany will also be highly sought after in future."

In the long term, photovoltaics could also become attractive again for the glass industry, says Timo Feuerbach, speaker at the "Forum Glastechnik" and adds: "At present the situation in the



Quality control: crystalline silicon cells are becoming ever cheaper. One reason for this is the improved properties of cell blanks, the so-called wafers. Photo: SolarWorld AG

flat glass segment is difficult since producers are struggling with excess capacities. But solar energy is definitely a business for the future."

Innovations in solar glass and solar modules will also be centre stage at the Congress "solar meets glass" at the forthcoming glasstec. For the time being, solar power can only compete with conventionally generated power in a few regions with abundant sunshine. To change this, PV producers must urgently make further progress in cost cutting – and this is best achieved with help from their suppliers.

Thin film resistance

Thin-film producers, in particular, have ambitious targets. As the prices of customary silicon modules dropped over the past few years they lost sight of their original aim to oust the comparatively "clumsy" crystalline competitors from the market by means of thin and low-cost coated modules. But the technology, which had almost been discarded, could now be heralding a comeback – and, hence, boost demand for high-tech glass. For instance, thin-film manufacturer and former Q-Cells-subsidiary Calyxo has just put a new 60-Megawatt line for cadmium-telluride (CdTe) into operation in the Eastern German city of Bitterfeld-Wolfen. The company invested EUR 54 million to expand production capacity at the site to a total of 85 Megawatt.

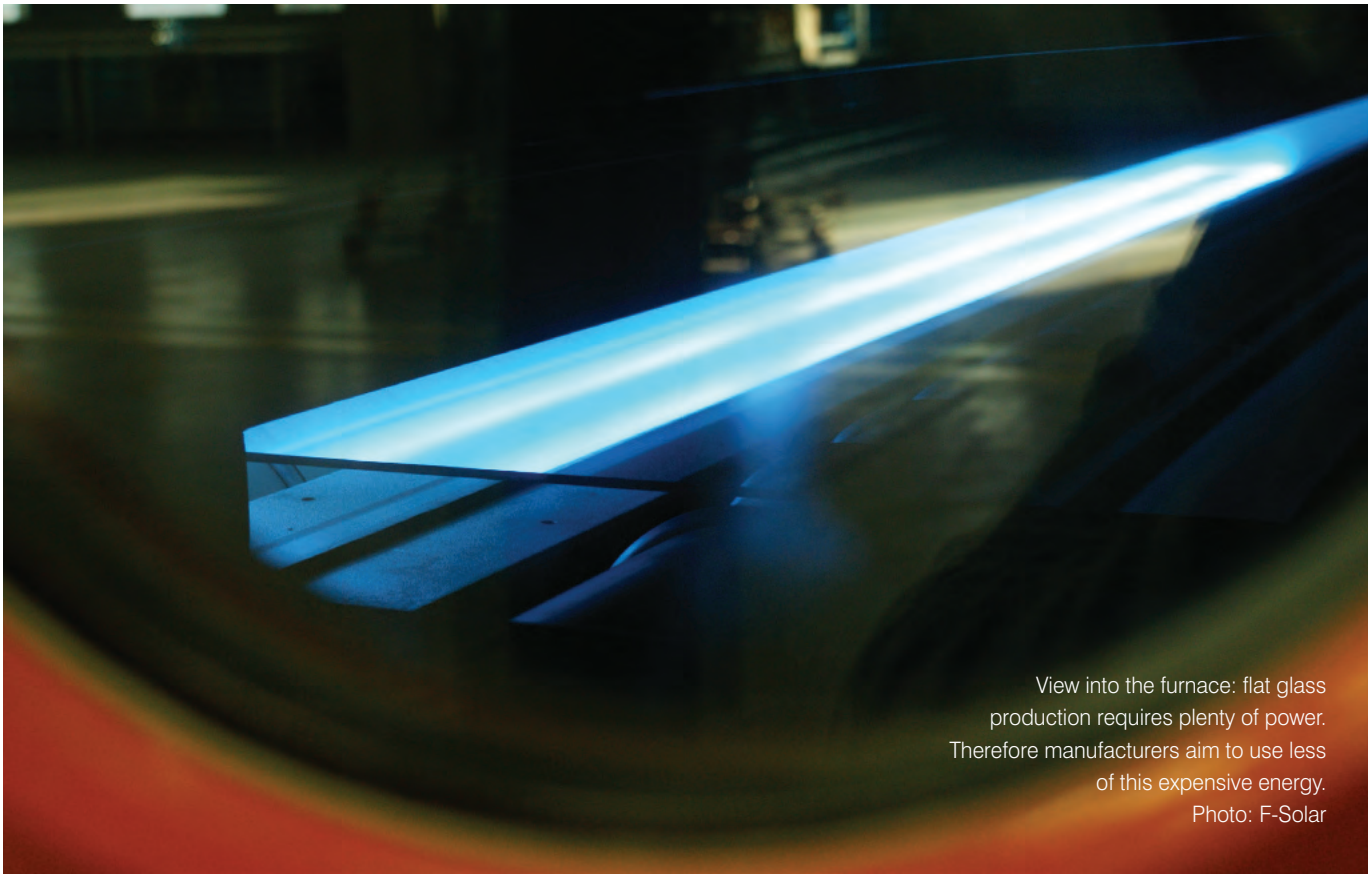
Calyxo had every reason for this capital expenditure. "We will bring down production costs in the medium term to less than US$ 0.50 per watt. We will then be producing at the lowest costs worldwide," says company boss Florian Holzapfel. To compare: according to US market research company GTM Research, manufacturing costs for crystalline "China modules" currently stand at US$ 0.60 per watt.Calyxo's optimism is based first and foremost on the ambitious announcements made by CdTe pioneer First Solar. In March the Americans announced new expansion and innovation plans triggering an immediate surge in their share price. By 2018 First Solar is planning to nearly double its capacity from its current 1.9 to 3.5 Gigawatt. Economies of scale thanks to higher capacities produced as well as the efficiency increase from 13.2% to 17.2% by 2017 are to "markedly bring down" manufacturing costs for CdTe modules, say First Solar.

The company sees its biggest sales market practically right on the doorstep. Agreed targets specified by the US federal states for renewable energies, the so-called Renewable Portfolio Standards, are forcing some American energy supply utilities to raise their green power levels drastically. The best option, particularly in the sunny south west of the USA, are large solar power plants. These can already produce a kilowatt hour for less than eight cents – cheaper than conventional coal and gas-fired power plants.

CIGS time is now

Also anticipating a significant rise in sales figures are the producers of CIGS-based, thin-film modules (copper, indium, gallium and selenium). Solar Frontier, a subsidiary of the Japanese Showa Shell group, explained that its CIGS factory with 900 MW in the Southern Japanese city of Kunitomi had been running at full capacity all last year thanks to strong domestic demand. Now Solar Frontier is planning another 150-MW factory in Northern Japan. In Taiwan the Taiwan Semiconductor Company (TSMC) wants to implement 1 GW of CIGS production capacity. Korean firm Samsung has announced a new 200 MW factory for 2014, which is also to be ramped up to one GW in 2015. The Chinese energy group Hanergy even plans to build 5.25 Gigawatt of new CIGS capacities.

Thin but rugged: solar glass is only two millimetres thick these days. This saves material costs and makes it possible to build robust double-glass modules. Photo: F-Solar



View into the furnace: flat glass production requires plenty of power. Therefore manufacturers aim to use less of this expensive energy. Photo: F-Solar

To Bernhard Dimmler, thin-film expert at the Swabian machine manufacturer Manz, companies are pursuing these expansion plans for a good reason: “CIGS hold great potential.” Dimmler refers to “CIGSfab”, a turn-key production line that Manz has offered since 2010. This 150-MW standard factory, he explains, now makes it possible to produce modules with an average efficiency of 14% and production costs of EUR 0.41, i.e. $ 0.57 per Watt. By 2017 Manz intends to optimise its CIGSfab to such a level that modules with up to 17% efficiency can be produced and production costs can be cut again by at least 10%. “This would give us more than a level playing field with crystalline producers,” says Dimmler.

However, market observers believe the catch-up race for thin-layer modules might prove more difficult than its protagonists assume. “You have to take their optimism with a pinch of salt. The race with competitors from the crystalline silicon segment is far from over,” feels analyst Johannes Bernreuter of Bernreuter Research. The fact is, producers of silicon modules are also keen on making rapid progress. February saw Kyocera from Japan and Ja Solar from China announce the production of multi-crystalline record cells with 18.6 and 19% efficiency. On the module level these new cells allow for over 16% efficiency. Both corporate groups already wanted to start commercial production as early as this summer.

Future innovation

In the revised edition of the International Technology Roadmap for Photovoltaics (ITRPV) published in spring, crystalline cell and module producers are outlining approaches for further efficiency increases. According to this information, higher crystal qualities, optimised electrode processes as well as improved charge carrier/conductive emitter and barrier layers can ensure that incident light is used even more efficiently. At the same time, crystalline manufacturers expect production costs to come down even further. On the one hand, these result from material savings in the wake of efficiency increases and on the other from falling production costs with the advent of new processes helping to reduce cutting losses in silicon wafer production and more sensitive processes allowing the processing of ever thinner wafer and grid fingers/bus bars. Experts also see further optimisation potential for solar glass. Today, manufacturers are capable of making glass sheets as thin as 2 millimetres while the PV industry is still using solar glass of four millimetres as its standard. In addition, these sheets are also easier to process further thanks to new coating machines. In future, photovoltaic success will increasingly depend on exploiting cost-cutting potential – and the glass industry and equipment will play a key role here.

Innovative path to efficiency

Sven Armbrecht, Area Sales Manager at LG Solar, discusses how new technologies such as N-type silicon wafers are increasing the performance of solar cells and innovations now available will make grid parity a viable prospect.

SOLAR POWER has been one of the biggest sources of new electricity generation for the last few years in Europe. Multiple factors have been boosting this development: homeowners and businesses looking for alternatives to ever-increasing energy prices, a trend for more environmentally friendly solutions and significant changes in the political and competitive landscape.

The increasing consolidation and competition in the market, as well as continuous research and investment, has led to more efficient panels and falling prices in the sector. Further fuelled by EU incentive schemes and feed-in tariff systems, migrating to solar energy has become more attractive than ever.
With lower prices and higher returns on investment, grid parity for solar energy is now within reach in the next five to ten years. Keeping this in mind, it is no wonder that to date, more than 120,000 homeowners and businesses made use of these benefits and installed solar power panels, according to Solar Energy UK.

Higher performance makes solar viable

Conventional solar cells based on photovoltaic (PV) technology have come a long way over the recent years. In the early years of PV energy, most systems were directly connected to the application or charged a battery that then provided power to the application. These so-called 'stand alone' systems were not yet connected to the grid.

The connection between solar cells and the grid started in 2000 when various EU governments introduced feed-in tariff schemes. Feed-in tariffs allowed the public to produce and utillise their own energy, to feed any excess energy back into the grid, giving them the chance to use grid electricity to balance peaks in demand.

Since then, the development of the solar industry has been remarkable. The feed-in incentives have fuelled demand in the both the corporate and residential sectors. This has resulted in decreasing prices for solar modules and more funding for research and development. With the aim of reaching grid parity sooner rather than later, efficiency and performance are the key objectives for the industry in the next few years.

The residential market is one of the strongest resources for profit in the solar sector. Manufacturers must be able to produce the same amount of, if not more, energy with fewer modules, in order to be a viable alternative to other energy sources. This is especially true for manufacturers in densely populated areas such as London. Thanks to new technologies, like the n-type silicon wafer, this is now possible.

N-type improvements

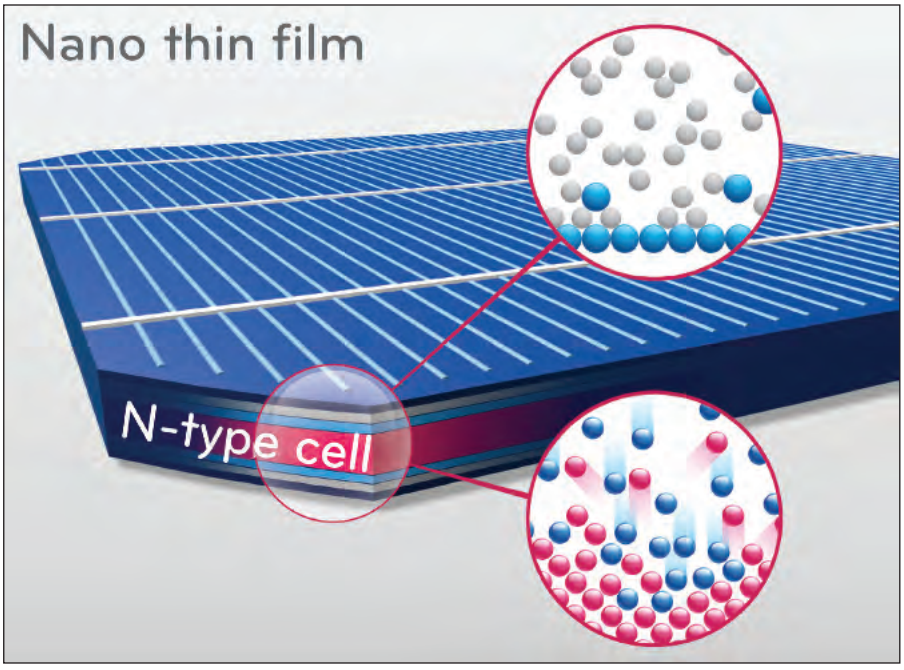
N-type cells are used as they give better performance or power output than the classic p-type cells. This means that the end customer will be able to use roof space much more efficiently, espcially in densely populated areas with limited roof space like London.

One of the key reasons for this is that n-type wafer has a better lifetime and minority carrier diffusion rate. These specific characteristics lead to more electric generation within the individual cells.

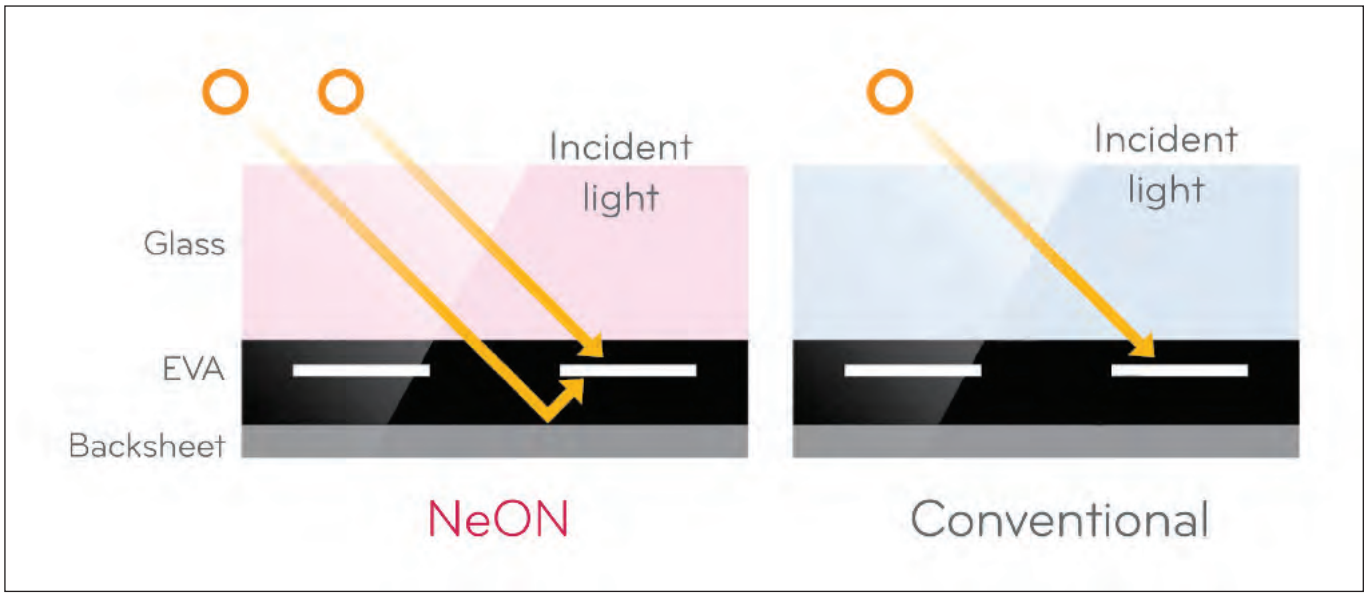
N-type cells also experience little-to-no light induced degradation or potential induced degradation, which can weaken the performance of the modules over time. The reason for this is that they use phosphorus doped wafers. The conventional p-type wafers are boron doped, meaning they react chemically with oxide and cause light induced degradation.

Another feature of n-type silicon wafers is that they are active from both sides. Each cell can make use of direct sunlight on the front side of the cell and indirect sunlight reflected onto the rear side of the cell, maximising light absorption.

This feature makes a significant impact in countries with fewer hours of sunshine and in the morning and evening when the sun's rays are at their weakest.



Structure of N-type cell



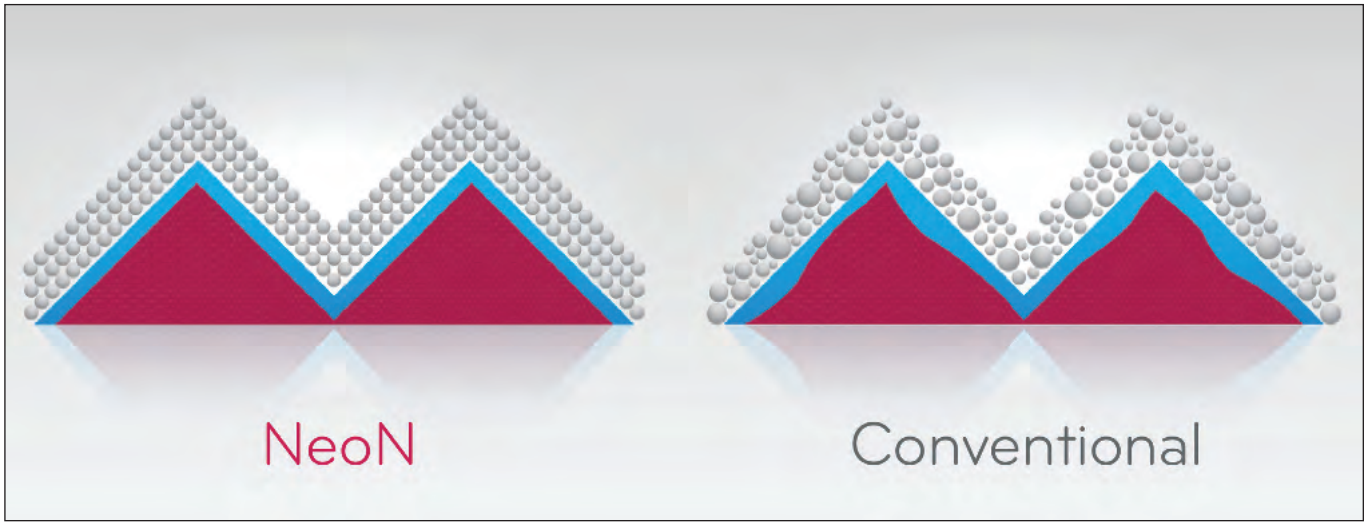
Comparison of a convential solar cell on the right with the NeON N-type cell

In addition to bi-facial cells, developments such as double anti-reflective coatings, the use of reflective glass and the reduction of the temperature coefficient have all led to further increases in module efficiency.

Lastly, the three AR (antireflective) effect – double AR coating on the cells, as well as AR coating on the cover glass – enables more photons to penetrate into the cell and produce more electric power.

High efficient future

The future holds even higher efficiency and independence from the grid. In the future, solar modules developed using n-type silicon wafers will become a staple in the solar photovoltaic industry. The increased longevity of the cells will lead to even greater savings for the user. Also manufacturers will continue to focus on research and development which will enhance module efficiency and lower prices. Households and businesses are now looking at ways to save money and have greater control, while distancing themselves from fossil fuels. Homeowners have a sense of environmental responsibility while businesses want to reduce the risks associated with a reliance on external energy providers, who are continuing to increase prices every year. The logical next step therefore would be to implement high-efficiency solar modules in smart homes to become more independent from the energy grid.



NeoN versus conventional shows the more rigid coating structure on the device

Solar awards nominations

The **Solar Industry Awards** are with us again and Solar International has the pleasure of announcing this years nominations. Get voting to ensure your favourites win.

Energy Usage Enabling Award

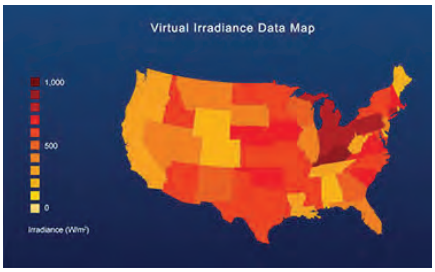
Locus Energy

Virtual Irradiance Tool

LOCUS ENERGY'S Virtual Irradiance™ VI tool provides PV power plant managers with a means of measuring the amount of sunlight that is striking the ground at a particular time and location.

Using historical and real-time data from weather stations and satellite imagery Locus Energy's proprietary algorithms provide high quality data on solar irradiance for any location in the continental United States.

VI provides a truly accurate assessment of how much energy a system should be producing based on the amount of sunlight that is available to the panels. When used with other modelling data such as the type of panel or inverter such data is invaluable.



This is true not only for system stakeholders, who can use it to identify and rectify problems, but also for financial institutions which can use the data as a means of ranking the value of solar PV assets.

Another advantage of VI is that it reduces the need for on-site sensors which may be prohibitively expensive for small- to medium-sized systems. For larger systems at which on-site sensors are installed VI validates sensor data which can become skewed due to soiling or have gaps due to downtime or other site problems. As solar becomes increasingly common VI is also expected to become an important tool in helping utilities integrate solar into the electricity grid. VI is part of a suite of analytics tools that Locus is developing called PVIQ.

Trojan Battery Company

Smart Carbon

TO ADDRESS the impact of Partial State of Charge (PSOC on cycling batteries in renewable energy (RE inverter backup and telecom applications Trojan Battery Co recently announced the addition of Smart Carbon as a standard feature to its Industrial and Premium flooded battery lines.

Smart Carbon is a proprietary Trojan formula which provides improved performance when the batteries operate in PSOC enhancing overall battery life in off-grid and unstable grid applications where the batteries are under charged on a regular basis. Along with increased life in a partial state of charge Trojan's Smart Carbon proprietary formula also provides improved charge acceptance and faster recharge in PSOC applications.

Trojan understands that batteries used in harsh RE telecom and inverter backup systems are regularly cycled at PSOC due to the intermittency of solar generation an unstable grid or to minimize operating costs of a hybrid Charge-Discharge-Cycle (CDC system. Operating at PSOC can quickly diminish the overall life of a lead acid battery which results in frequent and costly battery replacements.

With batteries now being one of the most expensive components of these systems it is critical to maximize the life of the battery bank in order to reduce total cost of ownership. To address the issue of PSOC

Trojan's engineering team developed the Smart Carbon advanced lead acid formula to enhance life and performance of Trojan batteries operating in PSOC. Trojan chose to add Smart Carbon first to its deep-cycle flooded batteries because flooded technology is the most widely used in off-grid and unstable grid applications globally due to its cycling performance ability to withstand harsh conditions widespread availability and economical price point.

Reuniwatt

Soleka

SOLEKA is a decision-making tool, intended to ease the introduction of renewable energies in the energy mix as it will enable to forecast the production of solar power plants at three time scales:

- 1 day ahead forecasting in order to convey to the distribution network operators the next day's production capacity enabling them to plan their means of production.
- 4 hours ahead, or intra-day forecasting which allows the PV electricity storage operators to confirm or invalidate their production commitments without risking penalties.
- 30 minutes ahead, or shortcasting which enables the electricity suppliers to securely provide their energy and to optimize their means of production inside the grid.

By giving predictions to PV plant managers and electricity grid operators, we can help them better plan their solar storage and their use of other energies.

The integration of PV in the grid is therefore eased and optimized. Soleka is a decision-making tool enabling a massive and secure injection of photovoltaic on the electricity grid thanks to its solar energy forecasts.
Thanks to the recent availability of volumes of applicable data, it is now possible to precisely simulate the missing link between the forecasted weather tendencies and the actual PV electrical production. In today's context of global PV growth and fight against climate change, Soleka appears as the Big Data solution for electrical grids' resistance against solar power's intermittency.

SolarEdge

Smart Energy Management Solution

THE SOLAREDGE SMART ENERGY Management solution includes a feed-in limitation feature that enables PV system owners to maximize self-consumption while maintaining compliance with local grid regulations and installation standards.

The average size of a PV system is trending upward allowing owners to minimize grid consumption throughout the day. However this boom in PV generation has also altered the structure of grid operations prompting a number of countries to put in place regulations that limit the amount of PV power that can be delivered to the grid – some have even banned PV systems from feeding into the grid altogether. In many cases customers cannot justify the economics of a PV system purely for self-consumption or are forced to reduce the size of their desired system to avoid exceeding the local feed-in limit. By enabling customers to dynamically manage the amount of PV power produced so that the power fed into the grid never exceeds the limit the SolarEdge feed-in limitation unlocks a new level of operational flexibility for system owners. SolarEdge's feed-in limitation is integrated directly into the inverter firmware ensuring it maintains the output power limit set forth by the utility at all times.

Toshiba Mitsubishi-Electric Industrial Systems Corp

Solar Ware Samurai 1.667 MW Inverter

THE SOLAR WARE SAMURAI is an outdoor PCS with a stand-alone capacity of 1,667kW. It's highly advanced cooling system offers fanless operation up to 50 percent of the output power rating,and maintains high reliability while reducing energy costs. The inverter also boasts the ability to operate efficiently under the harshest of environments, such as deserts where large-scale mega solar facilities are frequently installed.

The system includes advanced multilevel inverter with 56% of switching loss reduction. Wide MPPT range allowing for best-in-class DC/AC ratios and flexible DC-input configuration to meet complex array configuration. TMEIC sets the standard of utility-scale installation with its own proprietary design. Features include Power factor control, reactive/ active power control, fault ride through, voltage ride through (low voltage ride through), frequency ride through, TMIEC's proprietary anti-islanding technique utilizes a slip mode and frequency shift method.

Project Development Award

Gujarat Power Corporation Limited

Gujarat Solar Park

GUJARAT POWER CORPORATION LIMITED (GPCL) is the Nodal Agency for the development of "Solar Park" in Gujarat. Govt of Gujarat has taken proactive initiative in the Projects of Renewable energy to harness Clean and Green Energy. GPCL commissioned, Asia's largest "Gujarat Solar Park" to mitigate impact of Climate Change and to protect environment for our future generation.

The 590 MW capacity of "Solar Park" is located at village Charanka, District Patan in Gujarat spread across 5,384 acres of unused land. The integrated "Solar Park" has state of art infrastructure with provision to harness rain water besides power evacuation. Installed capacity of 224MW Solar Project has been commissioned by 20 developers.

The capacity will be enhanced by another 50MW by the end of this year, thus putting the installed capacity as 274MW., accounting to 25% of total Solar generation developed India. Solar Park has also capacity to generate 100 MW of

Development cost of "Solar Park" was Rs. 4500 Crores, which includes Rs. 550 Crores for infrastructure and land acquisition and Rs. 3,996 crores for Solar Power Plant (Developers investment), besides creating an Employment for more than 1,000 people on permanent basis.

GUJARAT SOLAR PARK

Project was launched on 30.12.2010 and commissioned on 31.12.2011 and formally dedicated to the Nation by Hon'ble Chief Minister on 19.04.2012.

"Gujarat Solar Park" has been one of the most innovative projects in the Solar Energy Sector having large concentration/ cluster of Solar Power generating units at single location, thereby reducing cost substantially (40%), and bringing down lower Solar Tariff to pave way for large scale development of Solar Power Projects.

Martifer Solar

Grid Parity with IKEA

Martifer Solar has delivered one of the first unsubsidized solar power plants in Italy for the Ikea Group on the rooftop of a new commercial store in Pisa Tuscany. The project has a total capacity of 696.15 kW and has been structured without relying on any government subsidies or feed-in-tariff approach.

The power generation from this PV project will be at a Levelized Cost of Electricity (LCoE which is equal to or less than the price of electricity being sold from the grid. Martifer Solar was responsible for the EPC (engineering procurement and construction) of this solar plant and will be responsible for the subsequent Operation and Maintenance (O&M) service. The grid parity project with approximately 2700 modules installed on fixed structures will produce the equivalent amount of electricity for nearly 800 inhabitants and will avoid 373 tons of CO2 emissions per year. With this recently installed PV project for IKEA Martifer Solar is showing that grid parity is a reality and will be a growing trend in the future of maturing.

Power Clouds

Power Clouds Project

Power Clouds Pte Ltd introduces an innovative solution for the development of photovoltaic through the direct and bottom-up involvement of the people. Anyone is free to buy a solar panel (Power Units and rent it out to the company contributing to the production of green energy that protects the planet. The same company carries out the plants and ensure through an extensive network of activities including energy production a fixed monthly income for 20 years for those who take part in the project.
The concept behind Power Clouds is seen as an alternative to traditional financing ways for the photovoltaic stations construction and at the same time leads to the direct involvement of a large number of people (40000 participants in the first year.

We are the only company which develops and manufactures large photovoltaic projects involving ordinary people who care for the environment and through the initiative they are able to get a fair economic benefit.

Scatec Solar

South Africa Project - 75 MW PV Plant Kalkbult

THE KALKBULT PLANT, situated in the Northern Cape region, is currently the largest solar plant in Africa. Connected three months ahead of schedule, it was the first Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) project to be grid connected and operational in South Africa.

The solar power plant was built by Scatec Solar and local partners and became the first utility-scale renewable energy facility to supply electricity to Eskom after connecting to the grid three months ahead of schedule. The 75 MW Kalkbult solar PV plant near Petrusville in the sun-drenched Northern Cape will generate 135 million kilowatt hours a year, equivalent to the annual electricity consumption of 33 000 households.

It was fully commissioned within 10 months. Construction commenced in late November 2012 and the first electricity delivered to the grid began in September 2013.

The Kalkbult plant covers 105 hectares of a working sheep farm and includes 312 000 solar panels mounted on 156 kilometres of substructure linked to inverters, transformers and a high voltage sub-station.

During peak construction periods, more than 600 employees, the majority from the local community, worked at the Kalkbult construction site, achieving more than 750 000 accident free hours.

Some 16% of employees were women, who participated at all levels, from management and administration to construction activities.

The nearest town to the project is Petrusville, about 100 kilometres north east of De Aar on the N1. Land for the project has been leased from a sheep farmer who will continue to run his business alongside the solar PV facility.

Turnkey Supplier Award

Centrotherm

Integrated Production Solution

CENTROTHERM is a pioneering supplier of turnkey production lines, coming from Germany, and with a track record of more than 50 completed projects around the globe, is now a major provider of integrated production solutions for the manufacturing of mono and multi-crystalline solar cells.

The company has comprehensive process know-how on all levels of the value chain, including everything from the raw wafer through to the finished module. They support their clients well beyond the ramp-up of production, providing a wealth of engineering and consulting services as well as training programs.

centrotherm offer integrated production solutions based on customers-specific requirements, enabling you to manufacture high performance solar cells competitively in combination with the respective processing, technology and service packages.

centrotherm's sustainable concept of integrated production solutions is ready for the future and offers solar cell manufacturers maximum flexibility: innovative technologies and systems can be integrated into existing production lines; production capacities and the level of automation can be boosted at any time.

Enrich Energy Pvt. Ltd.

Solar PV Turnkey Integrator

ENRICH ENERGY is a pioneer in India developing large scale private Solar PV Park and offers turnkey solutions. Services include Radiation Mapping, Land Acquisition Design & Engineering, Infrastructure Development, Power Evacuation, Supply Chain Management, Installation, Erection and Commissioning, and completing the chain with operations & maintenance services.

The company has developed a 40 MW Solar PV Park at a site at Mandrup, in the state of Maharashtra in India and are in process of setting another 60 MW Solar PV Park in the state of Andhra Pradesh. The company is building further infrastructure of more than 150 MW to create new Solar Parks in India.

The Solar PV Parks developed by Enrich Energy enables investors to own a piece of the project of any size, opening up opportunities to a broader section of the community.

The 40 MW Solar PV Park at Mandrup in state of Maharashtra is the first private Solar Park in India and has more than 26 investors owning a part of the Solar Project with sizes ranging from 0.6 MW to 6.65 MW. The Solar Park is spread across 200 acres of land and have provided significant boost to development of Solar Energy sector in India.

Panasonic

End-to-End Solar Solution

PANASONIC has developed a comprehensive integrated end-to-end solution that brings solar projects from concept and finance to installation and maintenance under one roof simplifying the process of going solar. As a "one stop shop" for going solar this solution helps organizations attain renewable energy, effectively and efficiently.

Traditional solar models often require the involvement of different third-party vendors at each phase of development. Sustainability officers facility owners developers and power purchasers don't have to be burdened by the aggravation of dealing with multiple parties at each step of the solar process. The Panasonic Eco team facilitates solar projects at every phase of development, streamlining the entire process and serving as a viable strategic partnership for a wide range of organizations. With Panasonic's integrated turnkey model organizations ensure solar success, avoid unnecessary stress and save time and money. For a wide range of organizations Panasonic provides the solution they need to fulfill social responsibility goals and reduce utility costs.

We are the only company to bring all phases of solar project development from finance to design installation to maintenance under one roof backed by a production guarantee. And because of its reputation of reliability and financial stability Panasonic alleviates a customer's worries about dealing with multiple

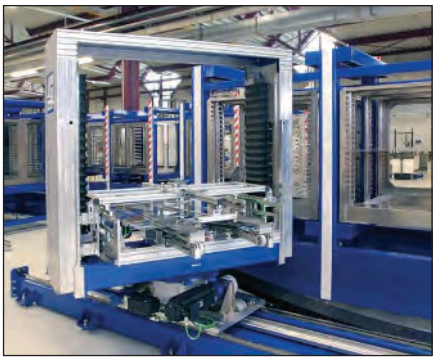
vendors of questionable reliability, stability and ability to cooperate and to complete projects on schedule and on budget.

Schiller Automation

TF Solar Module FAB automation

SINCE BEING SET UP in 1978, Schiller Automation began in 1978 and is a global supplier of automation and systems solutions. Their focus is on production and handling systems for manufacturing modules, crystalline solar cells and on complete fab automation for the production of thin-film solar cells. The company assists customers with the complete planning from idea to completion with a selection of efficient techniques and process equipment to design and develop production procedures. The TF Solar Module FAB automation tool is a complete automation and logistics solution precisely tailored to the respective customer requirement.

It dovetails the individual components and handling elements in an optimized process flow. This provides manufacturers of thin film-solar cells a flexible modular system solution from one source.



A key component of FAB automation is the accurate and smart SCHILLER LC host computer system which is tailored to the process, communicates with existing control systems, coordinates processes, and manages and processes the most important product data and states.

Productivity and quality result from the smooth interplay of all components. Complete one-stop know-how SCHILLER AUTOMATION offers manufacturers of thin-film solar cells a complete integrated automation concept: from concept to project management to successful commissioning.

It includes optimally matched logistics and handling components and the intelligent.

Industry Development Award

Komax

GX6 String Layup

THE GX6 is the latest generation Komax Solar layup system. It was completely redesigned to improve ease of use, performance, and feasibility for downstream automation.

A single robot facilitates pick and place from stringer to glass, with tab trimming and bend options. The active vision system provides industry leading string placement accuracy.

String quality monitoring options include optical and electroluminescence (EL) inspection. Patent Pending Technology allows strings to be accurately placed on glass using a patent pending advanced vision system (AVS).

An optimized layout with conveniently located dual HMI(s), enable a single user to operate both string systems and the GX6 layup system. Full product changeover by one user is easily accomplished in less than 20 minutes. The GX6 layup system supports two Xcell solar cell interconnection machines. The conveyor system incorporates glass input and output buffers to minimize glass exchange times and improve performance.

The conveyor incorporates a patented slip torque technology to optimize product flow across both the input buffer and layup zones.

The system incorporates a single articulated robot for string pickup and placement to glass. Strings are picked to match the module layup polarity requirements, and accurately placed on glass front (blue) side down using a patent pending active vision system (AVS).

HIT Solar Cell

PANASONIC has achieved a conversion efficiency of 25.6% in its HIT solar cells a world record for crystalline silicon-based solar cells of a practical size. The achievement of this new record was made possible by further research into Panasonic's heterojunction technology. Panasonic is the first company to push the efficiency level above the 25% benchmark for practical-size cells.

Reduction in recombination loss A key feature of HIT technology is its ability to reduce the recombination loss*7 of charge carriers particles of electricity generated by light through laminating layers of high-quality amorphous silicon on the surface of the monocrystalline silicon substrate where power is generated.

Reduction in optical loss In order to increase the current in a solar cell it is necessary to lead the sunlight which arrive at the cells surface to the monocrystalline silicon substrate which is the layer which generates the power with less loss. Minimizing resistance loss In solar cells the generated electrical current is accumulated in the surface grid electrodes and output externally. Panasonic applies improvements on front-contact shading to its own high-efficiency HIT cell structure: Imperfections at or near the surface of the crystalline silicon wafers used in the cells can trap electrons decreasing current and voltage. By applying thin films of silicon to the front and back of the silicon wafer this effect is countered.

Solar Energeasy

SOLAR ENERGEASY is a global program launched by Rexel to raise awareness and understanding of solar PV and make the installation of solar panels hassle-free for both the consumer and the electrical installer via a user-friendly online platform adapted to smartphones and tablets.

For the first time consumers also have a guarantee on the generation potential of their installation and the assurance that if the difference in the real energy output of the PV installation is more than 10% below the original estimate within the first 5 years, Rexel will pay them back the

difference. Through the professional portal electrical installers can also make clients aware of dedicated financing solutions that have been made available via Rexel's trusted financing partner as well as offer additional services such as the cleaning and maintenance of solar panels.

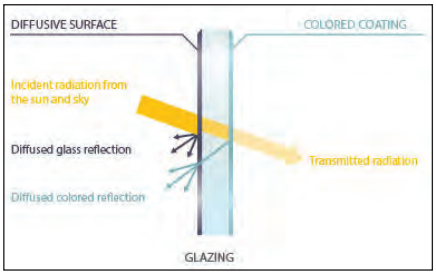
This is the first time a company is offering an end-to-end Solar PV package for both the installer and the consumer through an extremely user friendly and intuitive online platform, bringing both the installer and consumer a user experience more often associated with purely consumer-facing retail brands. This is the Apple IPhone equivalent of a solar installation package! We decided to launch Solar Energeasy because we recognized the potential for growth in solar PV and we were acutely aware of the need for a solution that would boost confidence in the industry among both installers and end-users. By creating a solar ecosystem that packs all the advantages of solar into a single neat online offering for both the end-user and the installer, we believe Solar Energeasy has the potential to do just that.

SwissINSO

Kromatix

COLOUR TREATED glass for Photovoltaic and Thermal panel applications involves the application of efficient and nanotechnology surface treatments optimized for PV and Thermal panels. Kromatix technology offers opportunities combining architectural design flexibility and panel aesthetics with optimum panel performance for solar building integration. The coloured glass is obtained by combining two different surface treatments. The deposition by vacuum plasma process of a coloured nano-scaled multi-layered treatment applied to the inner side of the glass.

The modification of the glazing outer surface. The multi-layered treatment is designed to reflect a narrow spectral band of the visible light, in order to provide a colour, the rest of the solar spectrum being transmitted to the solar device and converted into energy. They guarantee limited or negligible (depending on colour) loss of efficiency of the solar devices andensure a high angular colour stability.



The outer treatment provides diffused reflection to reinforce the masking effect of the solar device technical parts and to prevent glare effects.In simplified terms, the colour shade is given by the position of the reflection peaks of the reflectance curve. A good compromise has to be found, as the higher the reflectance, the lower the transmittance and the energetic performance of the solar device on which the coloured glass cover is installed.

Module Manufacturing Innovation Award

ET Solar

Cell Optimiser Module "COM"

AS AN INNOVATOR that adopts maximum power point tracking chips, ET Solar developed COM that offers maximum power tracking of individual solar cell string on real-time basis and thus achieves cell string-level power optimization.

The product represents a significant enhancement from the conventional solution that is based on bypass diodes and offers power optimization only at the module-level. Therefore, PV systems using COM would not have module mismatch problems and could increase electricity output by up to 20%.

ET Solar's stringent raw materials selection and robust production control ensure the product's highly reliable performance, minimize hot spot induced system failures and extend system life. With excellent environmental adaptability, the product substantially decreases power loss caused by shading and soiling on module surfaces.

Furthermore, COM would also enable higher density for constrained installation space, and reduce cost of installation, operation & maintenance of the PV system.

JinkoSolar

JinkoSolar Smart Module

SMART MODULES which increase the energy yield by limiting the common power loss caused by shadowing. Critical module temperatures can be achieved if one solar cell operates in reverse bios of its IV curve. In such cases a power loss drop can be attained at the shaded cell which is followed by temperature increase.

The temperature increases by operating the cell in reverse bios is defined as a hotspot. The hotspot is the major failor mechanism of solar PV modules.

Thanks to integrated solar cell optimizers hotspots are eliminated in JinkoSolar Smart Modules- that increases energy yields up to 20% compared to standard modules due to shadowing.

We are the only company offering 3 smart modules so our customers can choose which technology they prefer: Tigo Solaredge or Maxim- the described anti hot spot technology.

Shadowed modules produce less energy. As it is impossible to avoid shadows completely,clouds can always appear they are a big problem. Our Smart Modules reduce this effect and can increase the energy yields up to 20 % in comparison to regular modules.

Since shading is not a problem for smart modules it is possible to place more modules in a space. For example you dont have to work widely around chimneys. It is more efficient and looks better. The monitoring tools offer security.

LG Electronics Deutschland GmbH

MonoX ACe

THE MonoX ACe from LG Electronics is a breakthrough by combining solar module and inverter for an alternating current (AC) power output (220 V). The high-efficiency solar module rated 300 W has included an inverter/micro-inverter which is permanently installed at the back side of the module.

This inverter directly converts the direct-current (DC) power from the solar module into alternating current (AC) power.

With the inverter on the backside the known junction box with the bypass diodes is also included and can be saved in production.

The usual installation of an external micro-inverter is not necessary any more as it is already integrated in the junction box of LG's AC module.

The approach of the new LG Electronics AC Solar Module differentiates in three topics.

a) For the string inverter design the solar module with the lowest current determines the performance of the string. With the micro-inverter each solar module contributes its own maximum performance to the system.

b) With the micro-inverter there is no need to spend material, costs, and time to install the individual inverter for the module as it is already permanently installed at the module.

c) The micro-inverter of the LG Electronics AC Solar Module can deliver from the DC input power (280 W) the same amount of AC output power (280 W), the world best output power. d) LG Electronics provides the total solution (i.e. module + integrated microinverter) and fully warrants the total system.

This reduces purchasing complexity for LG Electronics customers as a "one stop shop.

UAB -Viasolis

Glass-Glass PV Module

IN THE PAST and currently, the standard photovoltaic module has been manufactured using 3.2 -4mm glass on the front and a polymer-based insulating back sheet.

Despite well known disadvantages of such concept many years has been no real changes to improve technology of manufacturing PV modules.

PV industrial machinery and glass processing technologies limited ability to step-out of using polymer-based backsheet in large scale of PV module production. Significant step further of glass tempering technology made possible to substitute polimer-based back sheet for ultra thin- 2 mm glass.

ViaSolis is a pioneer of using Glass-Glass PV module manufacturing technology.

This module provides important advantages incorporate use of thin glass that increases light transmission. This corresponds to 4% increase in yield (kWh per kWp) or in other words to a reduction of all optical losses in a solar module by 40%.

ViaSolis PV cell surface is specifically designed for the structure of lamination foil, which reduces banding losses up to 60 % (0.8% versus standard module - up to 5%)

Innovative approach as a optimal weight of the PV module provides extensive product's integration in to construction and architectural solutions.

Via Solis photovoltaic modules can be manufactured according to the needs of individual clients by exploiting the possibilities of the colour spectrum, size, desirable shape, different light transmission or insulating characteristics.

Rural Electrification Development Award

Phaesun GmbH

BOSS - Business Opportunities with Solar Systems

OFF-GRID solar power systems can be an important factor to support rural development in areas that are not connected to the electricity grid.

Most projects and concepts for rural electrification target the basic infrastructure needs such as the electrification of hospitals schools local administrations and private households.

But the commercial sector is another very important area of activity since prospering commercial activities are essential for the economic development of rural communities and therefore also contribute to social development.

Common names for energy solutions for the commercial sector are productive use of energy or Business Opportunities with Solar Systems (BOSS. As a system integrator the company Phaesun in cooperation with local partners and component manufacturer is developing and implementing different complete solar kits that can be used for income generation in rural non-electrified areas.

These solar powered systems for commercial use range from solar powered systems for daily services such as hair cutting TV and cinema mobile phone charging cooling and freezing of food and drinks to food processing such as juice squeezing and grain milling.

Services in rural areas in developing countries are often poorly developed due to the lack of electricity access. The processing trade is often concentrated on urban areas.

Off-Grid solar power systems offer a unique opportunity to implement new services in non-electrified rural areas and ensure that further process units will remain in the hands of locals.

SolarAid

SunnyMoney

INTERNATIONAL DEVELOPMENT charity SolarAid established SunnyMoney a visionary social enterprise to revolutionise solar light ownership in Africa by catalysing a market for solar amongst off-grid communities. SolarAid identified the market barriers werent just lack of quality products but one of trust distribution and scale. Solar power was not accessible to the majority markets in Africa those with low incomes living far from the grid.

This has been a great success with over a million solar lights distributed by March 2014 60% of which were sold in that financial year. SunnyMoney has achieved this by developing a community distribution model to raise awareness of solar products in partnership with Ministries of Education in Kenya Zambia Malawi Tanzania and Senegal.
As trusted figures in the community, teachers play a crucial role in encouraging

the adoption of solar technology. They also act as an initial distribution network for early sales by SunnyMoney.

As demand grows in the community SunnyMoney then trains and equips local agents to sell solar lights so that they become permanently available and so that the local economy can benefit from the growing solar market.

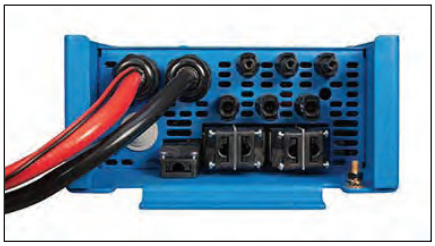
Through this model sales of solar lights have increased exponentially in the last 18 months and SunnyMoney is the lead retailer of solar lights across Africa.

The overall aim of the innovative distribution model is to eradicate the kerosene lamp from Africa by 2020. This requires stimulating a market for solar products that will provide rural low income families the opportunity to invest in them. Kerosene is dangerous and unhealthy but most notably is cripplingly expensive locking families into a cycle of poverty. Kerosene is purchased in small amounts regularly and is readily available.

Victron Energy B.V.

EasySolar

VICTRON ENERGY, a Dutch power solutions provider behind EasySolar, all-in-one solar power solution; combining an ultra-fast MPPT solar charge controller, an inverter/charger and AC distribution, all in one enclosure. EasySolar, is an integrated, smart, total power solution.



All that is needed to reap the full benefit of solar energy is EasySolar, some solar panels and batteries. EasySolar takes power solutions one stage further; by combining an Ultra fast BlueSolar charge controller (MPPT), an inverter/charger and AC distribution all in one enclosure.

With an reduction in wiring EasySolar provides ease of use combined with a maximum return on investment.

When using the 24V model, it is possible to use up to 1400 Watt of solar power and with 1600VA continuous inverter power, even peaks of 3000 Watt can behandled without any problems.

The AC distribution consists of an RCD and four AC outputs protected by circuit breakers. One output is controlled by the AC input and will switch on only when AC is available.

No additional fuse box is needed any more; EasySolar provides an easy to use, cost efficient and safe solution for AC distribution at for example a holiday home.

PowerAssist technology protects the utility or generator supply from being overloaded, by adding extra inverter power when needed.

PV Materials Enabling Award

Dow Corning

PV-5802 Electrically Conductive Adhesive

PV-5802 is a high performance, reliable, silicone-bazed, electrically conductive adhesive for back-contact photovoltaic module assembly.

Dow Corning PV-5802 Electrically Conductive Adhesive is a one-component metal-filled silicone which has been specifically designed for electrical and mechanical bonding between cells and conductive backsheets for back-contact PV modules.

The product is considered a reliable enabler for the emerging back-contact module assembly process, permitting automation, high throughput and high yield.

Dow CorningPV-5802 Electrically Conductive Adhesive is a state-of-the-art, proven silicone-based technology which offers superior performance, flexibility and durability.

DSM Advanced Surface

KhepriCoat

DSM ADVANCED SURFACES provides solutions for the development and application of smart coatings. KhepriCoat, is designed for glass and the company plans to expand this range into smart coatings for plastics and films. KhepriCoat enables glass to transmit more light, instead of reflecting it, thus boosting performance across a range of industries and applications.

KhepriCoat is a superior performing anti-reflective coating technology for solar cover glass. By reducing the amount of sunlight that is simply reflected back off the panels, KhepriCoat ensures that more of the sun's energy is captured – and therefore more energy produced by each solar panel. This is an important sustainability advantage – and a great example of how DSM is using its technology to help address climate change.

Wherever glass meets air, about 4% of the light hitting the glass at a perpendicular angle is reflected. And that percentage rises steeply as the light's angle of incidence increases. Obviously, for solar energy systems, reflected light is wasted light! KhepriCoat minimizes the reflection to deliver a record-breaking performance in terms of light transmission- a power gain over uncoated modules of around 3% in flash tests, and an improved additional light gain over the daily cycle of systems in the field exceeding 4% thanks to its outstanding angular effect.

The Heraeus Photovoltaics Business Unit

SOL9620 Series and SOL9621 Series

THE SOL9620 SERIES and SOL9621 Series represent Heraeus' latest pastes that enable cell manufacturers to further increase their c-Si cells' conversion efficiencies to an industry-leading level and beyond. The development of these two products are for customers with slightly different LDE applications and processing; however both pastes provide superior cell efficiencies while lowering customers' cost per watt.

The SOL9620 Series is outstanding for ultra-lightly doped emitters [ULDE], with surface doping concentrations down to 1xE20/cm3. The SOL9620 Series has demonstrated the highest performance during customer testing, particularly on monocrystalline wafers. Relative to the SOL9610 Series on 110 Ω/sq. monocrystalline wafers, the SOL9620 Series demonstrated an 80% reduction in contact resistance; approximately a 3mV increase in Voc; and up to 0.25% absolute efficiency gains.

The unique chemistry of SOL9620 Series also enable the ability to be fired through different combination of passivation layers and at a relative lower peak temperature than standard firing temperatures. This is ideal for PERC applications.

The SOL9621 Series has demonstrated great results for regular emitter and LDE applications. When tested against Heraeus' SOL9610 Series on 85 Ω/sq. multicrystalline wafers, customers experienced higher electrical performance: a 50% reduction in contact resistance; a 1 – 2 mV increase in Voc; and greater than 0.10% absolute efficiency gains. The SOL9621 Series provides customers with a flexible and robust process window, which aids in providing a lower manufacturing cost. SOL9621 is also highly recommended for the 1st and 2nd layer of double printing applications with customers confirmed efficiency gain greater than 0.10% over the best commercially available double printing pastes.

Krempel GmbH

AKASOL

AKASOL backsheet reliability protects PV modules against UV radiation and moisture during their useful life-long service. We offer a combination of polymer films and fluoropolymer films like TEDLAR-PVF film and KYNAR-PVDF film for tailored process solution. AKASOL has convinced manufacturers of PV modules across the globe of its high quality due to excellent mechanical, electrical and chemical properties as well as its exceptional weather resistance.

Product family groupings specially developed for photovoltaic engineering from combinations of various polymer films (PVF, PVDF, ETFE, PET, modified PET). Optional with aluminium foil as moisture barrier for thin-layer modules or with copper foil for back-contact solar cells.

Long service life and consistently high product quality guaranteed by ISO/TS 16949 and ISO 9001. The requirements of IEC 61730-1 and IEC 60664-1 are well exceeded. Certain types are approved as "UL Recognized Component" (File No. QIHE2. E312459) and are TÜVdotCOM certified (ID 0000033022).

Conform to RoHS and REACH. Practice-relevant variety: High-grade economical multi-layer combinations of 4-, 3- and 2-layer design. Numerous film colours to meet different visual requirements. Different thicknesses for different system voltages.

Compatible with all relevant encapsulating polymers. Excellent adhesive quality due to specially applied physical surface treatment.

Supplied as rolls or sheets for easy handling in customised dimensions. Press-cut structures on request. Labelling for traceability, also permanent marking for the life cycle of a module.

The Solar Industry Awards will be announced 9 September 2014 and the Awards ceremony will be held on the 23 September 2014 at Sofitel Legend The Grand in Amsterdam

Thin Film Innovation Award

First Solar

Thin Film Module Technology

SINCE the company's inception in 1999 First Solar has demonstrated thin-film cadmium telluride (CdTe) innovation. Developed in the United States, First Solar now has the only thin-film module technology that is proven more efficient and less costly than conventional crystalline silicon (C-Si Photovoltaic) PV modules. First Solar has dedicated research and development toward exponential innovation with multiple records for research cell efficiency increasing from 16.5% to today's record 20.4% and improving module efficiencies year over year.

First Solar currently holds the world record in CdTe research module 17% and research cell efficiency 20.4% using organic and acquired technology. First Solar has demonstrated repeated successful innovation cycles converting these historical technology developments by effectively scaling the advancements into more than 8GW of high volume production. First Solar's thin-film technology addresses the global issue of identifying an efficient cost effect and sustainable alternative energy source that competes with traditional energy sources today.

Reel Solar

1.5m² CdTe Solar Modules

COMPARED to conventional CdTe modules, RSI modules are almost three times the size, leading to greater power per module and therefore lower manufacturing & installation costs. Modules will be produced at less than 40 cents per Watt in 2015, with a path to less than 25 cents per Watt. RSI provides the option to use conventional solar glass or tempered glass with or without frames. Excellent high temperature and low light performance leading to superior kWh/kWp production. Panel size and output similar to 60 or 72 cell silicon modules, leading to similar balance of system and installation costs. RSI modules are two-thirds the cost for the same module size and energy output as compared to crystalline silicon modules. Industry standard CdTe module architecture with metal back contact, giving proven reliability.

Semprius

Four-Junction, Four-Terminal Stacked Solar Cell

SEMPRIUS, is a manufacturer of high concentration photovoltaic (HCPV) solar modules. The company recently announced it has manufactured the first four-junction, four-terminal stacked solar cell using its proprietary micro transfer printing process. In this effort, Semprius worked in collaboration with Professor John Rogers and his team at the Frederick Seitz Materials Research Laboratory at the University of Illinois at Urbana-Champaign and researchers at Solar Junction, a leading III-V high-efficiency solar cell manufacturer and important Semprius partner. The results of this project will be published this week in the journal Nature Materials.

The new stacked solar cell is comprised of a three-junction microcell that is stacked on top of a single-junction germanium microcell using Semprius' high-speed micro transfer printing process, which enables the simultaneous formation of thousands of stacked microcells with very high yields. Initial trials yielded solar cells with measured efficiencies up to 43.9 percent. This process is capable of achieving solar cell efficiencies greater than 50 percent in the near future. A key achievement of this project was the development of a new interfacial material that is placed between the top and bottom cell to minimize optical losses within the stack and thereby optimize overall conversion efficiency. In addition, the new stacked cell has four terminals, rather than the standard two. This reduces the spectral dependence of the solar cell and increases the solar cell's energy yield under normal operation in the field.

SOLARION AG

SOL Flex

SOLARION AG are the innovators behind SOL45Flex and SOL90Flex: modules in which cells are encapsulated in a flexible solar film package. The company aims to meet the market demand for lightweight and flexible modules. Solarion use copper indium gallium selenide (CIGS) technology in the production of the modules in which the cells are embedded in a flexible solar film composite.

The SOL Flex combines the features of the innovative roll-to-roll deposited CIGS thin-film technology with the market requirements for lightweight, flexible solar modules. The flex modules can be offered with a pressure-sensitive adhesive backing, simplifying installation and reducing installation costs due to the elimination of a mounting structure. These products thus offer the possibility of installation on a variety of roofing surfaces without the need for roof penetration.

Silicon Innovation Award

1366 TECHNOLOGIES

Direct Wafer Technology

CURRENT WAFER manufacturing is a multi-step, energy- and capital-intensive process that limits cell efficiency potential for manufacturers due to bulk quality defects that emerge in the wafer growth process.

1366 Technologies of Lexington, Mass., is a startup with VC funding and a DOE loan guarantee. The company's technology falls in the "kerfless wafer" category. The aim is to disrupt the traditional way that silicon-based photovoltaic wafers are fabricated.

Direct Wafer is a one-step, kerfless wafer-making process that has the potential to revolutionize wafer manufacturing. By delivering higher quality "drop-in" replacement multi-crystalline wafers with unique surface features, 1366's Direct Wafer technology forms a standard, 156mm multi-crystalline wafer directly from molten silicon.

The semi-continuous, high-throughput process eliminates silicon waste, resulting in a more powerful, low-cost wafer.

Direct Wafer produces one wafer at a time so each wafer sees identical processing conditions, enabling more spatially uniform wafers with lower dislocation densities and impurities.

Direct Wafer™ produces wafers in a controlled, environment, reducing wafer-to-wafer quality variations.

The tighter distribution simplifies manufacturing operations and product offerings, reducing inventory costs and sales challenges.

MANZ AG

PERC Production Solutions

To meet global market's soaring demand for high-efficiency solar cells and lower manufacturing costs, Manz AG offers industry-leading solutions for crystalline solar-cell (cSi) production which yields high conversion efficiencies of up to 20.5%. The new-generation production technology deploys Manz's VCS 1200 vertical vacuum coating system to deposit dielectric passivation layers on the rear of cells, together with the firm's LAS 2400 laser ablation technology, enabling cell manufacturers to achieve large-scale production of high-efficiency cSi solar cells at lowest Cost of Ownership.

The fully automated and maintenance-friendly tools boast a smaller footprint and improved efficiency over competitors' systems. They can be used for both mono- and multi-crystalline solar cells. Manz offers customers the necessary equipment and processing technology to convert standard cell production lines to manufacture the higher-efficiency PERC cells. Manz's VCS 1200 system uses a completely new technology for vertical processing, with a throughput of 1,200 wafers/hour.

Thanks to its powerful plasma source and a new carrier system, the coating process leaves no pin marks or flakes on the wafers – a problem of many competitors' systems. In addition, VCS 1200 enables single-side deposition of PECVD-layers without wrap-around of deposition on the other side. Manz's high performance PECVD process technology achieves optimum reproducibility and the industry's highest degree of cell efficiency and uniformity.

Alongside the VCS 1200 system, Manz's LAS 2400 laser ablation system provides a simple, precise and high-throughput solution for local contact opening of rear side passivation layers. Being a one-stop process, laser ablation offers the lowest cost of ownership for this step in cell production and offers safe wafer handling with the industry's lowest breakage rates.

MEI LLC

Pura Wet Processing System For Polysilicon

THE PURA wet processing system is a fully automated, robotic closed-loop system that combines an energy- and space-efficient etch and rinse system with our new FlashDry cold dry system. FlashDry uses no thermal energy for drying. MEI's Pura wet processing system is a self-cleaning, inline, configurable, automated, linear batch system made for high throughput at low cost. The Pura wet processing system is designed for dry-in and dry-out polysilicon processing.

The MEI Pura silicon chunk cleaning system is designed for removal of organic and metallic contamination found on silicon chunks, granular (FBR) or fines from the manufacturing process. Cleaning or etching silicon fines, granular polysilicon or chunks requires a high throughput wet etch system with good process control and outstanding drying capabilities to achieve optimal purity. MEI's automated system for chunk polysilicon cleaning removes silicon-

chunk surface contaminants and offers exceptional drying capability. MEI's Pura for Silicon finishing has significant advantages inherent in the carefully thought out design that considers not only operation, but resource use, safety, maintainability, control and flexibility.

Silicor Materials

Solar Silicon

SILICOR MATERIALS has developed and proved a proprietary solar-grade silicon manufacturing process that serves as an alternative to the over-engineered electronic-grade (EG) silicon commonly used throughout the PV industry, and without sacrificing performance. The Silicor process yields a material that delivers a consistent purity; regularly achieving in-line conversion efficiencies comparable to cells manufactured using primarily EG silicon.

With a production cost of less than $9/kg, Silicor's solar silicon can increase cell and module manufacturers' profit margins, whether it is utilized as a drop-in replacement for EG silicon or as part of a blend. The standard method of polysilicon manufacturing—the Siemens process—has remained largely the same since the 1960s.

The Silicor process holds numerous advantages over the Siemens process. Silicor's manufacturing process only requires between 10 and 25 kWh per kilogram of silicon produced, far less than the 75 and 125 kWh per kg of silicon produced required by the Siemens process.

Silicor's solar-grade silicon is able to offer the industry's lowest production costs while maintaining high material quality. With a production cost roughly half that of standard EG silicon offerings, Silicor enables cell and module manufacturers to, for the first time, improve profitability without performance tradeoffs.

System integration Award

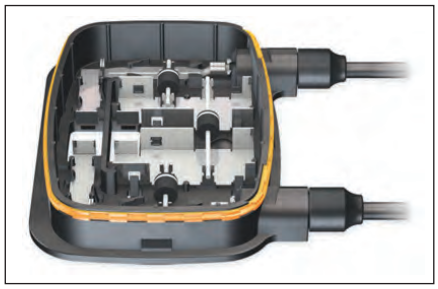
Multi Contact AG

PV Junction Box Westlake PV-JB/WL-H

MUTLI CONTACT has produced a junction box for electrical connection of horizontal ribbon conductors on crystalline modules The low profile construction of the box allows it to be installed directly under the module frame. This saves valuable time in the installation process by eliminating the need to bend the connecting ribbons.
Ribbon termination is achieved by welding, soldering, or, optionally, by terminal clips.

The box is fixed to the panel with silicone RTV. Additional protection given by the projecting cover, which prevents kinking of the cables at the point where they emerge from the cable gland.

Fully NEC 2011 compliant requiring the special tool PV-MS-PLS to disconnect the cable The Westlake is a particularly flat-built box, which can be installed directly underneath the module frame. This eliminates the need to bend the connecting ribbons, saving valuable time in the installation process.



Ribbon termination is achieved by clamping, welding or soldering.
The junction box fulfils protection class IP65 and is suited for the use in salty air.

Papendorf Software Engineering GMBH

SOL.Connect Monitoring

PAPENDORF SOFTWARE ENGINEERING stands for Monitoring, Metering and Management of energy producing systems. Under the label SOL.Connect or as OEM parts they deliver products and services to many system providers and manufacturers of photovoltaics.

The SOL.Connect Center, collects data from inverters via RS485-, RS232- or LAN interfaces.

Additional measureands like e.g. directed irradiation, module temperature, feed of power into the public grid etc. are being collected with the external sensor module SOL.Connect MultiScan and SOL.

Connect MultiIO module. SOL.Connect Web Portal und SOL.Connect Power Manager for grid security management of photovoltaic plants of more than 100 kW peak enhance the SOL.Connect product range. For all requirements the adequate product is available.

Thus a complex system is being built to validate the PV plant from local irradiation conditions up to feed parameter. Network problems as well as errors within the plant are not only being collected but also validated and selectively distributed.

skytron® pioneers of energy

Data Logger system

SKYLOG has been designed for data logging in large-scale photovoltaic power plants. The powerful data logging system for utility-scale PV installations, skylog has been designed with robustness and versatility in mind.

Communicating with the plant using any of the standard bus technologies (CAN, RS422, RS485, Ethernet), skylog can read and save data from a variety of terminal devices, irrespective of make. Its integrated uninterruptable power supply (UPS) provides power to all other monitoring components supplied by the CAN bus cable, ensuring dependable operation even in the event of a power failure.

In locations having unreliable internet connections, local data storage is secured by skylog's substantial data buffering capacity. skylog therefore forms an indispensable component of any monitoring system.

Just like any other member of the skylog data logger series, skylog records all measurement values collected in the plant, and can be employed in conjunction with almost any inverter type offered in today's solar market. The compiled and continuously updated database can be accessed on site, using a standard USB computer interface, or passed on to a third-party evaluation platform using a router.

skylog's integrated uninterruptible power supply (UPS) ensures data integrity even in power failures

awards solar NOMINATED

synapse

shoals technologies group

SolarSNAP Wireless Monitoring Tool

SHOALS TECHNOLOGIES GROUP, a manufacturer of photovoltaic (PV) Balance of Systems (BoS) components, and Synapse Wireless, an emerging innovator in wireless solutions that empower the Internet of Things (IoT), have built on their long partnership in the field of solar energy, and introduced SolarSNAP, an innovative monitoring tool that provides live-access monitoring of the installation of solar technology fields.

Solar Energy technology is defined in two parts, photovoltaic modules and "Balance of Systems." The Balance of Systems includes a combination of components, labour, assembly and installation.

As PV module pricing continues to decline, the solar energy industry is focused on reducing costs in the Balance of Systems, in order to better compete with other types of energy production.

The ability to more closely monitor and measure the installation of solar technology contributes to these savings by bringing solar energy on-line faster and more cost effectively than ever.

SolarSNAP is a monitoring tool created by Shoals and Synapse Wireless to increase speed-to-revenue for solar field owners by providing real-time data as the solar technology is installed.

SolarSNAP monitors and gives owners visibility into labour costs and contractor effectiveness, increasing the accuracy of time-to-commissioning forecasts.

It provides information on the entire solar energy commissioning process, down to the string level (between PV modules). With integration into Synapse's cloud-based SNAPShot platform, and a choice of fixed or mobile solutions, SolarSNAP provides live access to installation data from anywhere, at any time.

PV Tool Award

DEK Solar

HouYi Cell Metallization Platform

SINCE ITS INCEPTION IN 2008, DEK Solar has set out to be a solar process pioneer. The company, already market-leading suppliers of screen printing equipment worldwide, recognised that its decades of global print process expertise gave it a strategic advantage, providing the company with the know-how to develop a complete range of solutions to help photovoltaic manufacturers boost cell efficiency and reduce the total cost of ownership of their lines.

HouYi a 1350 wafers per hour, highly reliable metallization platform with a small footprint is DEK Solar's latest innovation. It builds on the performance of DEK's PV 1200 platform, with innovations that have delivered even greater reliability, enhanced print quality and further improved throughput.

As a result of these enhancements, no other metallization platform on the market is now able to provide the same levels of reliability, print quality, and throughput, delivering lowest cost of ownership within as small a footprint as HouYi.

HouYi has been specifically designed to meet the most pressing needs of today's PV firms.

INNOLAS SOLUTIONS

ILM-2 LCO-PERC Laser Machine

INCREASING CELL EFFICIENCY is the most effective way to reduce the cost of solar power, and PERC (Passivated Emitter and Rear Contact) is one of the technologies that meet the balance between manufacturing cost and efficiency.

InnoLas used its 15 years of experience in laser processing for the PV industry to design the cost effective ILM-2 production platform for lowest maintenance costs and best Cost of Ownership in the market. The ILM-2 platform is further optimized for easy integration into existing production lines and reduces handling steps if integrated e.g. via conveyor interface prior to a screen printer line or directly after a passivation tool.

InnoLas Solutions sees increasing demand for PERC solutions that can be adapted flexibly to current and future production line designs and requirements. The company designed the ILM-2 as a modular machine concept that can be used as a stand-alone or in-line system, with the option to use different laser sources.

The ILM-2 offers our customers a future-proof 24/7 production solution with an excellent uptime. This high volume production machine to open the passivation coating of PERC cells by a laser lift off process.

The ILM-2 comprises an improved laser and optical setup which allows perfect control of the contact opening at the highest process speed. It enables a dashed line pattern layout enhancing the cell efficiency.

For the first time a novel dashed line pattern layout was enabled at high process speed. Such the cell efficiency can be increased at lowest cost of ownership.

Meyer Burger Technology Ltd.

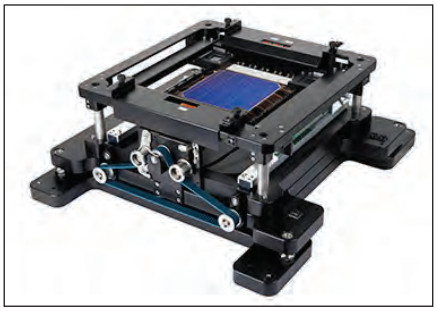
GridTOUCH

THE PATENT PENDING GridTOUCH contacting system is a solution that addresses the new market need of contacting busbarless cells for IV/EL performance measurements. This innovative system is a measurement jig consisting of an upper frame and a bottom plate. Both the plate and frame have a grid of wires.

These grids are aligned perpendicularly to each other thus ensuring an optimum connection of all fingers on the front side of the solar cell and a highly accurate evaluation of the fill factor (FF and other key IV parameters.

The GridTOUCH also ensures that the shadowing on the cell is minimised and that the IV measurement is both precise and highly reproducible. The system

enables customers to perform the most accurate sorting of busbarless cells at lowest costs.



The challenges faced are threefold. The first one is to ensure proper contacting of the fingers to minimise the contact resistance and obtain a reproducible evaluation of the FF.

The bowing difference between 2 cells as well as the discontinuous finger's height of a single cell is a real challenge. The second was to answer the market need of providing a solution suitable for various types of printing patterns rear side fully metallised perpendicular fingers etc.

The last challenge was to develop an industrial and cost effective unit that could be used to sort cells with highest precision.

The GridTOUCH has overcome all of these challenges through creative engineering design the convex bottom plate and the strength given to the upper wires maximise the number of fingers contacted while limiting the pressure on the cell and thus allowing measurement of really thin cells 120 μm.

In order to minimise the maintenance costs and downtime the system has been designed to maximise the number of contacts that exceed 3 million cycles. The replacement of the frame can be done within a few minutes.

NOMINATED

Unisim Compact Solar Simulator

THE 'UNISIM COMPACT' solar simulator provides the close-match spectra of our standard dual source 'Unisim' solar simulators in a low cost and compact form for bench top applications. The system provides a stand-alone instrument including front panel controls, a complete IV measurement system as well as a pneumatically controlled shutter and enclosure mechanism for easy, tool-less maintenance. This instrument is the first of its kind, allowing a whole group of researchers, who were previously limited to basic instruments, access to a high quality solar simulator to advance their research.

With high efficiency multi junction solar cells requiring a close match spectrum in order to achieve the most accurate calibration and results some research laboratories have been forced to use crude single source instruments for small scale research applications where only a relatively small beam size is required.

Many research groups are also limited by physical floor space or budget which means our larger solar simulators such as our standard Unisim range are not an option. The Unisim Compact makes the world leading close-match spectrum which TS-Space Systems is known for available in a bench top form and at a low cost whilst retaining all the salient features our customers love about our standard Unisim range.

This opens up a world class instrument to a range of researchers who were previously limited to basic single source simulators.

The Unisim Compact comes as a stand alone instrument with a full IV measurement system and built-in source meter. The dual source optics features our pioneering highly stable metal halide arc lamp and standard quartz halogen lamps which can be controlled and shuttered via the front panel. An intensity indicator is also built into the system in order to monitor lamp light levels.

The easy maintenance of the lamps and optics is aided by a pneumatically controlled enclosure lift mechanism providing full 360 degree access to the simulator optics without any tools or physical effort.

The system is also designed to take additional drop-in filter units which quickly and easily convert the close-match AM0 spectrum to AM1.5. We are the first and only company to produce not only a dual source solar simulator of this type but also in a form factor suited to smaller laboratory applications.

The Solar Industry Awards will be announced 9 September 2014 and the Awards ceremony will be held on the 23 September 2014 at Sofitel Legend The Grand in Amsterdam

PV Process Award

K-Space Associates, Inc.

KSA BandiT PV

K-SPACE manufactures state-of-the-art in-situ, real-time thin-film deposition monitoring tools, and has over 20 years of experience in the thin-film metrology field. Today's solar power generation industry is quickly evolving with a new breed of compound semiconductor materials leading the charge.

These new, thin-film based materials have already surpassed performance requirements needed for global deployment.

However, mass production and yield problems have limited broad commercialization of these promising thin-film PV materials.

A key factor in producing the highest efficiency cells at the lowest cost will be the successful deployment of automated high-volume production with tight process control. To achieve this goal, it is essential that monitoring methodologies be implemented for higher conversion efficiency and reduced manufacturing costs.

This includes implementing in-line metrology tools that monitor the performance metrics of thin-film PV materials being produced so that the manufacturing process variables can be controlled and optimized in real-time.

k-Space has directly addressed this important in-line metrology need with our kSA BandiT PV system.

kSA BandiT PV spectrally analyzes diffusely reflected light via solid state electronics to enable measurements over a wide spectral range. Modular designs and flexible geometries allow for rapid measurement at multiple locations across either glass panel or flexible substrate processing lines.

Meyer Burger Technology Ltd

Diamond Wire Management System (DWMS)

DIAMOND WIRE MANAGEMENT SYSTEM (DWMS) is an enhanced wire winding system uniquely designed and available for Meyer Burger diamond wire saws.

The DWMS is marketed under the name of DW288 as an integrated option of the successful DW288 platform for mono and multi silicone wafering in the PV industry.

During cutting the wire is wound and unwound on spools on each side of the wire web respectively. Without DWMS the aggressive wire is wound directly onto the storage spool on overlapping windings and can therefore damage itself. The innovative DWMS design separates the spool into a supplier (storage part and a working part.

On the working part the wire is wound in non-overlapping windings with a minimal pitch. This completely eliminates wire to wire contact and keeps the wire sharp.

The wire winding system of the diamond wire saws is enhanced by dividing the spools on both sides of the wire web into a supplier (storage and a working part.

Before starting the cutting/pilgrim mode fresh diamond wire is transferred from the storage part via the wire web onto the working part of the spool (on the wire supplying side of the web.

During the wafering process itself the wire is wound back and forth in non-overlapping windings without wire to wire contact.

The wire management systems of all wire saw suppliers are direct derivatives of wire management systems for slurry based cutting. Wires for slurry based systems are non-aggressive bare wires.

Such wires can be wound and unwound onto conventional spools in overlapping windings with no harm occurring to the wire itself.

Rudolph Technologies

Discover Solar Data Management Software Tool

DISCOVER SOLAR data management software tool helps photovoltaic (PV) cell manufacturers reduce manufacturing costs and increase average cell efficiencies.

The system is designed for both high volume c-Si cell production as well as thin films. Discover Solar provides a wealth of capabilities useful for manufacturing to control the line and engineering to optimize the performance of the line.

- Automatically pin points tool issues impacting cell efficiencies
- Fast and comprehensive “drill-down analysis”
- Automated reports
- Equipment performance and history tracking
- Comprehensive charting, correlation analysis, advanced filtering
- One-click data export to Microsoft Excel
- “Real-time” health of line monitor
- Identify incoming material issues
- Advanced SPC alarming specifically designed for PV manufacturing
- Identify second order effects between tools, process, steps or recipe settings

PV Balance of System Award

Horizontal Single-Axis Solar Tracker Exotrack HZ

EXOSUN’S EXOTRACK HZ is a horizontal single-axis tracker for utility-scale PV applications.

Exotrack HZ boosts system output by as much as 25 percent in comparison to fixed-tilt systems and its unique design mitigates maintenance costs for 25 years at minimum.

Solar trackers are an increasingly popular balance of system component installed to optimize yield in utility-scale systems. Exosun’s Exotrack HZ is a horizontal single-axis tracker for utility-scale PV applications that offers customers a more cost-effective and reliable tracking solution than competing technologies.

Exotrack HZ increases system output up to 25 percent verses fixed-tilt systems and is designed to mitigate maintenance costs for at least 25 years.

The technology features an east-west tracking range of ±50 degrees and a tracking precision of 1 degree.

At the heart of the Exotrack HZ is the Exobox a centralized monitoring and control system that supports up to 4 MW of trackers per unit.

Operators can further optimize Exotrack HZ-equipped systems by implementing Exosun’s proprietary backtracking algorithm to drive the tables’ positions in order to avoid panel on panel shading during periods of low solar height - early morning and late afternoon - thus limiting power production loss.

The Exotrack HZ includes a patented individual backtracking program called SMARTracking™ which limits the impact of panel on panel shading on the plant’s yield. As a result an additional 5 percent output can be gained in comparison to other traditional single-axis trackers.

Solaredge Technologies, Inc.

Module-Level Optimization byPower Optimizers

MODULE-LEVEL optimization of DC solar power harvesting is an innovative concept developed by SolarEdge which leads this market segment with 70% market share. The SolarEdge topology separates the two functions traditionally managed by the solar inverter so that DC/AC conversion is still carried out in the string level keeping system costs low while Maximum Power Point Tracking (MPPT is handled on the module level by power optimizers guaranteeing maximum power production from each module individually.

Power optimizers eliminate all power

losses that result from MPP mismatch between modules (due to shading soiling temperature mismatch uneven aging manufacturing tolerance and many other reasons.

Module-level power optimizers track the Maximum Power Point (MPP per module guaranteeing that it is producing the maximum possible power while not affecting the rest of the modules in the string.

SolarEdge power optimizers also measure the performance of the modules and transmit performance data to the module-level monitoring portal. This enables cost effective maintenance of the PV system due to pinpointed alerts on any underperformance issue. Additionally power optimizers keep a safe DC voltage during installation maintenance firefighting and any other emergency.

Whenever the inverter or the AC power are shut down power optimizers will automatically reduce modules voltage to 1V to prevent electrocution and fire.

Finally the module-level MPPT and fixed string voltage features of the SolarEdge solution eliminate all design limitations of traditional inverters allowing quick and easy system design with parallel strings of unequal length multiple orientations in one string modules with different power ratings in one string and full roof utilization for larger system capacity.

VarioString: Isolated Dual Channel High Voltage MPPT

VarioString is a high power isolated dual channel MPPT solar charge controller for off-grid systems and battery based energy management systems up to 105kW. It is compatible with all battery technologies (lead-acid lithium-ion NiCd etc. due to its programming options for the charge cycle. Its fast and accurate algorithm ensures an MPPT efficiency of more than 99%.

The ability to arrange the dual MPPT inputs independently or in parallel (with max 600Voc or in series (with max 900Voc allows the VarioString to be used in a wide variety of PV configurations and eliminates the need for some Balance of System (BOS components such as junction boxes string fuses and high gauge wire to connect the PV array to the battery storage area.

While battery based solar MPPT solar charge controllers are typically used for off-grid applications increasingly the DC-coupling of PV is used in battery based energy management systems with connection to the grid to increase system stability and system efficiency for energy consumed when the sun is not shining.

The VarioString responds to the need to decrease BOS costs increase flexibility and modularity of BOS components and at the same time increases system performance and overall energy yield.

The VarioString has been designed to meet the needs of battery based management systems. The high voltage DC input allows for longer strings of PV modules much like is common with standard grid-tie inverters which decreases the BOS costs and greatly simplifies installation.

The fully programmable 4-step battery charger extends the life of batteries which reduces O&M costs and the amount of batteries being disposed of. The VarioString makes it possible to create flexible residential PV systems with only one device. Studer had the forethought to create a product with high power and high efficiency for different PV arrays.

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Manufacturing **success**

Chinese manufacturer Serpahim is only a few years old but is alreay making a splasjh as making some of the best PV panels in the world. David Ridsdale looks at what was behind the success story and discovers a high tech background that is no surprise.

SOLAR MANUFACTURING has become a lucrative global enterprise with competition increasing as company's attempt to maintain a foothold in a consolidating market. Despite the opportunities available in a global market place there appeared to be little room for new entrants in PV and solar manufacturing and less likely that such a new comer would have much impact.

For this reason many industry observers were surprised when a relatively unknown start up company topped the 2012 yearly rankings for Photon International's annual performance and yield list. This followed their impressive debut the year before when they were ranked second. The results put Chinese company Seraphim firmly in the cross hairs of industry attention. How could a tier two company only three years old not only top the table but appear to surpass the performance of competitors who had been developing their product for much longer.

When I first came across the company I did a bit of reconnaissance and came across a video the company had released showing its manufacturing facility. I remember thinking at the time how much the facility and the video presentation reminded me of semiconductor manufacturing, where I had cut my editorial teeth. The high level of automated manufacturing and attention to detail struck me as closer to the rigours of semiconductor manufacturing than the usual PV cell manufacturing plant.

A quick look at the top brass at Seraphim confirmed my suspicions that the company had been set up by individuals from the semiconductor manufacturing sector. The technical team all have excellent backgrounds in the very competitive semiconductor industry at the highest levels.

Endy Qian is the Operation Director for Seraphim and holds an MD in Management and a Bachelor Of Mechanical-Electrical Integration. Endy began his career with semiconductor tool manufacture Semitool and from 2005 was technical support manager for Applied Materials where he held responsibility for East Asia. While these companies may not be as well known in the solar industry they are giants of the semiconductor manufacturing sector. Seraphim also boast Light Li as head of sales ad marketing. Light holds an MBA and Bachelor Of Science And Technology. Light worked for AMD in China at the turn of the century before managing Asia region business for semiconductor packaging leader Kulicke and Soffa.

The third leg of Seraphim's public leadership is Woophen Zhu who acts as Supply Chain Director for the company that has decided to tackle the PV value chain from ingot to module. Woophen holds a Bachelor Degree Of Micro-Electronics Science and spent more than 5 Years In KEC Korea, a Korean Wafer Fab and then as Sales Director for Sunpass PV equipment division.

These three key individuals have brought a very technical and well thought out plan to the company based on their semiconductor expertise. The road map for Seraphim from the very beginning was bullish in its goal to become the best PV module in the world. Such a claim at the start up phase of a company is best taken with a grain of salt but Seraphim has consistently backed its initial claims with consistent outcomes.

Of course it is not just the technical side that can allow a company to move so impressively along its chosen technical path. Setting up the factories and developing product along the entire value chain is not a cheap process and Seraphim has the full financial backing of diversified business giant Honland Group.

While the name may not be so well known outside of China, the Honland Group is a rapidly growing group of companies that began in 1969 as a farm machine manufacturer. The group has now diversified into furniture and lighting specialists with a strong Real Estate group developing and a section for rising technologies. They have developed a strong presence in the cabling sector and have a strong capital base.

At present the Honland Group is keeping a very low profile in Seraphim's affairs and as yet have not included it on the corporate structure. As a privately held company they do not disclose the financial support but considering the three FABs which cover everything from silicon ingot, solar cell and solar

modules, it is a considerable amount. All of these FABs are equipped with the state-of-art manufacturing and advanced testing equipment that again requires millions of dollars.

Whatever the deal struck, it has allowed Seraphim to stick to its technology roadmap without interference from constant financial reporting needs. Backed by the Honland group, Seraphim has the ambition to be a world-class professional provider of solar energy solutions, with more than enough stability and reliability to offer long term warranty to global customers.

Seraphim has not just shown foresight and trust in its product offerings but has the highest performance warranty of any manufacturer with panel performance guaranteed at 90% for a decade. Materials that make their modules also carry a decade long warranty, which is an industry first. The company also spent the time ensuring they have the right financial insurance and are considered a bankable provider of modules by leading financial institutions. It was an impressive start for a tier two company but how to make such plans a reality.

Tier of success

The financial world has imposed the idea of tier companies on the solar industry as a way to differentiate size and output for different companies. Unfortunately many have presumed that such a tiered system must also reflect success or standard of product. Companies are regarded Tier 1 when they spend a significant amount on R&D, have an automated manufacturing process and are vertically integrated in manufacturing cells and module assembly. They also have to have been running for more than five years as an indicator of longevity and likelihood to cover long warranties. Companies designated tier three tend to be assembling other people's efforts and despite been relative newcomers to the industry make up the bulk of panels for sale around the world.

Seraphim is still considered a tier two company which is a company with a smaller percentage of R&D and only partial automation. The company does not fit this description but does not have the years to be classified tier one as yet.
It would be fair to say that Seraphim initially suffered as many potential customers did not fully understand the tier system.

The only way for Seraphim to make progress was to prove their claims of the world's best solar panels. Partnered with leading material suppliers like Fujifilm in Japan, Seraphim has conducted an enormous amount of R&D to improve the PV module's reliability and power output performance.

Not content with taking top position on the Photon panel list, Seraphim became the first company to pass the TUV "Thresher Test". The test is based on 3 times stringent testing standards than regular IEC61215 + IEC61730, the PV modules that pass the Thresher Certification offer a much higher level of confidence in terms of long-term reliability as compared to those having standard certification. The R&D team has also poured efforts into improving the PID performance through optimal material configuration, processing control to final product performance verification. All tests have shown the module to be PID free.

Heading the rankings

At present the only public system that tests and ranks PV modules is the Photon International independent research with a test site in temperate Germany. Traditionally monocrystalline has provided a higher efficiency output than polycrystalline in these tests although the difference has been shrinking and was only 0.6% in the 2013 rankings. Seraphim has been high in the rankings since 2011 and produced a high performance ratio of 93.6%. The company demonstrates its trust in its efforts with its 90% guarantee for 10 years.

In 2012, Seraphim topped the chart in the Photon yield test not counting Sunpower's entry which is a different type of technology. In 2013, Seraphim dropped to 12th place, which appears a drop but it stayed with a strong rank. It beat all other panels that had been tested for 12 months or more. In the 2013 findings, Seraphim panels were the highest placed panel that have a two year history on the test and only lost 1% in performance in the time between the two tests. If the test was adjusted to show initial performance ratios and then subsequent annual results, then instead of 12th place on the chart Seraphim would come in at number 3.

The company has drawn on its semiconductor roots in also internally developing an advanced Management Information System (MIS) to realise a "real transparent production system". The sytem allows customers to be aware and track every detail of an order. Companies can place an order with Seraphim and then remotely follow the progress from material production through the processing and then testing all the way to packaging, to the till and then delivery.

Getting to know you

Despite the conventional wisdom that monocrystalline panels outperform polycrystalline panels, this is not the case in hotter climates. Testing in areas such as Australia's north sees polycrystalline become more efficient suffering less degradation in the heat than monocrystalline efforts. Seraphim has used this knowledge and focused early sales efforts in such regions with good effect.

The company is now expanding further and faster into European and US markets as well as gaining strong business in Asia as a premium solar supplier. Every potential customer issued to sales people saying they have the best panel for sale but very few can back the claim.

By using the experience in semiconductor manufacturing the team at Seraphim have created one of the highest functioning manufacturing facilities in the solar industry. By applying the same high standard of manufacturing as can be found in the semiconductor world, Seraphim has achieved a standard of PV manufacturing that is fast becoming the industry benchmark.

As they move into each new area they develop local infrastructure such as the Rotterdam site they have set up to feed European demand. The company is fastidious in achieving the highest quality product and have passed every test available. Including fire tests, ammonia certificate, salt mist compliance and on-site power measurement validation.

It would appear the company's only remaining problem is gaining brand awareness. Based on their early success in early markets and a reputation as the most technically adept polycrystalline manufacturer in the industry, I think it is fair to say the company will only gain in recognition and be regarded as a tier one choice regardless of external perceptions and rankings.

INNOVATIVE SUPPORT

In order to remain competitive, solar photovoltaic (PV) installers are continuously looking for ways to cut installation costs; both with improved hardware and with faster installation. Nora Hendrickson, Solar Engineering Consultant at norizz solar design and Tom Hood, CEO and Founder of Giga Solar FPC describe current U.S. residential trends and innovations in solar mounting hardware for sloped-roof, and introduces a new concept in PV module and support structure design.

2013 was a record-breaking year for the U.S. solar industry, with a 41% increase in the number of total installations. 2014 is on track to be another record-breaking year of solar growth, and there is a continued strong focus on cost reduction. Module prices have come down dramatically over the past few years, and it is not clear that additional large cost reductions can continue, and therefore the emphasis is now on cost reduction in the balance of systems (BOS).

As an example, in 2012, the solar market was introduced to the idea of using microinverters to create AC output at the module level. It seemed that every major module manufacturer was in some stage of contemplating or developing an AC module. The initial idea behind AC modules was to allow for solar installations on roofs that have shading issues. In just a couple of years AC modules using microinverters have become commonplace in the residential market. The benefits of AC modules are three-fold: flexibility in system design, reduced installation risks and, lastly, increased overall system efficiency. All of these benefits result in lower installed systems cost.

Although microinverters are not in and of themselves lower cost than the junction box and series inverter hardware, the introduction of AC modules has lowered the on-the-roof installation time by 30 percent. The time spent in the factory to combine microinverters with the solar modules is a significant cost savings that has reduced installers' operating expenses, and ultimately the system price for the homeowner.

As mentioned, innovation for solar rooftop systems is now focused on the balance of systems (BOS) hardware along with installation labor and soft costs (i.e. permitting, inspection, etc). Much of this activity is centered on the development of low-cost, durable racking solutions that are easy and fast to install.

Current racking hardware characteristics

Rooftop solar installations can be both tricky and time consuming due to the complexity of current mounting and racking hardware, along with the unique characteristics encountered with each roof. Currently, residential solar racking hardware consists of field-assembled parts that are attached to the homeowner's roof. Available racking hardware is compatible with many different types of solar modules, but most of the hardware is not

Left: Figure 1: EcoFasten's simple design with few parts (Source: EcoFasten)

specifically designed to be paired with any one module type or manufacturer. It is common for roof mounting hardware to be selected by the installer. This hardware is manufactured and supplied by companies that do not produce the solar PV module. This separation of module and racking leads to a very large number of possible equipment combinations on the rooftop. Equipment variability combined with installer workmanship directly impacts longevity of a project. As a result, the homeowner is exposed to a wide range of potential outcomes from a quality, cost, appearance and performance perspective. If racking could be integrated with the module, a great deal of variability and uncertainty would be removed from the installation and equipment selection process.

In the U.S. residential solar installations require penetrations into the rooftop to secure the modules, and therefore, one of the risks with any PV installation is the potential for roof leaks. Because PV systems are expected to have a 25-year lifetime, all roof penetrations must be properly sealed. The hardware design and installation quality directly impact the integrity of each roof penetration. An improved system would reduce the total number of penetrations, while also providing a secure sealing method that is proven to provide many years of leak-free performance.

This paper describes a currently popular hardware system (consisting of the EcoFasten Solar bracket combined with a Unirac rail system) to a newly-developed, direct-mount, integrated module and support system from Giga Solar FPC, Inc., a northern California start-up focused on innovative PV modules and mounting systems.

Current hardware design

To accommodate different types of rail supports for solar modules EcoFasten Solar offers three mounting hardware solutions for composition shingle roofs. Figure 1 shows the EcoFasten Solar, GreenFasten GF-1 bracket system. The EcoFasten Solar bracket system is a fast-growing, low-cost attachment method. The GF-1 bracket system consists of only four pieces of hardware as shown .

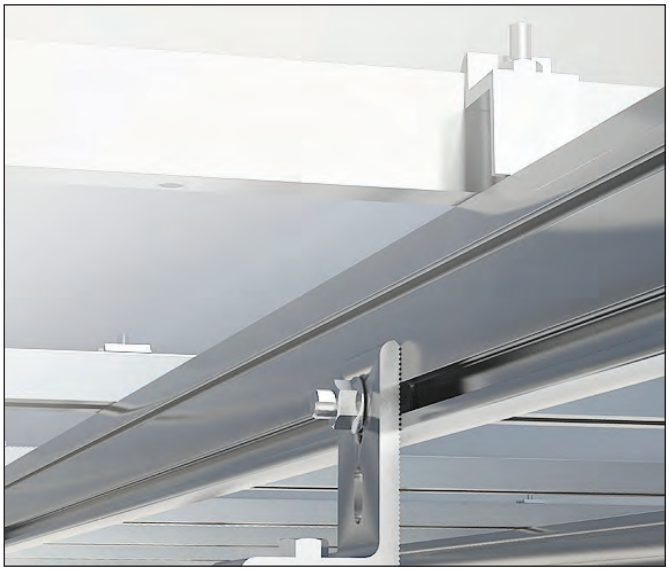


Figure 2: Unirac SolarMount' rail system (Source: Unirac)

1. Flashing
2. Compression bracket
3. Bonded washer
4. Lag screw

Another step to lower the cost of hardware and installation was announced by Unirac. The company introduced a new type of rail that has built-in wire clips. This simple design change reduces Unirac's manufacturing costs by 5 to 10 percent - savings that are passed along to installers and homeowners.

Wire clips have traditionally been manufactured as separate parts from rails and mounting hardware. By eliminating the need to manufacture separate wire clips, Unirac's development will reduce production cost and increase the efficiency of a system. One less part to order, manage, kit, and install saves installation time and resources. Unirac's product roadmap indicates that incorporating power management and electrical components into racking hardware is the direction for future products.

Figure 3: Giga Solar PV module and support structure

Current costs

The U.S. national average installed system price for residential PV systems was $4.93/Watt for Q1 2013 Hardware cost is generally unaffected by project location, but there can be a large regional installation cost difference due to labour rates as well as installer-specific issues; such as level of expertise, installer company size and use of best practices. A significant portion of a solar PV system's cost today is labour related. Labour costs include the upfront engineering and system design, combined with installation and project follow-up. For example skilled labour in Texas is less expensive than in California, and this contributes to a mean installed cost difference of nearly $2/Watt (2012 data) with Texas at $3.90/Watt and California at $5.70/Watt. Current cost of installation in the mid-Atlantic is thought to be between $3/Watt to $4/Watt .

The US Department of Energy (DOE) SunShot program has a 2020 target installed system cost of $1.50/Watt for solar PV residential systems (see Table 1, below). Module pricing has dropped from $3.50/Watt in 2008 to approximately $0.70/Watt today, so the cost reduction emphasis must be on non-module costs. The DOE SunShot goal of $1.50/Watt is based on the cost structure for the system.

The total BOS-related cost (not including the electronics) in the DOE 2020 scenario is $0.84/Watt, which is a 76% reduction from the BOS costs of $3.50/Watt8 reported for 2010. The 2012 BOS costs in U.S. residential PV was reported as $3.82/Watt, indicating that very little progress has been made on reducing BOS costs over the last several years. It's thought that currently ~$1.00/Watt is attributable to the installation labour and non-power electronics hardware which are a part of the BOS costs.

A new approach

Giga Solar modules appear visually similar to traditional glass modules, but the benefits are behind the solar cells. Giga Solar has developed modules that are lightweight and include integrated mounting hardware. Giga Solar modules alone are 60% lighter than traditional glass modules. Giga Solar modules are a non-glass and frameless design that rely on a high-strength, rigid composite to support the crystalline silicon cells.

In the factory Giga Solar's module is directly attached to a lightweight, low-cost aluminum support structure, thus creating a single component for easy and fast installation at the job site. The corrugated pattern of the metal support structure (shown in Figure 3) allows for both the cooling of the modules, as well as, for an efficient transfer of wind and snow loads from the module to the roof. The bolt slots at the ends of the support structure allow for quick attachment to the roof. Giga Solar modules offer a true flush-mount on a composition shingle roof, giving a clean look to the system (Figure 4).

A typical 260 Watt, 60-cell glass solar module weighs 40 - 45 pounds, while a 60-cell Giga Solar module (only) weighs just 16

Figure 4: 2, 260Wp Giga Solar modules installed on a test roof

lbs. and produces the same power. The combined weight of a 60-cell Giga solar module plus support structure is 27 lbs, still a 35% weight reduction from the traditional glass solar module (alone). Heavy modules lead to higher transportation costs, longer installation time, potential installer injury and higher roof loads.

The module support structure includes pre-drilled wire management holes with silicone grommets. Figure 5, below, shows a junction box and jumper cables that run through the integrated mounting support structure. This solution prevents conductors from being directly exposed to UV and the weather, as well as to (hungry) animals. It also eliminates any chance that the conductors will become loose and sag onto the rooftop where they could wear prematurely. The inter-module connection (see Figure 6,) is made at the edge of the module support structure where the MC3 or MC4 connector passes through the aluminum wall to the adjacent module. This design provides a true plug-and-play installation.

Giga Solar benefits

The benefits of Giga Solar's technology can be grouped into three main categories – hardware cost, installation labour cost and design flexibility. The Giga Solar product is designed to make every installation quick and simple.

There are only two main components to attach to a composition shingle roof:

1. The roof flashing, and
2. The integrated module/support structure

The Giga Solar aluminium roof flashing is similar to an EcoFasten flashing but is supplied in long strips. These long strips come with pre-drilled holes on 16" or 24" centres for attachment with lag screws to the underlying rafters. Once the first rafter is located, the flashing is placed and attached, providing a template for additional rafter-attachments through the pre-drilled holes. This saves time during installation and increases accuracy of locating rafters. The combination of light weight and direct mount allow for approximately 20-30% fewer penetrations than current systems, saving labour and decreasing the likelihood of a leak later on.

The flashing strip includes pre-assembled bolts that "stick up" from the roof surface. The inter-bolt spacing is matched to align with the inter-hole spacing on the aluminium support structure mentioned earlier. Once the flashings are in place the module/support structure is lowered onto these bolts, a washer and nut are used to secure them to the roof via the flashing strip as shown in Figure 7. Module racking and mounting hardware described earlier in this article contributes approximately $0.44/Watt to the cost of a US residential solar installation. The value-add of module-integrated mounting, such as proposed by Giga Solar, is expected to save 50% or more, eliminating a minimum of $0.22/Watt from the cost of residential mounting hardware today.

Labour costs

From a labour standpoint, the time that it takes to install a residential solar system depends on:

- System size
- Roof complexity
- Hardware design
- Skill level of the installation crew

The Giga Solar system is designed to go onto the roof much quicker than the existing systems. Today's labor costs for US Residential PV systems is in the range of $0.51 to $0.55/Watt . Although Giga Solar cannot provide actual installation cost data at this point in time, the company believes that it's simplified, direct-mount system can reduce installation cost by as much as $0.35-$0.40/Watt.

Summary of cost savings

The combined savings from hardware and labor for the Giga Solar system in residential rooftop installations could therefore be as much as $0.55 -$0.60/Watt. On a 6kW system these savings amount to $3,600 and helps to bring the total installed system costs that much closer to the DOE SunShot goals for 2020.

Design flexibility

Standard crystalline solar PV modules are typically either 60-cell or 72-cell configurations. Giga Solar is currently evaluating modules larger than 72-cell to allow for greater design flexibility (and lower BOS costs). Giga Solar modules are feasible in large sizes because of their lightweight design. With the ability to

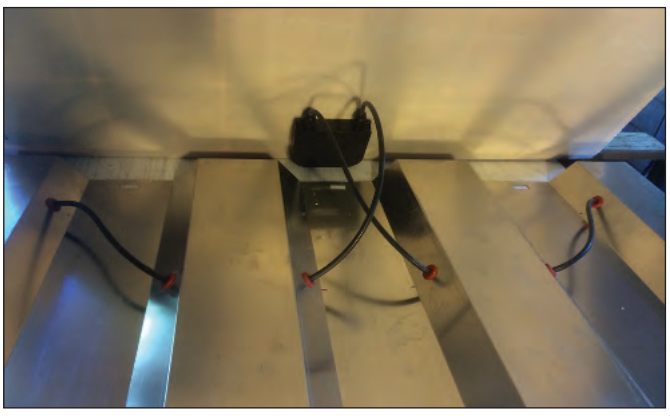


Figure 5: Giga Solar JBox with electrical conductor management

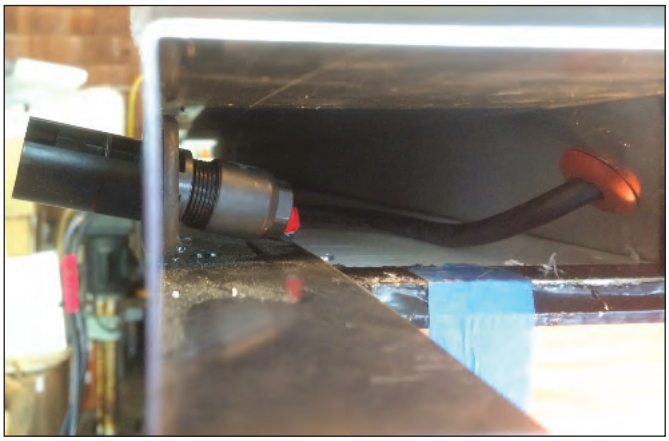


Figure 6 – Traditional PV connectors for high-integrity module-to-module connections

construct rooftop modules from 105 to nearly 500 Watts, Giga Solar modules have the potential to dramatically change how rooftop solar projects look and how they are designed.

In addition to a limited variety of sizes, the current residential PV module manufacturers offer a limited number of solutions for complex roofs. Small and non-rectangular modules could provide increased roof coverage resulting in higher system performance and better appearance.

This design variation is difficult for standard module manufacturers due to the fact that module glass is cut to a specific size and then tempered, which does not allow for off-size or custom shapes. Giga Solar's non-glass construction and large module sizes could satisfy multiple needs for complex roofs. To validate the concept of Giga Solar's lightweight modules,

Figure 7 – Attachment of the module/support structure to the roof

several residential solar installers were polled. The overall initial reaction was very positive, with some common questions about grounding details, running homerun wires for large arrays, and (micro)inverter compatibility.

The most common comment was related to the lightweight design of the Giga Solar modules. Diego Creus, owner of Argent Solar in Arizona said, "I'd love to be loading 15 pound modules on a roof. I am too old for the 40 to 45 pound modules." Creus was also impressed with the ability to select modules larger than 72-cells. In Arizona, there are many planned communities that have tract homes with large open roof space. Creus mentioned that if he could use a single large lightweight module to cover an entire roof surface with a lower $/Watt cost, "he'd switch to Giga Solar modules in a heartbeat."

Shahin Haynes of Peak Power Solutions in California thinks that the concept of the lightweight module is good, but sees several potential setbacks related to permitting. Haynes' main concern is related to the corrugated racking material, he said, "I see issues with the wind getting up underneath that material and acting like a sail and I know cities would be asking tons of questions as well. In order to fully validate the strength of the corrugated support structure, Giga Solar must have the modules tested, evaluated, and certified by proper listing agencies before they are available for market use."

Market entry

The next steps of development include electrical hardware certification, power management compatibility and testing, fire-rating testing, accelerated lifetime testing, and formal listing by California Solar Initiative (CSI). The modules must be certified by UL or ETL to validate their electrical components and ensure that they meet all requirements set forth by the National Electric Code (NEC). Giga Solar's modules and mounting structures are available today, but come without full IEC/UL certification. The certification of the Giga Solar modules will have to include evaluation of the integrated support structure. This certification will include wind and snow load calculations to confirm that the support structure is able to meet the expected stresses in extreme weather conditions.

Conclusion

The solar PV industry is growing fast and is expected to have an exciting future. The rate of growth will depend heavily on how quickly new products can reduce the cost of the PV system. There is great potential for solutions like Giga Solar's lightweight, integrated module and support structure to change the way that residential solar systems are installed. Once tested and certified, Giga Solar modules will provide lightweight, racking-integrated, size-scalable modules with flexible design options.

Combined with power management technology such as microinverters and DC-DC optimizers, PV technology of the future can provide homeowners high-performance and low-cost renewable energy solutions that are easy and fast to install.

Pushing performance to the *maximum*

The current methods for PV and solar manufacturing has developed a particular process for each type. Some of these methods are reaching their natural end and manufacturers are seeking higher efficiencies with manufacturing improvements. Filip Duerinckx and Jozef Szlufcik of international research centre imec discuss how to push conventional 2-sided contacted solar cells to its maximum capacity.

ABOUT 90% OF THE SILICON solar cells commonly manufactured are based on screen-printed Silver (Ag) front contacts and an aluminium-BSF (Back Surface Field) as rear passivation. The success of this type of cell lies in the relatively low manufacturing cost and straightforward production technology.

But they also have a downside: the typical efficiency on monocrystalline silicon is limited to about 19%. To overcome this hurdle, alternative cell concepts are being developed, such as PERx-type solar cells promising efficiencies of 22% and higher. Researchers at imec have developed n-PERT solar cells, a specific version of a PERx-type cell, with unique properties, achieving as much as 21.5% with a clear roadmap to reach 22.5% .

The PERx family

The main silicon solar cell structure used in industry today is based on the Aluminum Back Surface Field (Al-BSF). It typically consists of a p-type multi- or monocrystalline silicon substrate doped with phosphor on the front side to create an n-type emitter. Silver contacts are applied as front metallization by screen-printing on top of a silicon nitride layer (SiNx) which serves as anti-reflection coating. The rear side is covered completely with screen-printed aluminum, used as contact. Subsequently, a firing step is applied to make good electrical contact between the screen-printed metals and the silicon substrate. During this process, the aluminum alloys with silicon forming a highly doped BSF. This layer passivates the rear side of the cell by means of an electric field and thus reduces recombination of free carriers.

The drawback of this kind of solar cells is that the efficiency is limited to about 19% on monocrystalline wafers. This is due to the moderate passivation at the rear side which is not sufficient to prevent some recombination losses. Also, the internal reflection at the rear surface is limited to values around 70% so a considerable part of the light is lost by parasitic absorption. Another issue of Al-BSF cells is warping due to a mismatch in thermal expansion coefficient between silicon and aluminum. This will cause problems as substrates get thinner, which is the expected trend in the PV industry in order to save on silicon material costs.

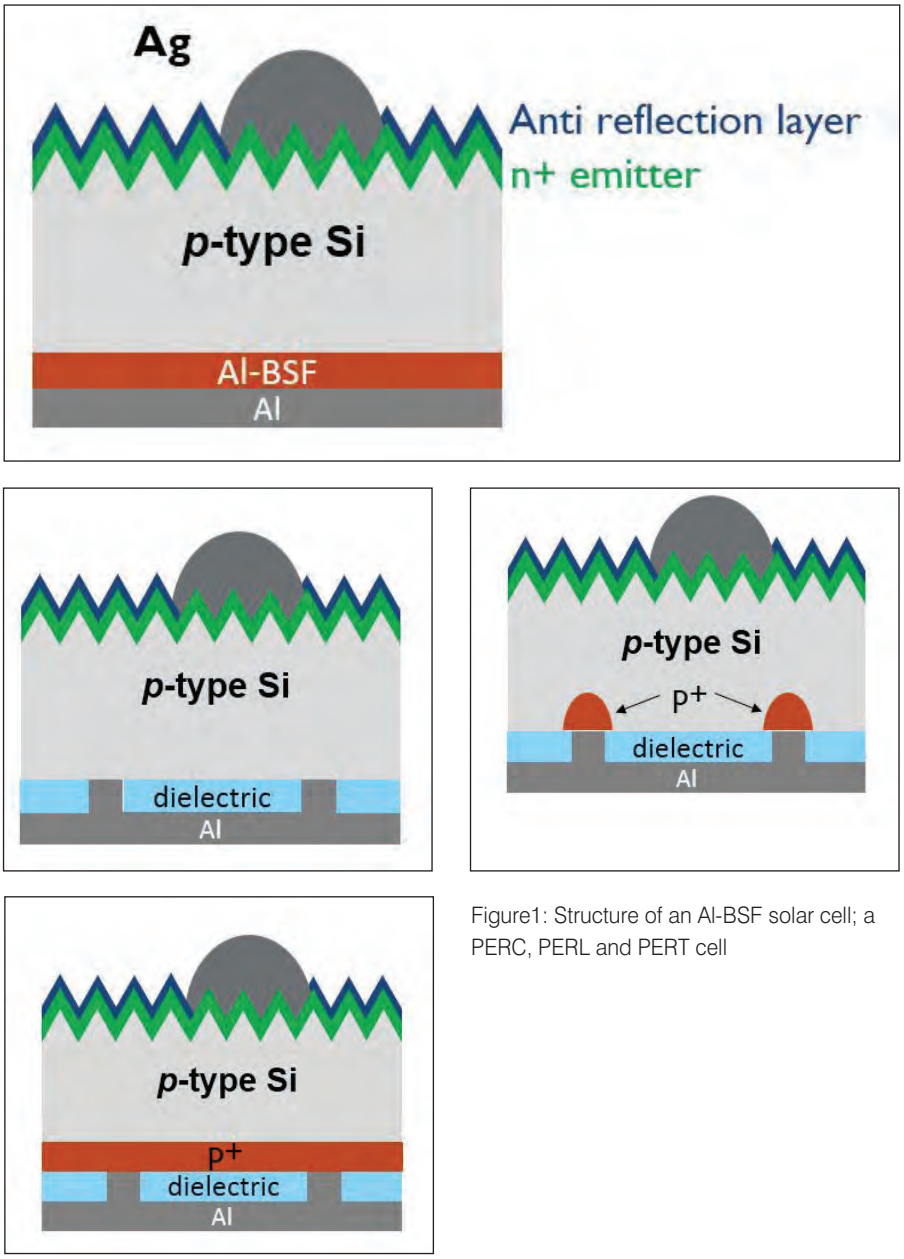


Figure1: Structure of an Al-BSF solar cell; a PERC, PERL and PERT cell

For all these reasons researchers are studying PERx-type cells which promise efficiencies of more than 22%. These cells come in different 'flavours' but all have two points in common: local contacts next to a dielectric passivation layer (e.g. SiO_2, Al_2O_3) at the rear side. In PERC (Passivated Emitter and Rear Contact cell) cells there is no additional passivation present around the local contact openings

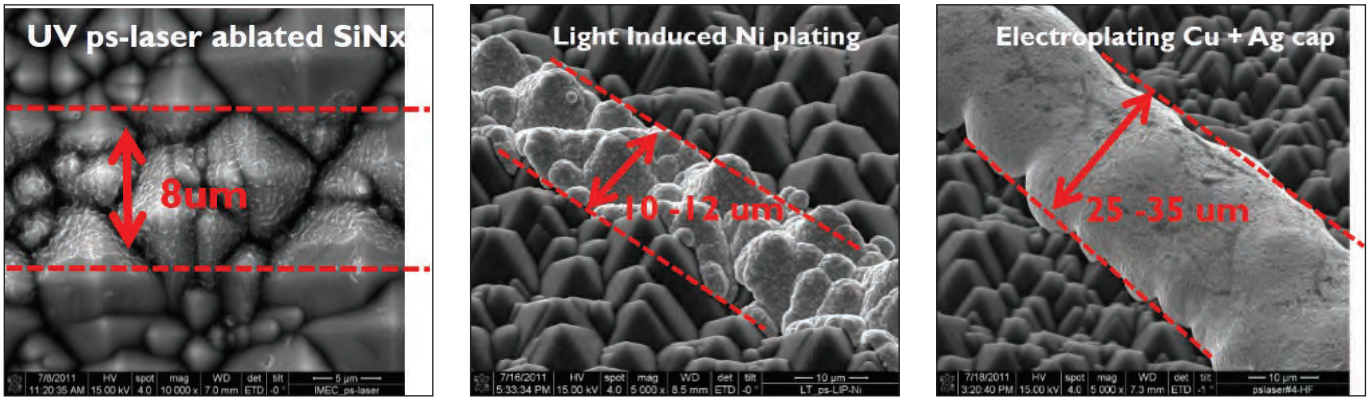


Figure 2: The subsequent steps in making Ni/Cu contacts on the front side of the n-PERT solar cells.

(no BSF). In the case of PERL (Passivated Emitter and Rear Locally diffused) cells the BSF is locally present while for PERT (Passivated Emitter and Rear Totally diffused) cells it covers the whole rear side of the cell. The advantage of this type of rear structure compared to an Al-BSF cell, is that there is less free carrier recombination (improved passivation) as well as an improved internal reflection (> 90%) at long wavelengths. This explains the higher conversion efficiency that can be realized as compared to Al-BSF cells.

Many research groups worldwide, including imec, are studying PERx-type cells. Imec's PERT cells, which reached world-leading efficiencies up to 21.5%, showcase several innovations such as the use of monocrystalline n-type material (instead of the p-type silicon most commonly used by manufacturers); Ni/Cu plated contacts on the front side (instead of screen-printed Ag contacts) and an emitter applied at the rear side.

n-PERT cells with Ni/Cu contacts

The PERT cells made at imec have some specific characteristics:

A first one is the use of Ni/Cu plated contacts at the front side. Ag screen-printed contacts, which are normally used in mainstream production lines, are rather expensive. This problem will only get worse, as the PV production capacity increases worldwide, because of the scarcity of this noble metal. Cu on the other hand is 100 times less expensive than Ag (per kilogram) and faces no availability issues. Other advantages of Ni/Cu contacts over Ag screen-printed contacts are the lower series resistance, the lower contact resistance and the largely reduced process temperatures.

The low contact resistance is achieved through the use of Ni as contact layer to the underlying silicon while it also serves as diffusion barrier for Cu. Finally, the Ni/Cu contacts are sealed with a very thin Ag 'flash' layer to prevent oxidation of Cu. All three materials (Ni/Cu/Ag) are applied in one integrated plating sequence. The developed plating process allows to form much narrower metal lines or 'fingers' which results in less shadow losses and thus more light entering the cell. All these advantages make that this process is clearly a very promising metallization technology for the solar cell industry. In the end, its mass application will depend on solving the last issues which are mainly related to long term reliability.

The PERT cells of imec are built on an n-type monocrystalline silicon substrate. Monocrystalline silicon in general has a higher quality than multicrystalline and thus leads to solar cells with a higher conversion efficiency.

The expected increase in use of this type of material is clearly predicted by the International Technology Roadmap for PhotoVoltaics (ITRPV). Next, n-type monocrystalline silicon in particular is

"Monocrystalline silicon in general has a higher quality than multicrystalline and thus leads to solar cells with a higher conversion efficiency. The expected increase in use of this type of material is clearly predicted by the International Technology Roadmap for PhotoVoltaics (ITRPV)."

less sensitive than p-type to a wide range of metallic impurities and degrades much less under the influence of light. It is also expected that n-type wafers will have a similar manufacturing cost as p-type silicon once it is produced in larger quantities. ITRPV further predicts that n-type solar cells will become more important in the future, particularly in the segment of a high efficiency solar cells.

A final important characteristic for the imec nPERT cells is that the emitter is made at the rear side of the solar cell instead of the more commonly used front side. Firstly, this was done to be able to build further upon the research results that imec achieved in earlier research projects on p-type PERL cells. In both cases (p-type PERL with front emitter and n-type PERT with rear emitter), Ni/Cu contacts are applied to the phosphor-doped front side of the cell.

Apart from this, there are other potential advantages for a rear-side emitter. One of them is the larger distance between the junction and the Cu contacts which can have beneficial influence on the reliability of the solar cells. Also, a rear side p+ emitter can be less sensitive to degradation by light than a front side emitter. However, with a rear-side emitter, measures have to be taken to minimize recombination at the front side (because the charge carriers have to travel a longer distance to the rear p-n junction). Therefore, a Front Surface Field (FSF) and a high quality passivation stack of SiO2/ SiNx is used.

An n-PERT cell with 21.5% conversion efficiency

At imec, three research routes are followed in the study of nPERT cells. The difference between them lies in the way the emitter is realized.

A first route that is followed to make the rear side emitter is diffusion of boron (from BBr_3). For the passivation of the emitter either SiO_2 or Al_2O_3 is used. The former is thermally grown while the thin Al2O3 layer is applied via Atomic Layer Deposition (ALD). In the latter case, the dielectric layer is thickened with an additional SiOx layer, deposited by Plasma Enhanced Chemical Vapor Deposition (PECVD).

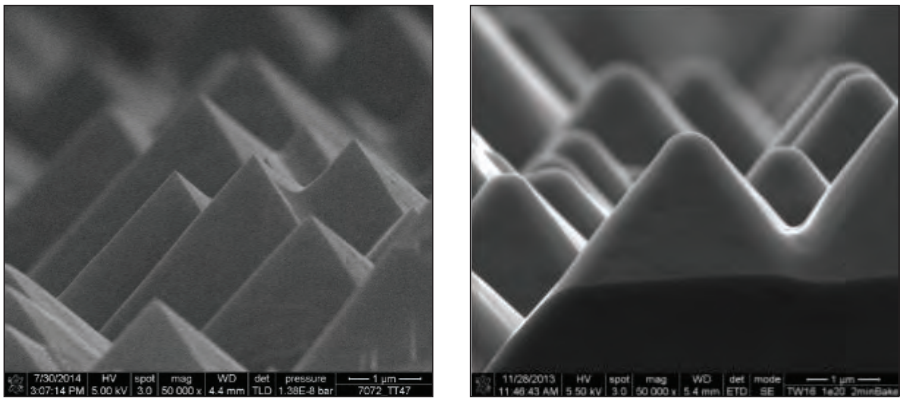
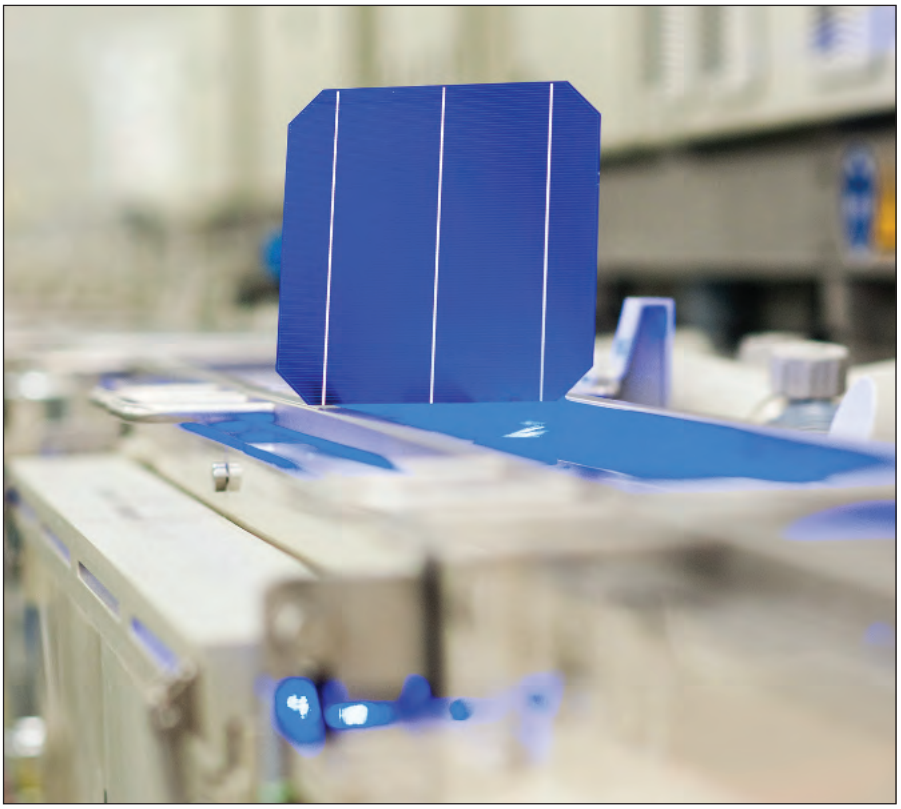


Figure 3: SEM picture of the textured rear side of an n-PERT solar cell before (left) and after (right) epitaxial growth of the emitter.

This resulted in n-PERT cells with respectively 21.3% (SiO_2) and 21.5% (Al_2O_3) efficiency. This conversion efficiency of 21.5% was independently confirmed by ISE CalLab and is, to the best of our knowledge, a record efficiency for this type of solar cells.

The process to make the n-PERT cells with a diffused emitter is currently still too complex to use at an industrial scale. Therefore, further research concentrates on simplifying the processing sequence. Next to this, alternative routes to make the rear side emitter are explored. One of these alternatives is to use epitaxy with in-situ doping instead of diffusion. In this case thin silicon epitaxial layers are grown in the presence of boron doping precursors. The advantage of epitaxy is that it can be done only on one side (in this case the rear side of the solar cell) whereas gas phase diffusion is a 2-sided process. In the latter case, the layers at the front side have to be removed by etching , or avoided by masking, which are extra process steps.

Another advantage of epitaxy is the flexibility in doping profile. A passivation layer stack of ALD-Al_2O_3 +PECVD-SiOx also gave the best results for the PERT



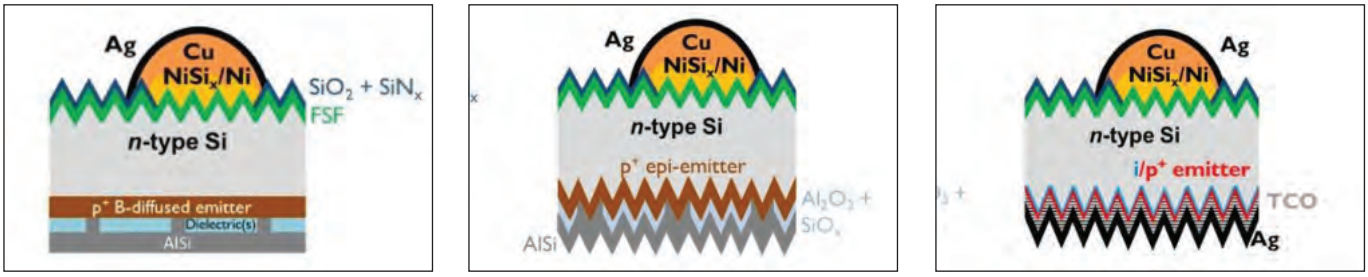


Figure 4: The 3 routes that imec explores for n-PERT cells: rear-side emitter made by diffusion (left), epitaxy (middle) or heterojunction (right). First results show efficiencies of respectively 21.5% (ISE CalLab confirmed), 20.5% and 20%.

cells with epitaxial emitter. Due to the rounding of the pyramids during epitaxy and the effective Al_2O_3 passivation, it is possible to skip the rear surface polishing typically used for diffused emitters. This leads once more to a reduction in process steps. The very first experiments with epitaxial emitter cells showed efficiencies up to 20.5% (polished rear surface) and 20.3% (textured rear surface).

A third route to make the rear side emitter is by making a heterojunction of intrinsic (undoped) and boron-doped amorphous silicon deposited onto the crystalline silicon surface. The resulting band bending translates into less recombination of charge carriers and a higher open circuit voltage. A Transparent Conductive Oxide (TCO) is used to increase the internal reflection of light in the cell. It also makes a good contact between the amorphous silicon and the thin Ag contact which covers the whole rear surface. First solar cell results with this technology are very promising with efficiencies around 20%.

The future

It is clear that PERx-type cells and more specifically PERT cells will become increasingly important towards the future. In addition, the use of n-type monocrystalline silicon will lead to efficiencies above 22% for these types of cells. Ongoing research will further contribute in adapting the PERT processes for industrial production lines, making them more economically feasible.

For the imec researchers in particular, future work will focus on reducing and simplifying several of the process steps and on pursuing higher efficiencies by optimizing current processes and by implementing new technologies (e.g. selective laser doping, tuning profile of epitaxial emitters, implementing passivated contacts, new cell interconnection technologies.).

Jsc (mA/cm2)	Voc (mV)	FF (%)	Eff. (%)
39.1	677	81.3	21.5

Table 1: Ni/Cu plated nPERT cell with Al_2O_3 rear surface passivation (result independently confirmed by ISE CalLab)

Acknowledgement
The authors gratefully acknowledge all members of the PV department at imec for their contribution to this work, as well as the financial support of the partners of Imec's Industrial Affiliation Program for Photovoltaics (IIAP-PV).

Authors
Filip Duerinckx obtained the Master of Science in Engineering degree in 1994 followed by the Ph.D. Degree at the end of 1999 from KU Leuven (Belgium) while working at imec on silicon nitride passivation for industrial-type solar cells. After expanding his interest to the world of epitaxial crystalline thin film solar cells, he joined Photovoltech in 2008 working on passivation processes for PERC-type cells. At the end of 2012, he rejoined imec leading the iPERx platform in the Photovoltaics department.

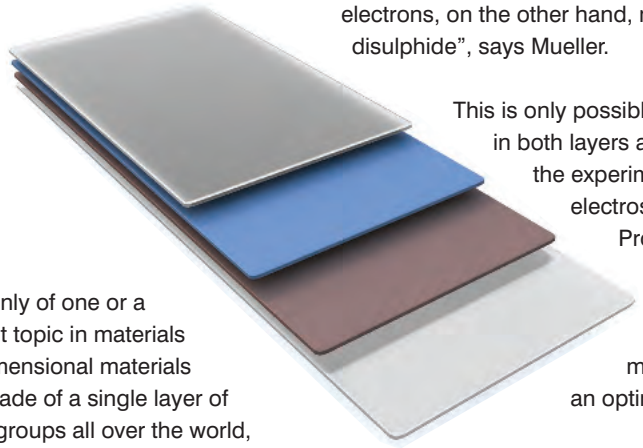
Jozef Szlufcik received the M.Sc. and Ph.D. degree, both in electronic engineering, from the Wroclaw University of Technology, Poland. From 1981 till 1989 he worked as a Research Assistant and later as a postdoc at the Silesian Technical University, Poland carrying out research on hybrid microcircuits and low cost silicon solar cells. He joined imec, Leuven, Belgium in 1990 where he was leading the research on low-cost crystalline silicon solar cells. He was one of the co-founders of the solar cell manufacturer Photovoltech, Belgium where from 2003 till 2012 he held the position of the R&D and Technology Manager. Currently he is Department Director Photovoltaics and Program Manager of Silicon PV at imec, Leuven, Belgium, including research on photovoltaic materials, concepts and technologies.

Vienna researchers reveal new material for ultra thin PV

Scientists at the Vienna University of Technology have managed to combine two semiconductor materials, consisting of only three atomic layers each. This new structure holds great promise for a new kinds of solar cell.

Extremely thin, semi-transparent, flexible solar cells could soon become reality. At the Vienna University of Technology, Thomas Mueller, Marco Furchi and Andreas Pospischil have managed to create a semiconductor structure consisting of two ultra-thin layers, which appears to be excellently suited for photovoltaic energy conversion

Several months ago, the team had already produced an ultra-thin layer of the photoactive crystal tungsten diselenide. Now, this semiconductor has successfully been combined with another layer made of molybdenum disulphide, creating a designer-material that may be used in future low-cost solar cells. With this advance, the researchers hope to establish a new kind of solar cell technology.



Ultra-thin materials, which consist only of one or a few atomic layers are currently a hot topic in materials science today. Research on two-dimensional materials started with graphene, a material made of a single layer of carbon atoms. Like other research groups all over the world, Thomas Mueller and his team acquired the necessary know-how to handle, analyse and improve ultra-thin layers by working with graphene. This know-how has now been applied to other ultra-thin materials.

“Quite often, two-dimensional crystals have electronic properties that are completely different from those of thicker layers of the same material”, says Thomas Mueller.

His team was the first to combine two different ultra-thin semiconductor layers and study their optoelectronic properties. Tungsten diselenide is a semiconductor which consists of three atomic layers. One layer of tungsten is sandwiched between two layers of selenium atoms.

A solar cell made only of tungsten diselenide would require countless tiny metal electrodes tightly spaced only a few micrometers apart. If the material is combined with molybdenium disulphide, which also consists of three atomic layers, this problem is elegantly circumvented. The heterostructure can now be used to build large-area solar cells.

When light shines on a photoactive material single electrons are removed from their original position. A positively charged hole remains, where the electron used to be. Both the electron and the hole can move freely in the material, but they only contribute to the electrical current when they are kept apart so that they cannot recombine. To prevent recombination of electrons and holes, metallic electrodes can be used, through which the charge is sucked away - or a second material is added.

“The holes move inside the tungsten diselenide layer, the electrons, on the other hand, migrate into the molybednium disulphide”, says Mueller.

This is only possible if the energies of the electrons in both layers are tuned the right way. In the experiment, this can be done using electrostatic fields. Florian Libisch and Professor Joachim Burgdörfer (TU Vienna) provided simulations to calculate how the energy of the electrons changes in both materials and which voltage leads to an optimum yield of electrical power.

“One of the greatest challenges was to stack the two materials, creating an atomically flat structure”, says Thomas Mueller. “If there are any molecules between the two layers, so that there is no direct contact, the solar cell will not work.”

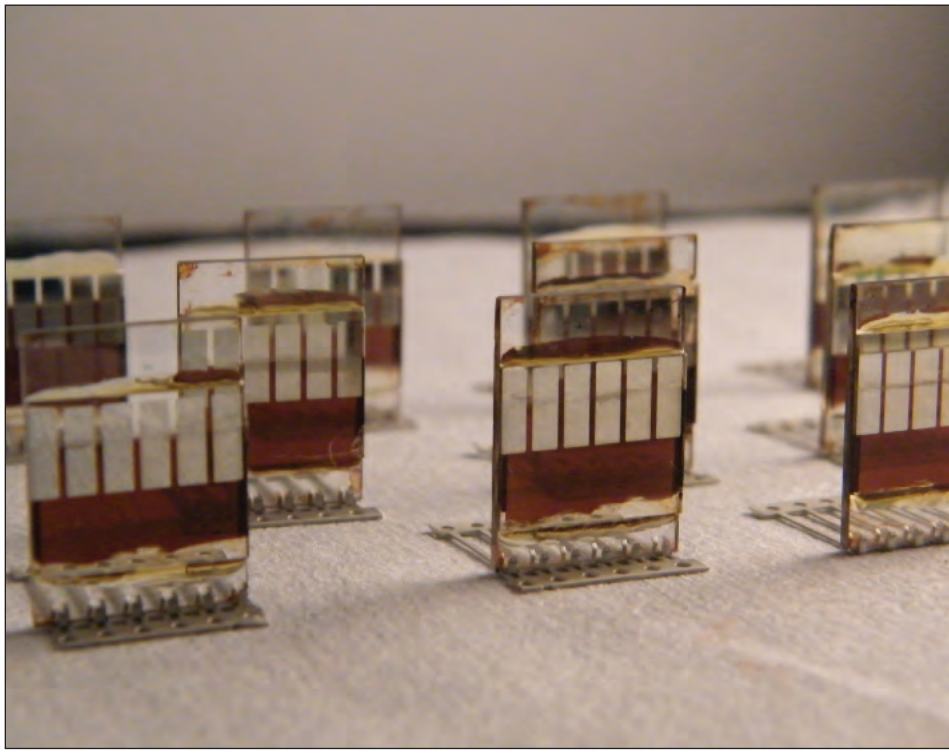
Eventually, this feat was accomplished by heating both layers in vacuum and stacking it in ambient atmosphere. Water between the two layers was removed by heating the layer structure once again. Part of the incoming light passes right through the material. The rest is absorbed and converted into electric energy.

Journal Reference:
Marco M. Furchi, Andreas Pospischil, Florian Libisch, Joachim Burgdörfer, Thomas Mueller. Photovoltaic Effect in an Electrically Tunable van der Waals Heterojunction. Nano Letters, 2014; 140728125936002 DOI: 10.1021/nl501962c.

Researchers reveal spray on perovskite solar

A team of scientists at the University of Sheffield are the first to fabricate perovskite solar cells using a spray-painting process – a discovery that could help cut the cost of solar electricity.

RESEARCHERS FROM the University's Department of Physics and Astronomy and Department of Chemical and Biological Engineering have previously used the spray-painting method to produce solar cells using organic semiconductors - but using perovskite is a major step forward.



Efficient organometal halide perovskite based photovoltaics were first demonstrated in 2012. They are now a very promising new material for solar cells as they combine high efficiency with low materials costs. The spray-painting process wastes very little of the perovskite material and can be scaled to high volume manufacturing – similar to applying paint to cars and graphic printing.

Lead researcher Professor David Lidzey said, "There is a lot of excitement around perovskite based photovoltaics.

"Remarkably, this class of material offers the potential to combine the high performance of mature solar cell technologies with the low embedded energy costs of production of organic photovoltaics."

While most solar cells are manufactured using energy intensive materials like silicon, perovskites, by comparison, requires much less energy to make. By spray-painting the perovskite layer in air the team hope the overall energy used to make a solar cell can be reduced further.

Professor Lidzey said, "The best certified efficiencies from organic solar cells are around 10 per cent.

"Perovskite cells now have efficiencies of up to 19 per cent. This is not so far behind that of silicon at 25 per cent - the material that dominates the world-wide solar market."

He added, "The perovskite devices we have created still use similar structures to organic cells. What we have done is replace the key light absorbing layer - the organic layer - with a spray-painted perovskite. Using a perovskite absorber instead of an organic absorber gives a significant boost in terms of efficiency."

The Sheffield team found that by spray-painting the perovskite they could make prototype solar cells with efficiency of up to 11 per cent.

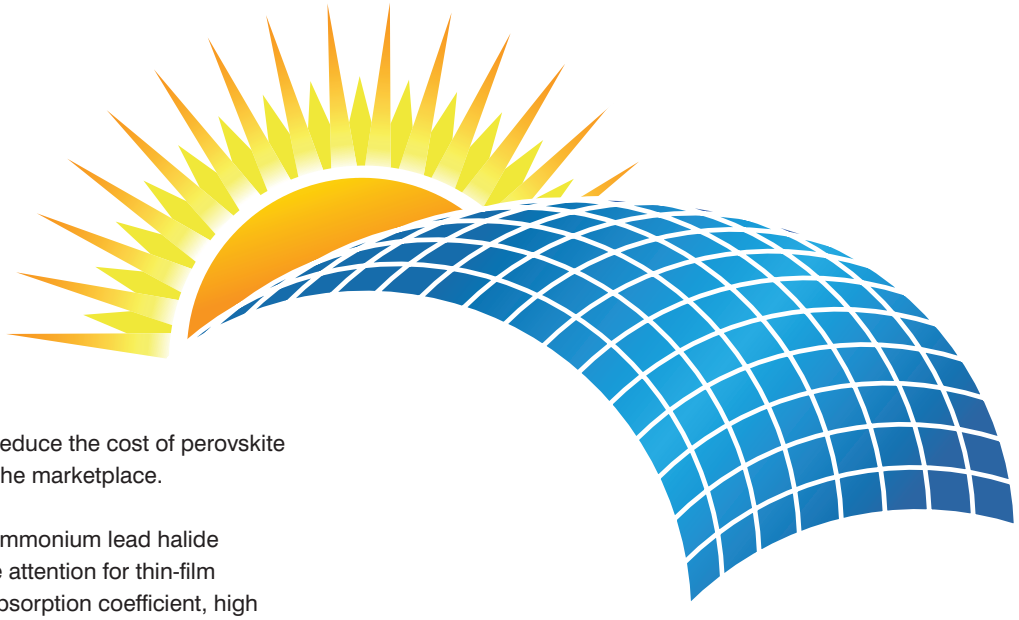
Professor Lidzey said: "This study advances existing work where the perovskite layer has been deposited from solution using laboratory scale techniques. It's a significant step towards efficient, low-cost solar cell devices made using high volume roll-to-roll processing methods."

Solar power is becoming an increasingly important component of the world-wide renewables energy market and continues to grow at a remarkable rate despite the difficult economic environment.

Professor Lidzey said: "I believe that new thin-film photovoltaic technologies are going to have an important role to play in driving the uptake of solar-energy, and that perovskite based cells are emerging as likely thin-film candidates. "

Stable and cost-cutting perovskite solar cell

Perovskite solar cells show tremendous promise in propelling solar power into the marketplace. The cells use a hole-transportation layer, which promotes the efficient movement of electrical current after exposure to sunlight. However, manufacturing the hole-transportation organic materials is very costly and lack long term stability.



PUBLISHING IN SCIENCE, a team of scientists in China, led by Professor Hongwei Han in cooperation with Professor Michael Grätzel at EPFL, have developed a perovskite solar cell that does not use a hole-transporting layer, with 12.8% conversion efficiency and over 1000 hours stability under full sunlight in ambient temperature. The innovation can reduce the cost of perovskite cells, and firmly propel them into the marketplace.

Hybrid organic–inorganic methylammonium lead halide perovskites have attracted intense attention for thin-film photovoltaics, due to their large absorption coefficient, high charge carrier mobility and long diffusion length. However, these cells are also costly because of the hole-transportation layer, which demands high purity materials and complicated fabrication procedures.

A team of scientists at the Michael Grätzel Centre for Mesoscopic Cells of Huazhong University in China in cooperation with the Laboratory for Photonics and Interfaces at EPFL directed by Michael Grätzel have successfully manufactured a perovskite solar cell that does not need a hole-transportation layer. The solar cell shows comparative energy conversion efficiency (12.8%) and was shown to be stable for over 1000 hours in direct sun exposure.

The scientists fabricated the new solar cell by drop-casting a solution of lead iodide, methylammonium iodide, and 5-ammoniumvaleric acid iodide through a porous carbon film. The solar cell's scaffolding was made using a double layer of titanium dioxide and zirconium dioxide covered by a porous carbon film and amino acid templating agent was used to promote the pervoskite nucleation and crystal growth within the pores . The resulting perovskite crystals showed much higher electrical charge generation and collection efficiency than conventional hole conductor free perovskite cells. The use of organic-hole conductor free triple layer also resulted in strikingly high stability. Perovskite solar cells are ideally placed to meet the increasing demands for renewable energy in the future. This breakthrough innovation addresses one of their major limiting factors, and paves the way for a new, cost-effective branch of development in this type of solar cell.

This work represents a collaboration between EPFL's Laboratory of Photonics And Interfaces and the Michael Grätzel Centre for Mesoscopic Cells of Huazhong University of Science and Technology (China).

Journal Reference:
Mei A, Li X, Liu L, Ku Z, Liu K, Rong Y, Xu M, Hu M, Chen J, Yang Y, Grätzel M, Han H. A hole-conductor–free, fully printable mesoscopic perovskite solar cell with high stability. Science 345:6194 DOI: 10.1126/science.1254763
Letters, 2014; 140728125936002 DOI: 10.1021/nl501962c.

Zinc Porphyrin dyes absorb broader range of light

Dye-sensitized solar cells (DSSCs) rely on dyes that absorb light to mobilize a current of electrons and are a promising source of clean energy.

JISHAN WU at the A*STAR Institute of Materials Research and Engineering and colleagues in Singapore have now developed zinc porphyrin dyes that harvest light in both the visible and near-infrared parts of the spectrum1. Their research suggests that chemical modification of these dyes could enhance the energy output of DSSCs.

DSSCs are easier and cheaper to manufacture than conventional silicon solar cells, but they currently have a lower efficiency. Ruthenium-based dyes have been traditionally used in DSSCs, but in 2011 researchers developed a more efficient dye based on a zinc atom surrounded by a ring-shaped molecule called a porphyrin.

Solar cells using this new dye, called YD2-o-C8, convert visible light into electricity with an efficiency of up to 12.3 per cent. Wu's team aimed to improve that efficiency by developing a zinc porphyrin dye that can also absorb infrared light.

The most successful dyes developed by Wu's team, WW-5 and WW-6, unite a zinc porphyrin core with a system of fused carbon rings bridged by a nitrogen atom, known as an N-annulated perylene group. Solar cells containing these dyes absorbed more infrared light than YD2-o-C8 and had efficiencies of up to 10.5 per cent, matching the performance of an YD2-o-C8 cell under the same testing conditions (see image).

Theoretical calculations indicate that connecting the porphyrin and perylene sections of these dyes by a carbon–carbon triple bond, which acts as an electron-rich linker, improved the flow of electrons between them. This bond also reduced the light energy needed to excite electrons in the molecule, boosting the dye's ability to harvest infrared light.

Adding bulky chemical groups to the dyes also improved their solubility and prevented them from aggregating — something that tends to reduce the efficiency of DSSCs.

However, both WW-5 and WW-6 are slightly less efficient than YD2-o-C8 at converting visible light into electricity, and they also produce a lower voltage. "We are now trying to solve this problem through modifications based on the chemical structure of WW-5 and WW-6," says Wu.

Comparing the results from more perylene–porphyrin dyes should indicate ways to overcome these hurdles, and may even extend light absorption further into the infrared. "The top priority is to improve the power conversion efficiency," says Wu. "Our target is to push the efficiency to more than 13 per cent in the near future."

Journal Reference:
Luo, J., Xu, M., Li, R., Huang, K.-W., Jiang, C. et al.
N-annulated perylene as an efficient electron donor for porphyrin-based dyes: Enhanced light-harvesting ability and high-efficiency Co(II/III)-based dye-sensitized solar cells.
Journal of the American Chemical Society 136, 265–272 (2014).

Researchers reveal material structure that keeps PV cool

Scientists may have overcome one of the major hurdles in developing high-efficiency, long-lasting solar cells. Keeping them cool, even in the blistering heat of the noonday sun.

BY ADDING A SPECIALLY PATTERNED LAYER of silica glass to the surface of ordinary solar cells, a team of researchers led by Shanhui Fan, an electrical engineering professor at Stanford University in California has found a way to let solar cells cool themselves by shepherding away unwanted thermal radiation.

Solar cells are among the most promising and widely used renewable energy technologies on the market today. Though readily available and easily manufactured, even the best designs convert only a fraction of the energy they receive from the sun into usable electricity.

Part of this loss is the unavoidable consequence of converting sunlight into electricity. A surprisingly vexing amount, however, is due to solar cells overheating.

Under normal operating conditions, solar cells can easily reach temperatures of 130 degrees Fahrenheit (55 degrees Celsius) or more. These harsh conditions quickly sap efficiency and can markedly shorten the lifespan of a solar cell. Actively cooling solar cells, however—either by ventilation or coolants—would be prohibitively expensive and at odds with the need to optimize exposure to the Sun.

The newly proposed design avoids these problems by taking a more elegant, passive approach to cooling. By embedding tiny pyramid- and cone-shaped structures on an incredibly thin layer of silica glass, the researchers found a way of redirecting unwanted heat—in the form of infra-red radiation—from the surface of solar cells, through the atmosphere, and back into space.

“Our new approach can lower the operating temperature of solar cells passively, improving energy conversion efficiency significantly and increasing the life expectancy of solar cells,” said Linxiao Zhu, a physicist at Stanford and lead author on the Optica paper. “These two benefits should enable the continued success and adoption of solar cell technology.”

Solar cells work by directly converting the Sun’s rays into electrical energy. As photons of light pass into the semiconductor regions of the solar cells, they knock off electrons from the atoms, allowing electricity to flow freely, creating a current. The most successful and widely used designs, silicon semiconductors, however, convert less than 30 percent of the energy they receive from the Sun into electricity – even at peak efficiency.

The solar energy that is not converted generates waste heat, which inexorably lessens a solar cell’s performance. For every one-degree Celsius (1.8 degree F) increase in temperature, the efficiency of a solar cell declines by about half a percent.

“That decline is very significant,” said Aaswath Raman, a post-doctoral scholar at Stanford and co-author on the paper. “The solar cell industry invests significant amounts of capital to generate improvements in efficiency. Our method of carefully altering the layers that cover and enclose the solar cell can improve the efficiency of any underlying solar cell. This makes the design particularly relevant and important.”

In addition, solar cells “age” more rapidly when their temperatures increase, with the rate of ageing doubling for every increase of 18 degrees Fahrenheit.

To passively cool the solar cells, allowing them to give off excess heat without spending energy doing so, requires exploiting the basic properties of light as well as a special infra-red “window” through Earth’s atmosphere.

Different wavelengths of light interact with solar cells in very different ways—with visible light being the most efficient at generating electricity while infrared is more efficient at carrying heat. Different wavelengths also bend and refract differently, depending on the type and shape of the material they pass through.

The researchers harnessed these basic principles to allow visible light to pass through the added silica layer unimpeded while enhancing the amount of energy that is able to be carried away from the solar cells at thermal wavelengths.

“Silica is transparent to visible light, but it is also possible to fine-tune how it bends and refracts light of very specific wavelengths,” said Fan, who is the corresponding author on the Optica paper. “A carefully designed layer of silica would not degrade the performance of the solar cell but it would enhance radiation at the predetermined thermal wavelengths to send the solar cell’s heat away more effectively.”

To test their idea, the researchers compared two different silica covering designs: one a flat surface approximately 5 millimetres thick and the other a thinner layer covered with pyramids and micro-cones just a few microns (one-thousandth of a millimetre) thick in any dimension. The size of these features was essential. By precisely controlling the width and height of the pyramids and micro-cones, they could be tuned to refract and redirect only the unwanted infra-red wavelengths away from the solar cell and back out into space.

"The goal was to lower the operating temperature of the solar cell while maintaining its solar absorption," said Fan. "We were quite pleased to see that while the flat layer of silica provided some passive cooling, the patterned layer of silica considerably outperforms the 5 mm-thick uniform silica design, and has nearly identical performance as the ideal scheme."

Zhu and his colleagues are currently fabricating these devices and performing experimental tests on their design. Their next step is to demonstrate radiative cooling of solar cells in an outdoor environment. "We think that this work addresses an important technological problem in the operation and optimization of solar cells," he concluded, "and thus has substantial commercialization potential."

Journal Reference:
L. Zhu, A. Raman., K. Wang, M. Anoma, S. Fan, "Radiative Cooling of Solar Cells," Optica 1, 32-38 (2014).

MIT discusses solar powered steam generating material

MIT is reporting that a new material structure developed at the institute is capable of generating steam by soaking up the sun. The structure, a layer of graphite flakes and an underlying carbon foam, is a porous, insulating material structure that floats on water.

WHEN SUNLIGHT HITS THE STRUCTURE'S SURFACE, it creates a hotspot in the graphite, drawing water up through the material's pores, where it evaporates as steam. The brighter the light, the more steam is generated. The material is able to convert 85 percent of incoming solar energy into steam, a significant improvement over recent approaches to solar-powered steam generation. What's more, the setup loses very little heat in the process, and can produce steam at relatively low solar intensity. This would mean that, if scaled up, the setup would likely not require complex, costly systems to highly concentrate sunlight.

Hadi Ghasemi, a postdoc in MIT's Department of Mechanical Engineering, says the spongelike structure can be made from relatively inexpensive materials. An advantage for a variety of compact, steam-powered applications.

"Steam is important for desalination, hygiene systems, and sterilization," says Ghasemi, who led the development of the structure.

Ghasemi and mechanical engineering department head Gang Chen, along with five others at MIT, report on the details of the new steam-generating structure in the journal Nature Communications. Solar-powered steam generation involves vast fields of mirrors or lenses that concentrate incoming sunlight, heating large volumes of liquid to high enough temperatures to produce steam. However, these complex systems can experience significant heat loss, leading to inefficient steam generation.

The MIT approach generates steam at a solar intensity about 10 times that of a sunny day — the lowest optical concentration reported thus far. The implication, the researchers say, is that steam-generating applications can function with lower sunlight concentration and less-expensive tracking systems.

"This is a huge advantage in cost-reduction," Ghasemi says. "That's exciting for us because we've come up with a new approach to solar steam generation."

The approach itself is relatively simple: Since steam is generated at the surface of a liquid, Ghasemi looked for a material that could both efficiently absorb sunlight and generate steam at a liquid's surface.

After trials with multiple materials, he settled on a thin, double-layered, disc-shaped structure. Its top layer is made from graphite that the researchers exfoliated by placing the material in a microwave. The effect, Chen says, is "just like popcorn": The graphite bubbles up, forming a nest of flakes. The result is a porous material that can better absorb and retain solar energy. The structure's bottom layer is a carbon foam that contains pockets of air to keep the foam afloat and act as an insulator, preventing heat from escaping to the underlying liquid. The foam also contains very small pores that allow water to creep up through the structure via capillary action.

As sunlight hits the structure, it creates a hotspot in the graphite layer, generating a pressure gradient that draws water up through the carbon foam.

As water seeps into the graphite layer, the heat concentrated in the graphite turns the water into steam.

The researchers tested the structure by placing it in a chamber of water and exposing it to a solar simulator — a light source that simulates various intensities of solar radiation. They found they were able to convert 85 percent of solar energy into steam at a solar intensity 10 times that of a typical sunny day.

"There can be different combinations of materials that can be used in these two layers that can lead to higher efficiencies at lower concentrations," Ghasemi says. "There is still a lot of research that can be done on implementing this in larger systems."

Increasing solar power with nanoholes

Increasing the cost-effectiveness of photovoltaic devices is critical to making these renewable energy sources competitive with traditional fossil fuels. One possibility is to use hybrid solar cells that combine silicon nanowires with low-cost, photoresponsive polymers.

THE HIGH SURFACE AREA and confined nature of nanowires allows them to trap significant amounts of light for solar cell operations. Unfortunately, these thin, needle-like structures are very fragile and tend to stick together when the wires become too long.

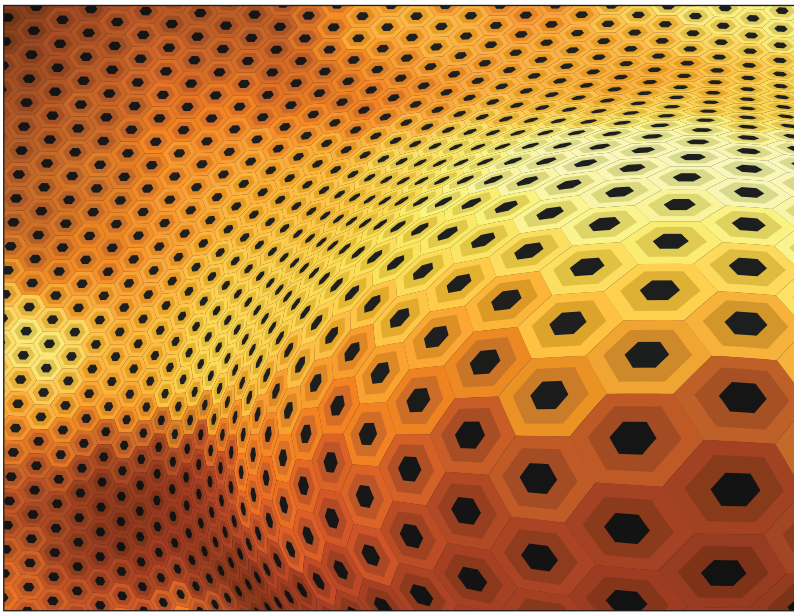
Now, findings by Xincai Wang from the A*STAR Singapore Institute of Manufacturing Technology and co-workers from Nanyang Technological University could turn the tables on silicon nanowires by improving the manufacturing of silicon 'nanoholes' — narrow cavities carved into silicon wafers that have enhanced mechanical and light-harvesting capabilities1.

Nanoholes are particularly effective at capturing light because photons can ricochet many times inside these openings until absorption occurs. Yet a practical understanding of how to fabricate these tiny structures is still lacking. One significant problem, notes Wang, is control of the initial stages of nanohole formation — a crucial period that can often induce defects into the solar cell.

Instead of traditional time-consuming lithography, the researchers identified a rapid, 'maskless' approach to producing nanoholes using silver nanoparticles. First, they deposited a nanometer-thin layer of silver onto a silicon wafer which they toughened by annealing it using a rapid-burst ultraviolet laser. Careful optimization of this procedure yielded regular arrays of silver nanospheres on top of the silicon surface, with sphere size and distribution controlled by the laser annealing conditions.

Next, the nanosphere–silicon complex was immersed into a solution of hydrogen peroxide and hydrofluoric acid — a mixture that eats away at silicon atoms directly underneath the catalytic silver nanospheres. Subsequent removal of the silver particles with acid produced the final, nanohole-infused silicon surface (see image).

The team analyzed the solar cell activity of their nanohole interfaces by coating them with a semiconducting polymer and metal electrodes. Their experiments revealed a remarkable dependence on nanohole depth: cavities deeper than one micrometer showed sharp drops in power conversion efficiency



from a maximum of 8.3 per cent due to light scattering off of rougher surfaces and higher series resistance effects.

"Our simple process for making hybrid silicon nanohole devices can successfully reduce the fabrication costs which impede the solar cell industry," says Wang. "In addition, this approach can be easily transferred to silicon thin films to develop thin-film silicon–polymer hybrid solar cells with even higher efficiency."

The A*STAR-affiliated researchers contributing to this research are from the Singapore Institute of Manufacturing Technology

Journal Reference:
Hong, L., Wang, X., Zheng, H., He, L., Wang, H., Yu, H. & Rusli, E. High efficiency silicon nanohole/organic heterojunction hybrid solar cell. Applied Physics Letters 104, 053104 (2014).

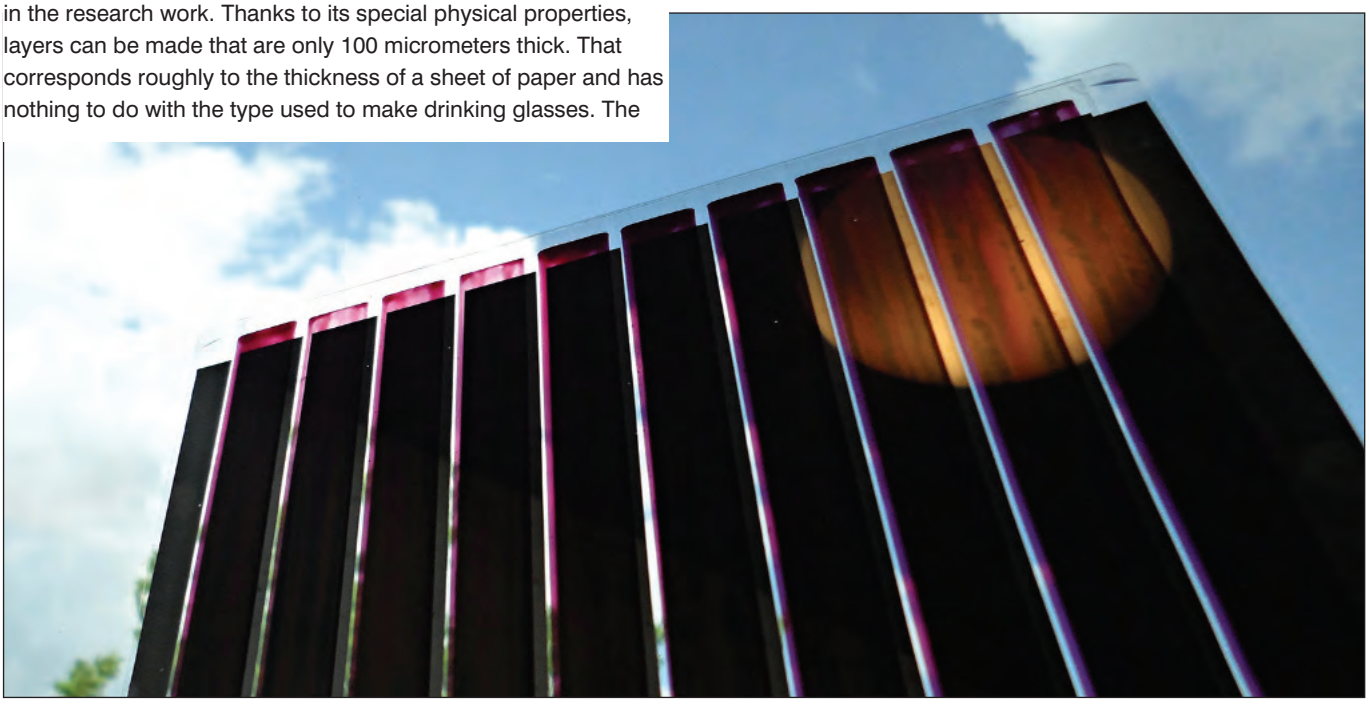
Solar modules embedded in glass

Organic solar modules have advantages over silicon solar cells. However, one critical problem is their shorter operating life. Researchers are working on a promising solution: they are using flexible glass as a carrier substrate that better protects the components.

Using flexible glass as a carrier is an approach is already being employed in electronic devices to some extent today: organic photovoltaics (OPVs) are embedded in film. These OPVs are a promising alternative to silicon-based solar cells. The materials can also be processed at atmospheric pressure. However, the main advantage is the modules can be manufactured using printing technology – this is faster and more efficient that the involved processes necessary for fabrication of inorganic components. A flexible type of substrate material is necessary for fabrication that uses a printing process. Polymer films that have certain serious disadvantages have been employed up to now. The films are somewhat permeable to humidity and oxygen. Both of these attack the sensitive solar modules and significantly reduce their operating life. Up to now, substrates with barrier layers have protected the OPV modules, depending on the application. For higher processing temperatures and longer operating life, different carrier substrates must be used.

Researchers of the Fraunhofer Institute for Applied Polymer Research IAP in Potsdam, Germany, are working with a new carrier material at present. They are embedding the solar modules in a thin layer of glass. “Glass is not only the ideal encapsulating material, it also tolerates process temperatures of up to 400 degrees,” explains Danny Krautz, project manager in the Functional Materials and Components research section at IAP. A specialized glass from Corning Inc. is being employed in the research work. Thanks to its special physical properties, layers can be made that are only 100 micrometers thick. That corresponds roughly to the thickness of a sheet of paper and has nothing to do with the type used to make drinking glasses. The special glass is not only fracture-resistant and extremely strong, it is so flexible that it can be gently bowed even in its solid form. The researchers in Potsdam in cooperation with their partner Corning have already created the first working OPVs with this material by processing stacks sheet-by-sheet.

The goal is to fabricate these modules in rolls as well. The carrier substrate will be wound on a roll in this case, similar to how newspapers are printed. An empty roll is positioned opposite it. The photoactive layers and electrodes are printed in several steps between the two rolls. Large surfaces can be manufactured effectively in series using this fabrication technology. The team from IAP has already begun a first test of how the flexible glass could be processed in this way. “We were immediately successful on our first run in producing homogenous layers on smaller substrate dimensions,” according to the scientist. The technology needs to be modified at many points for the process to meet the demands of industrial applications – and the Potsdam team is already working on these. Long-lived, robust, high-performance OPVs can be fabricated with this technology for use in a wide range of applications – from tiny solar cells in mobile phones to large-scale photovoltaic modules.



Stanford researchers move closer to pure lithium anode batteries

In a paper published in the journal Nature Nanotechnology, researchers at Stanford University report that they have taken a big step toward accomplishing what battery designers have been trying to do for decades – design a pure lithium anode.

ALL BATTERIES HAVE THREE BASIC COMPONENTS: an electrolyte to provide electrons, an anode to discharge those electrons, and a cathode to receive them. At present, we say we have lithium batteries, but what we have are lithium ion batteries. The lithium is in the electrolyte, but not in the anode. An anode of pure lithium would be a huge boost to battery efficiency.

"Of all the materials for an anode, lithium has the greatest potential. Some call it the Holy Grail," said Yi Cui, a professor of Material Science and Engineering and leader of the research team. "It is very lightweight and it has the highest energy density."

"Lithium has major challenges that have made its use in anodes difficult. Many engineers had given up the search, but we found a way to protect the lithium from the problems that have plagued it for so long," said Guangyuan Zheng, a doctoral candidate in Cui's lab and first author of the paper.

In addition to Zheng, the research team includes Steven Chu, the former U.S. Secretary of Energy and Nobel Laureate who recently resumed his professorship at Stanford.

"In practical terms, if we can improve the capacity of batteries that would be exciting. You might be able to have cell phone with double or triple the battery life or an electric car with a range of 300 miles that cost only $25,000," Chu said.

In the paper, the authors explain how they are overcoming the problems posed by lithium. Most lithium ion batteries, like those you might find in your smart phone or hybrid car, work similarly. The key components include an anode, the negative pole from which electrons flow out and into a power-hungry device, and the cathode, where the electrons re-enter the battery once they have traveled through the circuit. Separating them is an electrolyte, a solid or liquid loaded with positively charged lithium ions that travel between the anode and cathode.

During charging, the positively charged lithium ions in the electrolyte are attracted to the negatively charged anode and the lithium accumulates on the anode. Today, the anode in a lithium ion battery is actually made of graphite or silicon. Engineers would like to use lithium for the anode, but so far they have been unable to do so. That's because the lithium ions expand as they gather on the anode during charging. All anode materials, including graphite and silicon, expand somewhat during charging, but not like lithium.

Researchers say that lithium's expansion during charging is "virtually infinite" relative to the other materials. Its expansion is also uneven, causing pits and cracks to form in the outer surface, like paint on the exterior of a balloon that is being inflated. The resulting fissures on the surface of the anode allow the precious lithium ions to escape, forming hair-like or mossy growths, called dendrites. Dendrites, in turn, short circuit the battery and shorten its life.

The second engineering challenge is that a lithium anode is highly chemically reactive with the electrolyte. It uses the electrolyte and reduces battery life. An additional problem is that the anode and electrolyte produce heat when they come into contact. Lithium batteries, including those in use today, can overheat to the point of fire, or even explosion.

To solve these problems the Stanford researchers built a protective layer of interconnected carbon domes on top of their lithium anode. This layer is what the team has called nanospheres. The Stanford team's nanosphere layer resembles a honeycomb: it creates a flexible, uniform and non-reactive film that protects the unstable lithium from the drawbacks that have made it such a challenge. The carbon nanosphere wall is just 20 nanometers thick. It would take some 5,000 layers stacked one atop another to equal the width of single human hair.

"The ideal protective layer for a lithium metal anode needs to be chemically stable to protect against the chemical reactions with the electrolyte and mechanically strong to withstand the expansion of the lithium during charge," Cui said.

The Stanford nanosphere layer is is made of amorphous carbon, which is chemically stable, yet strong and flexible so as to move freely up and down with the lithium as it expands and contracts during the battery's normal charge-discharge cycle.

Solar sail to power spacecraft

THE PLANETARY SOCIETY, the world's largest space interest group, has announced that its LightSail solar sail spacecraft will reach space on a SpaceX Falcon Heavy launch in 2016.

"It's fantastic that at last we have a launch date for this pioneering mission," said Planetary Society CEO Bill Nye The Science Guy.

The Planetary Society also has a long history of solar sail activity. In June of 2005 the Society attempted to launch Cosmos 1, which would have been the first solar sail in space. The failure of a Russian booster doomed that effort, but the Society never gave up the dream of sailing the cosmos on the gentle yet constant pressure exerted by sunlight. Solar sailing promises tremendous advantages over traditional chemical rockets. There is no need to carry fuel for complex rocket engines, as the Sun provides an endless source of energy for propulsion. Solar sailing and related techniques have been called the only practical way to reach other stars.

While there have been other solar sail missions in the last decade—notably Japan's IKAROS—none have attempted what LightSail will. It is the first to be entirely funded by Planetary Society members and other citizen supporters. Technologies developed for LightSail may enable other small, interplanetary spacecraft to achieve success. The creation and launch of CubeSats is within reach of universities and other organizations that could once only dream of flying their own missions.

CubeSats utilize a standard design based on 10-centimeter (about 4-inch) cubes. LightSail is three cubes, or just 30 centimeters long. Tucked inside this tiny package are four ultra-thin Mylar sails that will be deployed a few weeks after orbital insertion. These brilliantly reflective wings will expand to 32 square meters (344 square feet), making LightSail easily visible to naked eye observers on Earth.

LightSail will reach Medium Earth Orbit (MEO) stored inside another innovative spacecraft: Prox-1. Prox-1 has been developed by the Georgia Institute of Technology to demonstrate new technologies enabling two spacecraft to work in close proximity. After ejecting LightSail, the largely student-built Prox-1 will track and image LightSail, including the sail deployment.

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Editor-in-Chief David Ridsdale
T: +44 (0)1923 690210 E: david.ridsdale@angelbc.com
Director of Solar Publishing Jackie Cannon
T: +44 (0)1923 690205 E: jackie.cannon@angelbc.com
Sales Manager Shehzad Munshi
T: +44 (0)1923 690215 E: shehzad.munshi@angelbc.com
Director of Logistics Sharon Cowley
T: +44 (0)1923 690200 E: sharon.cowley@angelbc.com
Design & Production Manager Mitch Gaynor
T: +44 (0)1923 690214 E: mitch.gaynor@angelbc.com
Circulation and Subscriptions Assistant Annette Weatherilt
T: +44 (0)1923 690200 E: annette.weatherilt@angelbc.com

Published by: Angel Business Communications Ltd (London Office), Hannay House, 39 Clarendon Road, Watford, Herts WD17 1JA, UK

USA Representatives: Tom Brun, Tom Brun Media,
T: 724 539-2404, E: tbrun@brunmedia.com
Janice Jenkins, Tom Brun Media.
T: 724 929-3550, E: jjenkins@brunmedia.com

Japan Representative: Katsuhiro Ishii,
Ace Media Services Inc.,
T: 81-3-5691-3335 E: amskatsu@dream.com

China Representative: Parker XU, Unionbandy Limited,
T: 86-755-83753881, E: xp@unionbandy.net
Directors:
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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. © 2014.

"People want to see real-life examples of how they can work PV into their operations and evidence that it works and reduces costs. The market will evolve based on reference," says Dierckxsens from 3E.

Finally, hybrid PV diesel solutions which according to Dierckxsens at 3E are "increasingly the way to go rather than 100% renewable options" still need to be refined. CRONIMET, for example, warns that synchronising the operation of the two energy sources can be a complex process.

Dierckxsens predicts that the uptake of PV solutions in South Africa will be steady rather than spectacular: "I don't think business will be booming, but it will be healthy and we can expect growth. It is definitely something to watch over the next five or so years."

Armstrong from CRONIMET is even more optimistic that PV is the future. "First movers will increase their margins," he says. "They will also force the laggards to adopt energy cost cutting methods. If not the latter risk being taken over, missing their targets or even going out of business."

PV project Development Africa will be addressing the issues addressed in this article at this years event in September organised by **PV Insider.**

Key facts and figures for the South African market

- $500,000 is the value CRONIMET says it has saved since setting up a 1MW PV facility at its Thaba Mine in Bushveld, South Africa, in 2012
- 84 million litres of fuel is the amount of fuel savings a 10MW solar-diesel facility could achieve in 25 years in South Africa
- 25 percent is he rate at which electricity prices in South Africa have risen over the last six years
- 8 percent is the rate at which South Africa's electricity supplier Eskom is allowed to raise prices by every year for the next five years
- 20 to 25 years worth is the amount of day time electricity a PV facility effectively provides up front

electricity for one upfront price. So, if you expect energy to increase over the next two decades, then that hedge your purchase is security to your business margins," he says. Solar PV is also seen as potentially more secure than power from the grid in South Africa.

The state-run utility Eskom started rolling scheduled blackouts in March after rain interfered with its coal supplies, raising questions about the reliability of its electricity supplies.

"PV plants can help ensure security of supply by functioning as a form of back-up for electricity generation as well," according to Melanie Naidoo- Vermaak, Environmental Executive at mining firm Harmony.

A complicated, multi-stage process

Nonetheless, solar faces a number of challenges in South Africa. Making the business case can be complex, and involves a multi-stage due diligence process.

"The process includes a host of things such as data collection and modelling, coming up with a potential design, verification of those design plans and investigations, and purchase price allocations for the financial side of things," says Carlos Dierckxsens, a researcher at the Belgium- based renewable energy advisory firm 3E. "There are a variety of different PV options that firms also need to explore during the due diligence process, from one hundred percent renewable to diesel-PV.

"In terms of the latter, firms can evaluate various options, including a fuel saver approach which does not have to interfere with the diesel controls but means a mine can switch to PV when required," he adds. The up-front costs of solar can be hefty, however, although some claim that mining companies can expect to break even within a few years.

"Mining companies want to be sure that their maintenance costs do not significantly increase as a result of integrating solar," says Dierckxsens. "Often they want to make sure that they can fall back on an existing energy supply setup."

Proven success stories in an embryonic industry is another challenge. Many companies offering solar products to mining firms can only draw on manufacture designs rather than evidence from fully realised past projects when trying to convince companies that integrating solar PV into their energy sourcing is worthwhile.

to construct a 5-7MW solar park in Free State province. It will start being built later in 2014. The company also intends to erect a 18MW solar plant in Mareetsane, North West province, to boost supplies to the Eskom Grid. It is anticipated that capacity should eventually climb to 40MW. According to Melanie Naidoo-Vermaak, Harmony's Environmental Executive, the goal is to alleviate pressure on peak energy usage.

Meanwhile, US solar company First Solar has said that it is in advanced negotiations with African mining firms over their solar products, although the firm is yet to reveal further details.

Solar PV and the bottom line

The potential to save money is one of the key arguments in favour of PV solar in the South African mining industry. Reducing expenditure on energy was a key goal for CRONIMET, as the company was getting through almost two million litres of diesel every year before turning to PV.

After it set up its hybrid PV diesel facility in 2012, CRONIMET claims to have saved half a million dollars. "For us it was a pure economic decision and we set out in 2012 to prove that it was both economically and technically feasible," says Armstrong.

John Eccles, First Solar's fuel replacement solutions director, also argues that one of his company's 10MW solar-diesel facilities could achieve over 84 million litres of fuel savings in 25 years in South Africa.

High electricity prices and power insecurity have had a direct effect on the profitability of mining firms in South Africa. In 2008, many mines, including those owned by Anglo American, suspended their operations due to an electricity deficit, which Eskom has since endeavoured to tackle through a project following through to 2017 that has seen electricity prices rise by 25% annually over the last six years.

South Africa's Eskom has been given permission to increase electricity prices by an average of eight percent a year for the next five years.

"A mining manager really has to table a good excuse for the shareholders when they explain that they would rather pay more cash to diesel suppliers than higher dividends," says Armstrong from CRONIMET. "The potential for integrators and IPPs such as ourselves is immense," he also says, adding that, if electricity costs continue to increase then PV offers a further financial advantage: "When procuring PV on balance sheet, you are effectively acquiring 20 to 25 years of daytime

Can solar meet the energy demands of

South Africa's mining industry?

High energy costs are plaguing South Africa's mining industry. The price of electricity in the country is one of the highest in the world and blackouts have started affecting supply. There are signs that, with most of South Africa enjoying over 2,500 hours of sunshine each year, its mining firms are slowly looking to PV solar as a potential alternative.

CRONIMET, are a German mining company that first entered South Africa in 2011 by establishing the Thaba Mine in North Western Bushveld. The 1MW facility is integrated into the firm's extant diesel-based power system.

"The engineering, installation and the ensuing one and a half years of operations have been a great success," says Rollie Armstrong, Managing Director at CRONIMET Mining Power Solutions, an organisation which develops and deploys hybrid energy solutions in the mining industry and is associated with the CRONIMET mining company.

"We now are working with a number of third party African based mining companies to apply our business model to their on-site captive power solution, just as CRONIMET has. We have operated the PV Diesel hybrid system for over a year and a half, and we are constantly learning and improving upon our execution activities at the many PV - diesel interfaces," Armstrong adds.

South Africa's third largest gold mining firm, Harmony Gold Mining Company Limited (Harmony), has also started working PV into its energy sources. Harmony is working with the state

are still seeking closer relationships with project developers. For component suppliers, this is particularly essential in order to sustain and grow revenue streams.

Only 14 percent felt that regulators would be the most effective people to meet for the expansion of their business. So while 54 percent had suggested a decrease in bureaucracy was the most important measure needed to facilitate the development of the industry, actually meeting with regulators was not a high priority for many of the companies.

Signs of a market evolution

Despite the REIPPP being the current driver of the South African market, interestingly, only 21.5 percent specified the programme as the most credible source of growth in the next 5-10 years. And with a mere 10 percent identifying utility-scale generation outside of the REIPPP as the most reliable avenue of growth, this was even more indicative of the lack of faith in large-scale PV development.

What is remarkably significant is that almost 51 percent see 1-5 MW industrial and commercial deployment as the most credible area for growth in the next 5-10 years, and almost 17 percent see residential deployment as the future source of growth.

These findings show that the market views small-medium scale deployment of PV as a bigger commercial opportunity than the REIPPP; a perspective which is in line with the other question that found overdependence by companies on the REIPPP among the biggest causes of unsustainability in the market.

“The REIPPP has beyond repute driven growth and investment in the PV market in South Africa, however, here is a clear evidence that firms are wary of their dependence on it,” the PV Insider survey report highlights. But the most important finding, it states, is that companies view the potential of distributed generation over and beyond that of utility-scale deployment.

In conclusion, the South African PV market is on a steep upward curve of project development, as witnessed by the rising revenues and plentiful business opportunities.

While these profits are naturally a welcome boost to balance sheets, companies are wary of the market’s ability to sustain this growth over the next five years. As a result, many firms are putting plans in place to look beyond the REIPPP and to secure a client base amongst the industrial and commercial sectors, thereby ensuring a sustainable project pipeline should any changes occur.

development, the limited supply of long-term finance for non-REIPPP projects and the ongoing problems with small-scale feed-in domestic and commercial installations were highlighted as other substantial problems by the rest of the respondents.

What regulators can do

In examining what can be done by South African regulators to facilitate the development of a sustainable solar industry over the next 3-7 years, the majority of respondents – around 56 percent – believed that a decrease in bureaucracy was the answer.

About 20 percent said a change was needed in the way the REIPPP was administered, while 19 percent felt that higher local content requirements would be a beneficial measure.

Only five percent cited restrictions on foreign companies entering the market as advantageous to the development of the industry, which indicates that South Africa will continue to benefit from keeping its doors open to foreign investment and expertise. Additional responses revealed that many companies are craving specific legislations which provide a clear framework for the growth of rooftop PV or an effective framework to conclude private power deals.

Revenue growth

Confidence in South Africa's PV market in the mid-term was once again evident when a staggering 87 percent of respondents said they were expecting an increase in their business development budgets over the next three years. About 40 percent went as far as saying they were expecting a substantial growth in their budgets over this period.

Such positive expectations indicates that companies may be looking to expand their operations in Sub-Saharan Africa and is a clear sign of rising revenues and a continued view of profitability.

As for which Sub-Saharan African markets outside of South Africa represented the biggest potential for PV project development in the next five years, Namibia topped the polling with 33 percent.

Ghana, Nigeria, and Kenya all polled very similarly with around 18 percent each, suggesting that amongst these nations there was a lack of consensus on which would be the best investment opportunity. Other markets being eyed by PV players in the region were said to be Botswana, Mozambique, Tanzania, Zambia and Zimbabwe.

Delving deeper into what would form the largest part of the companies' business development spend over the next five years, the survey found that South Africa had the highest potential growth, with 53 percent pointing to this market as their priority.

"This is perhaps reflective of companies waiting for demand markets to mature further in the region or for a stronger set of regulatory incentives in neighbouring countries to be set out to incentivize development," states the PV Insider survey report.

Nevertheless, for about 33 percent, expanding into other Sub-Saharan African markets was their priority over the next five years, while 13 percent underlined cost reductions or technological development as their primary focus.

To effectively develop their business strategies and expand, companies typically need to collaborate and form mutually beneficial relations with government authorities, developers and financial institutions. In South Africa, about 40 percent of survey respondents said that meeting with financiers was what they needed to help them broaden their business, which indicates that many companies in the market may have issues getting low-cost or quick access to capital.

About 20 percent said that meeting with developers would help them improve their business, suggesting that some suppliers

South Africa to spearhead solar revolution

South Africa is being tipped as a major market for growth opportunities but where is the South African PV market heading? A recent look at the growing market place shows that companies are beginning to look beyond the country for market opportunities. South Africa seems to becoming the entry point for many companies to the rest of the African continent.

A RECENT SURVEY by PV Insider on the commercial development and sustainability of the South African photovoltaic market revealed some surprising results on the near-term expectations for revenue growth, market drivers and business development strategies.

Not only are companies seeing opportunities beyond the REIPPP program, but they're also looking beyond South Africa as they investigate other promising Sub-Saharan African markets.

With a total target of 9,770 MW worth of PV deployments by 2030 following the policy-adjusted Integrated Resource Plan, and with the rollout of the Renewable Energy Independent Power Producer Procurement (REIPPP) programme, South Africa's PV market has shown tremendous growth potential for developers, manufacturers and service providers.

According to the results of a new PV Insider survey which interviewed more than 100 leading professionals, nearly half of the participants have witnessed a revenue increase in the South African PV market over the past year, while about 42 percent said their revenue streams had remained constant.

This is evidence that the profits of the REIPPP are seeping through to the budgets of those active in the market, driven by the undersupply of power in the market and the guarantee of the government procurement programme, which to date has awarded 33 PV projects.

Overall, more than 1 GW of PV has been deployed in South Africa. However, as the production deficiency void shrinks, firms will have to be increasingly competitive to secure consistent revenue streams.

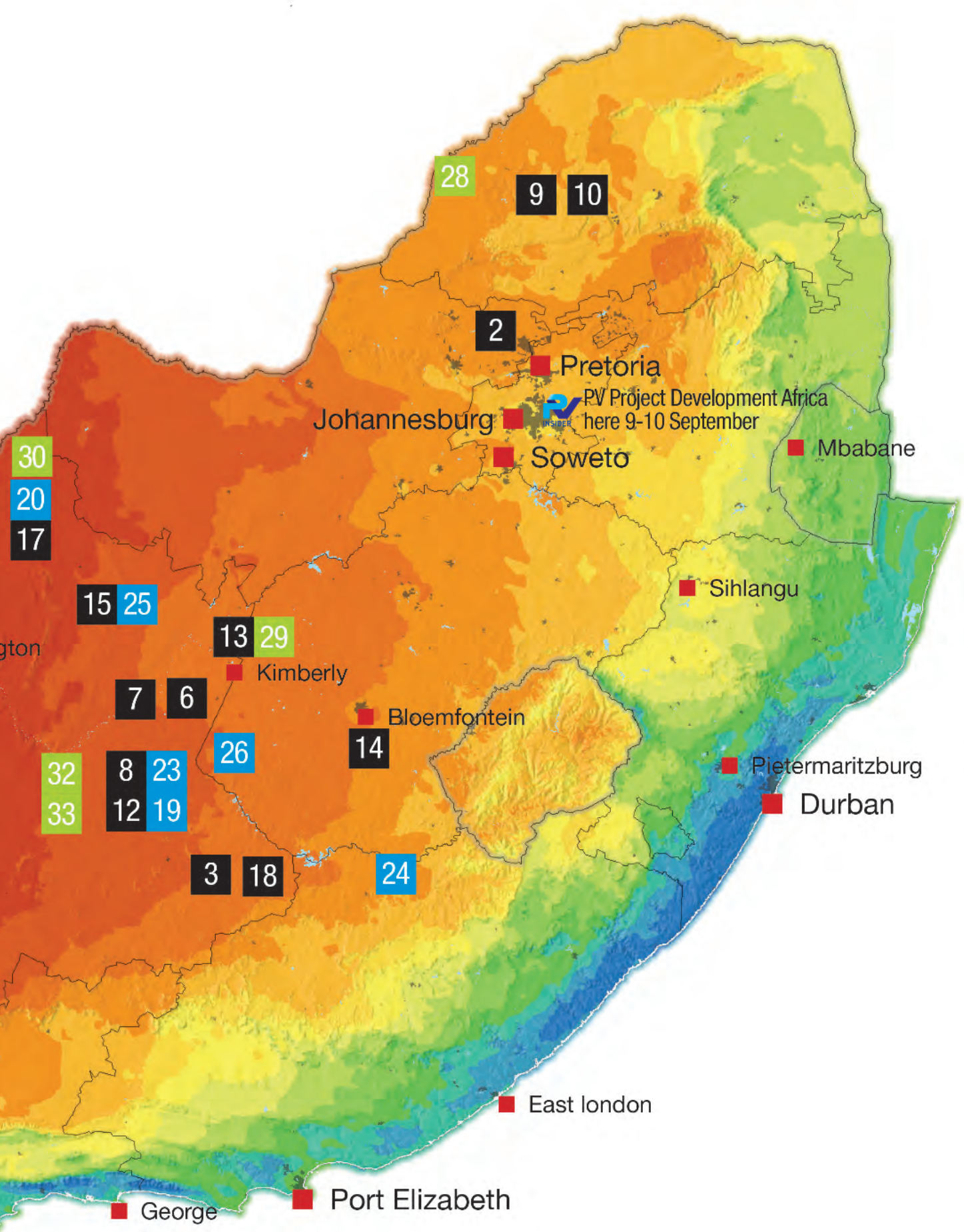
Underlying concerns

Throughout the survey, it became evident that there was an underlying concern within the market over the commercial sustainability of the current development process.

Although 65 percent of respondents said they saw the market as fairly or totally sustainable over the next three to seven years – which shows a good degree of confidence in growth prospects – about 24 percent said they were unsure about how the market would evolve over this period. In addition, 10 percent believe that the development pattern is slightly or very unsustainable.

Moreover, half of the respondents acknowledged that their business was too dependent on the REIPPP, and that this was the biggest cause of uncertainty for them. Another 30 percent revealed that price levels were dropping too low to for them to stay competitive.

"This fear is certainly backed up by the figures, with the average price of awarded projects in Round 1 of the REIPPP around 270 cents and the average price in Round 3 about 95 cents," the PV Insider survey report highlighted, adding that if price levels drop any lower, it is clear that some in the industry would no longer be able to be competitive. Consequently, companies may begin to start taking steps to mitigate against the risk by sourcing a private client base. Meanwhile, the lack of domestic manufacture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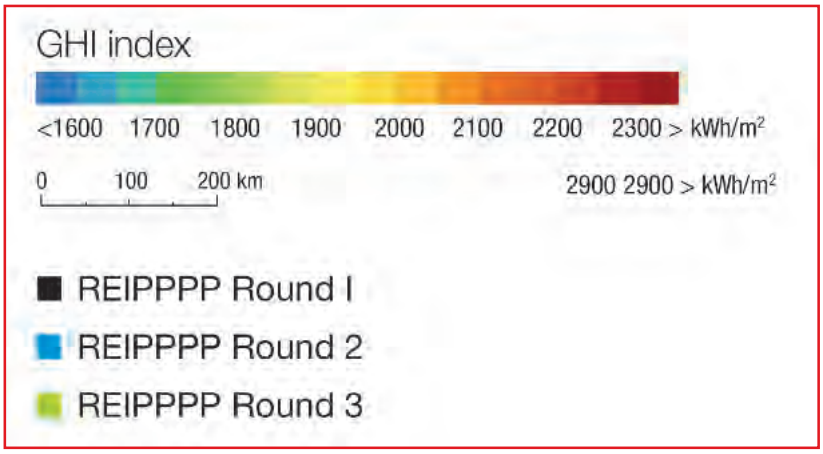
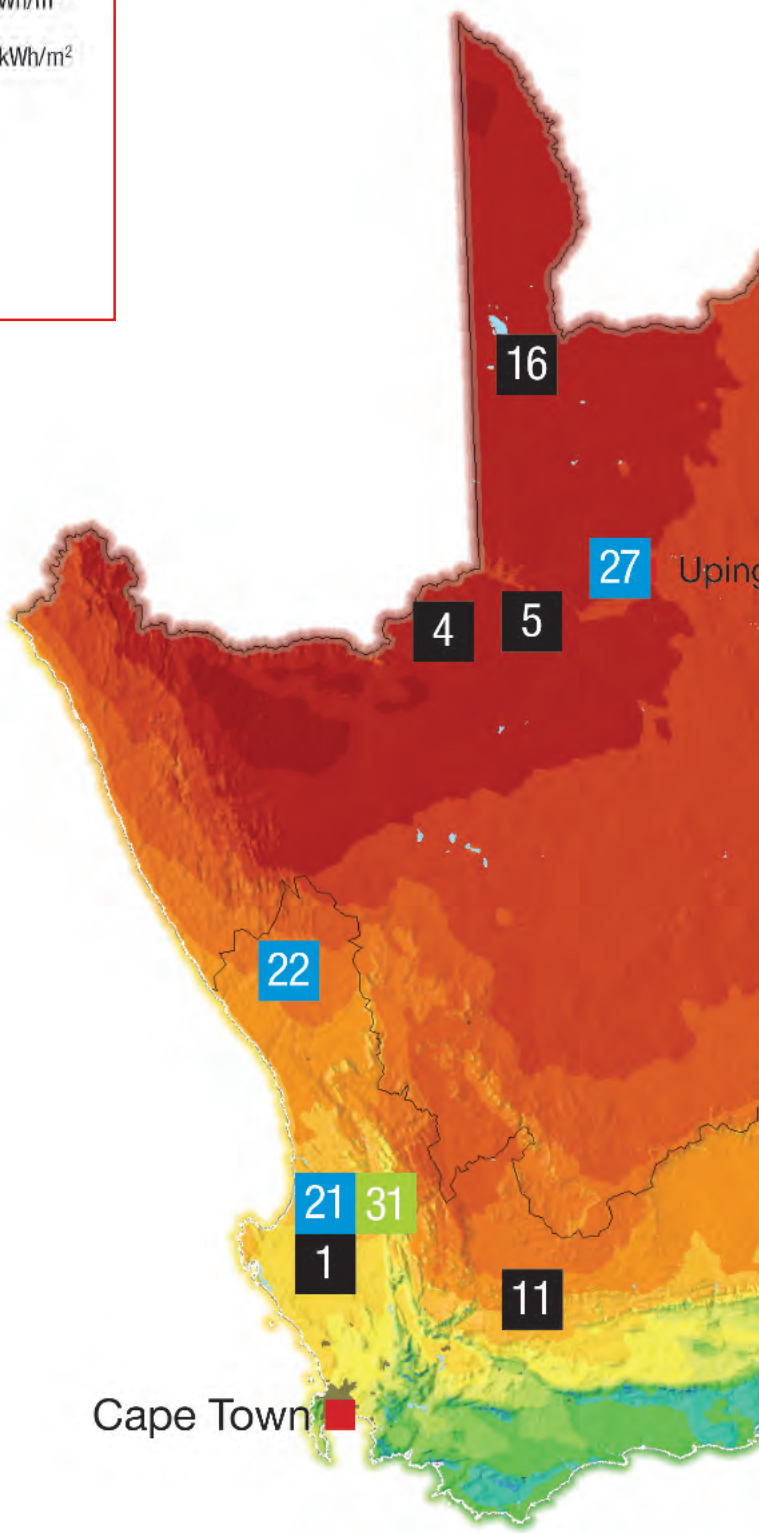
REIPPPP Round 1, II & III Project Map

Annual sum of global horizontal irradiation, average 1994 - 2012





REIPPPP Round I

By December 2011 the Department of Energy had received 53 bids across all the different technologies, awarding 28 projects to independent power producers made up of 632MW of PV, 150MW of CSP and 634MW of Wind. In total 18 PV projects were awarded preferred bid status, ranging from 5MW-75MW in capacity. (For further information on these projects see the REIPPPP Round I - Project List & Map)

REIPPPP Round II

The bidding for window II of the REIPPPP closed on 5 March 2012 with 79 bids received. The total capacity of bids amounted to 3,255MW, far exceeding the 1,275MW cap. As with the first round, wind and solar-PV dominated with 9 projects totalling 417.1MW for solar PV and 7 projects totalling 562.5MW for wind. 2 small hydro projects totalling 14.3MW and 1 CSP project totalling 50MW were given preferred bidder status. The 19 projects represent 1,043.9MW of a total of 1,225MW allocated for the second round. In total 9 PV projects were awarded preferred bid status, ranging from 8.8MW-75MW in capacity

REIPPPP Round III

The winners of the Round 3 of bidders of the REIPPPP were announced on the 29th of October 2013. 435MW of new PV solar capacity was issued to six preferred bidders. The signing and effective date of PPAs, Direct Agreements, Implementation Agreements and Connection Agreements and Financial Close are all due to be completed 30 July 2014. The round was dominated by Enel Greenpower with 4 of the 6 projects awarded.

PV Insider is holding PV Project Development South Africa September 9th-10th and can be contacted about the event via Marco Geraghty at marco@pv-insider.com

REIPPPP Round II - Project List

	Project	Developer	Net Capacity (MW)	Location
19	Solar Capital De Aar 3	Moncada Energy Group SRL & Solar Capital (Pty) Ltd	75.0	De Aar, Northern Cape
20	Sishen Solar Facility	ACCIONA Energy (ANA) and Aveng Grinaker-LTA (AGL)	74.0	Dibeng, Deben, Northern Cape
21	Aurora Solar Park	Solairedirect	9.0	Aurora, West Coast DC, Western Cape
22	Vredendal Solar Park	Solairedirect	8.8	Vredendal, Western Cape
23	Linde	Scatec Solar	36.8	De Aar, Northern Cape
24	Dreunberg	Scatec Solar	69.6	Dreunberg, Eastern Cape
25	Jasper PV Project	SolarReserve	75	Postmasburg, Northern Cape
26	Boshoff Solar Park	SunEdison	60	Boshof, Free State
27	Upington Solar PV	Enel Green Power	8.9	Upington, Northern Cape

REIPPPP Round III - Project List

	Project	Developer	Net Capacity (MW)	Location
28	Tom Burke Solar Park	Enel Green Power	60	Lephalale, Limpopo
29	Pulida Solar Park	Enel Green Power	75	Kimberley, Free State
30	Adams Solar PV 2	Enel Green Power	75	Hotazel, Northern Cape
31	Solar PV Paleisheuwel/Electra Capital	Electra Capital (Pty) (100% owned by Enel Green Power)	75	Sandveld Region, Western Cape Province
32	Mulilo Prieska PV	Total, Mulilo Solar Entreprises, Sunpower	75	Prieska, Northern Cape
33	Mulilo Sonnedix Prieska PV	Sonnedix, Mulilo Renewable Energy, Juwi	75	Prieska, Northern Cape

REIPPPP Round I - Project List

	Project	Developer	Net Capacity (MW)	Location
1	SlimSun Swartland Solar Park	SlimSun	5.0	Swartland, Western Cape
2	RustMo1 Solar Farm	Momentous Energy	6.8	Rustenburg, North-West Province
3	Mulilo Renewable Energy Solar PV De Aar	Gestamp Mulilo Consortium	9.7	De Aar, Northern Cape
4	Konkoonsies Solar	Limarco 77 (Pty) Ltd	9.7	Pofadder, Northern Cape
5	Aries Solar	Sevenstones 159 (Pty.) Ltd.	9.7	Kenhardt, Northern Cape
6	Greefspan PV Power Plant	AE-AMD Independent Power Producer 1 (Pty) Ltd (AE–AMD Renewable Energy is a union between Spanish firm AMDAenergía SA and local renewable firm ALT-E Technologies	10.0	Douglas, Northern Cape
7	Herbert PV Power Plant	AE-AMD Independent Power Producer 1 (Pty) Ltd	19.9	Douglas, Northern Cape
8	Mulilo Renewable Energy Solar PV Prieska	Gestamp Mulilo Consortium	19.9	Prieska, Northern Cape
9	Soutpan Solar Park	Erika Energy (Pty) Ltd	28.0	Waterberg, Limpopo
10	Witkop Solar Park	Core Energy (Pty) Ltd	30.0	Waterberg, Limpopo
11	Touwsrivier Project	Soitec Energy and Scheider Electric Energy. CPV Power Plant No. 1	36.0	Aquila Private Game Reserve. Touwsrivier, Western Cape
12	De Aar Solar PV	South Africa Mainstream Renewable Power De Aar PV (Pty) Ltd	48.3	Pixley Ka seme, Northern Cape
13	South Africa Mainstream Renewable Power Droogfontein	South Africa Mainstream Renewable Power Droogfontein (Proprietary) Ltd	48.3	Kimberley, Northern Cape
14	Letsatsi Power Company	Intikon Energy, consortium consisting of Kensani Capital Investments (Pty) Ltd, SolarReserve South Africa (Pty) Ltd and Oakleaf Investment Holdings 80 (Pty) Ltd	64.0	Bloemfontein, Free State
15	Lesedi Power Company	Intikon Energy, consortium consisting of SolarReserve South Africa (Pty) Ltd, Kensani Capital Investments (Pty) Ltd and Oakleaf Investment Holdings 80 (Pty) Ltd	64.0	Postmasburg, Northern Cape
16	Kalkbult	Scatec Solar	72.5	Kalkbult, Northern Cape
17	Kathu Solar Energy Facility	Lokian Trading & Investments (Pty) Limited	75.0	Kathu, Northern Cape
18	Solar Capital De Aar (Pty) Ltd	Inca de Aar Solar (Pty). Solar Capital De Aar (Pty) Ltd	75.0	De Aar, Northern Cape

Renewable energy
supported update

The South African government revealed their ambitious renewable programme entitled the Renewable Energy Independent Power Producer Programme 2010-2013 (REIPPP). The success has propelled the country to a top solar producer. PV Insider caught up with the latest developments.

IN MARCH 2010 South Africa's Department of Energy (DOE) finalised details of the Integrated Resource Plan (IRP), a 20-year blueprint that showed the government's commitment to energy from renewable sources. The IRP indicated that renewable energy will make up a substantial 42% of all new electricity generation (totalling 17,800MW) from 2010- 2030, and gave strong backing to Wind, Solar Photovoltaics (PV) and Concentrated Solar Power (CSP) within this new energy mix. Under the IRP the DOE committed to produce 8400MW from PV, 8400MW from Wind and 1000MW from CSP through the REIPPPP.

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