Solar+Power MANAGEMENT
A GLOBAL BUSINESS JOURNAL
ISSUE I 2016 I WWW.SOLARPOWERMANAGEMENT.NET

# Silicor Materials

New silicon manufacturing approach cuts costs

ASYS SOLAR

# NEW Making The Invisible Obvious

## Enhanced Cell Tester with EL- and Hotspot Measurement

**Increasing** **High-Quality Yield of Cell Production.**

**Detecting**
// Finger Interruptions
// Micro Cracks
// Inhomogenities
// Contaminations
// Low Efficiency Regions
// Firing and Contact Issues
and more...

Alignus 2.0

**The New Generation of Class-Leading Metallization Lines**

**More Than 10 New Developments and Feature Enhancements!**

// Testing: EL and hotspot measurement
// Printing: print head combining a motorized setup with pneumatic closed loop operations
// Printing: automatic air knife for the removal of particles
// Drying: VOC management including heat exchanger and oxidizer
and more ...

**ASYS GmbH**
Benzstrasse 10, 89160 Dornstadt, Germany

**www.asys-solar.com**

# viewpoint

# Energy independence is a fitting legacy

WHEN THE Irish government announced plans to embrace renewable energy by 2050 and eliminate all fossil-fueled power by 2100 it created a legacy for future generations.

It was a bold move: change the way a nation heats, cools and energizes its homes, businesses and farms. After years of study and ample evidence that renewable energy can achieve cost parity with fossil-fueled power, Irish leaders concluded the country was ready.

Embracing change is never easy, especially where traditions are firmly held. But Irish leaders recognized that change in some form was inevitable due to global warming. They also recognized that the sooner they adopted renewable energy the more likely they were to achieve long-term benefits for Ireland and its people.

Now is an ideal moment to begin the process. The cost of renewable energy technology is dropping; evidence of its positive impact is growing. Recently, the KIC InnoEnergy group (the Netherlands) announced a new software modeling tool to track multiple renewable energy forms and ways innovation will impact the cost of PV solar, wind power, hydroelectric and geothermal energy. Their conclusion? In solar/PV power alone, costs should drop nearly 50 percent by 2030 (see p60).

Ireland today is already transitioning to renewable energy. About 23 percent of Irish power comes from renewable resources – the majority from inland wind generation. Being an island has advantages, including superb conditions for coastal wind turbines – 10 times that of other European locations. The amount of solar power deployed in Ireland is small, but the success of solar energy in other northern latitudes demonstrates that Ireland could benefit.

Ireland is thinking long-term, which is refreshing for any government. Leaders recognise that transitioning will not be easy where generations have depended upon peat, oil and coal for electricity, heat and jobs.

Change will impact employment – particularly jobs tied to existing fossil fuels. But the fact that new jobs – a net increase – can come from new energy resources, services and industries also means that change can be positive.

Ireland is not alone. Germany set a similar course and today derives between 20 and 50 percent of its power from renewable resources. It has created countless jobs in manufacturing, installation and services, as well as software development. Germany is at the forefront of PV/solar energy innovation because its government and people broke from the past and sought a new future built around energy independence.

Creating independence, new jobs and new industries is a perfect legacy. Future generations will be glad that Irish leaders took bold initiatives when they saw that now was the time to act (see p56).

**Editor / Publisher** Jackie Cannon
T: +44 (0)1923 690205
E: jackie.cannon@angelbc.com

**Technical Contributor:** Mark Andrews
E: mark.andrews@amcsolutions.info

**Sales Manager** Shehzad Munshi
T: +44 (0)1923 690215
E: shehzad.munshi@angelbc.com

**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

**Design & Production Manager** Mitch Gaynor
T: +44 (0)1923 690214
E: mitch.gaynor@angelbc.com

**Director of Logistics** Sharon Cowley
T: +44 (0)1923 690200
E: sharon.cowley@angelbc.com

**Directors:**
Bill Dunlop Uprichard – CEO
Stephen Whitehurst – COO
Jan Smoothy – CFO
Jackie Cannon, Scott Adams, Sharon Cowley, Sukhi Bhadal, Jason Holloway

**Circulation and Subscriptions**
T: +44 (0)1923 690200 E: circ@angelbc.com

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

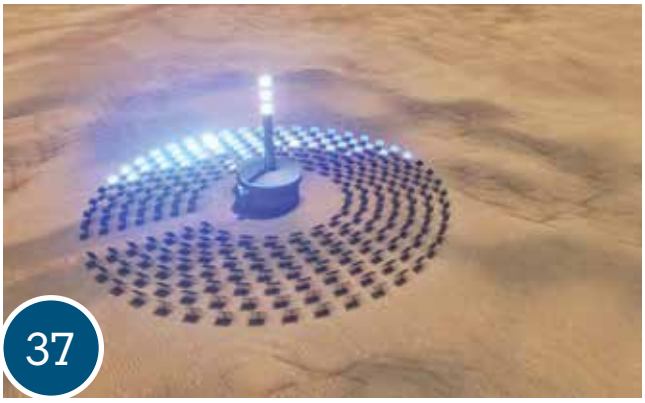
**Registered Office:** Angel Business Communications Ltd (Coventry) UK, Registration Number: 1972952

AN ANGEL BUSINESS COMMUNICATIONS PUBLICATION

Solar+Power MANAGEMENT

ISSUE I 2016 I WWW.SOLARPOWERMANAGEMENT.NET


# features...

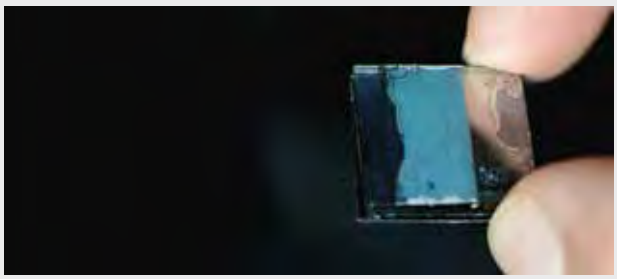


# industry news...



# research...





# azimuth...



# Canadian Solar secures $70 million investment

CANADIAN SOLAR has announced that it has entered into agreements with International Finance Corporation ("IFC"), to receive a financing package of up to US$70 million in loans and equity investment.

IFC's financing package includes: (i) loans to Canadian Solar of up to US$ 60 million and (ii) subscription of up to US$10 million in common shares of the Company. The partnership with IFC underscores the Company's commitment to expanding in Asia and Latin America, as well as conducting its operations in compliance with IFC's environmental and social performance standards.

IFC, a member of the World Bank Group, is the largest global development institution focused exclusively on the private sector in emerging markets. Proceeds of the investment and financing package will be used to fund Canadian Solar's module production facility in Vietnam and expansion of solar cell and/or module production capacities in other emerging markets.

"We are delighted to secure support from IFC. This partnership is another milestone that enhances our leading position in the global solar power industry," said Dr. Shawn Qu, Chairman and Chief Executive Officer of Canadian Solar. "With IFC's commitment, we are able to expand our production capacity to meet the increasing demand for solar energy worldwide. We look forward to continuing our cooperation with IFC to accelerate the adoption of solar energy around the world, especially in developing economies, and to mitigate climate change."

Alzbeta Klein, Director, IFC Manufacturing, Agribusiness and Services said, "The solar industry is at an exciting juncture, where rapid cost declines have made it a scalable option for emerging markets. IFC views this transaction as a first step in a long-term partnership with Canadian Solar, a global leader in the industry, and we look forward to collaborating on business models that will enable low-carbon energy access."

# Residential battery storage in Australia gets big boost for residential areas

A USD $36.5 million investment in Sunverge Energy's world-leading technology is set to advance the uptake of residential energy storage in Australia. ARENA CEO Ivor Frischknecht said the new round of financing included a USD $20 million commitment from AGL Energy Limited (AGL) and was a clear signal of confidence in Sunverge's smart storage systems.

"This USD $20 million commitment from AGL will see one of Australia's largest energy companies join other investors – ARENA, SBCVC, Siemens Venture Capital and Total Energy Ventures – to bring new residential storage technology to the Australian market," Mr Frischknecht said.

"This new investment will build on more than USD $7 million that ARENA and SBCVC have already invested through the Southern Cross Renewable Energy (SXRE) Fund to help Sunverge establish operations in Australia and overcome barriers to the widespread deployment of storage systems."

Mr Frischknecht said ARENA and SBCVC had first invested in Sunverge Energy through the SXRE Fund in 2014 and had played a critical role in the success of Sunverge Australia. "The company has continued to grow and this latest success will allow it to employ more staff in Australia and explore options for locally manufacturing its systems in the future," Mr Frischknecht said. "Residential battery storage is currently in its infancy in Australia. While only a small number of systems are currently installed, there is a lot of interest in the technology. "The partnership between AGL and Sunverge will accelerate the roll out of a state-of-the art grid integrated battery storage solution to Australia's large household storage market.

"As storage becomes more commonplace in Australian homes, we expect to see energy retailers firm up business models for selling new products and work through some of the regulatory constraints facing Australia's emerging storage market.

"Solving these challenges will ultimately allow consumers to get more value from their rooftop solar systems and increase the supply of renewable solar power in our electricity networks, contributing to grid stability and reducing peak load stress."

Sunverge's Solar Integration System combines advanced lithium batteries with a sophisticated control platform that allows power flows to and from the grid to be controlled as part of a Virtual Power Plant.

# Access Power launches US$7 million co-development facility for African projects

ACCESS POWER, a developer, owner and operator of power projects in emerging markets, has announced the launch of ACF 2016, the second edition of its successful Access Co-Development Facility for renewable energy projects in Africa. The launch took place at the Making Solar Bankable conference in Amsterdam.

ACF 2016 is a US$7 million financial support mechanism designed to provide local power project developers and originators with the technical experience, expertise and funding required to bring their renewable energy projects to life. Following the competition's successful launch last year, the ACF increased its funding pot from US$5m in 2015 to US$7m for this year's winners. The successful projects will be selected by a panel of expert judges whose decision will be based on commercial, technical and environmental merits, the local regulatory environment, and the project team.

The winners of ACF 2016 will be announced on Tuesday 21st June 2016 before a live audience during the Africa Energy Forum in London (see Notes to Editors for further details). The winners will enter a Joint Development Agreement with Access Power, which will take an equity stake in the winning projects and fund third-party development costs such as feasibility studies, grid studies, environmental and social impact assessments and due diligence fees. Access Power will also provide technical support, financial structure and development process management.

Reda El Chaar, Executive Chairman, Access Power commented, "ACF 2016 is leading the way in demonstrating and supporting the type of renewable energy projects that will help meet Africa's massive and urgent need for electrification.

"Through this unique facility, we hope to encourage innovation and support companies in their efforts to deliver power to places that desperately need

it. Last year we received a total of 55 submissions from 18 countries across Africa, including solar, wind, hydro, hybrid and bio-mass projects.
"2016 looks set to build on that success.

We look forward with great interest to receiving this year's entries and hearing the judge's final decision during an exciting live event at the Africa Energy Forum in London this summer."
The inaugural ACF in 2015 was won by Quaint Solar Energy from Nigeria and Flatbush Solar from Cameroon. Other competing projects hailed from Cape Verde, Kenya, Madagascar, South Africa, Morocco, Ghana, Rwanda and Tanzania.

One project has already pre-qualified for ACF2016. A 25MW solar project being developed in Sierra Leone by Africa Growth and Energy Solutions (AGES) won the Solar Shark Tank competition at the Making Solar Bankable conference in Amsterdam on 18th February. In a keenly fought contest, three emerging markets developers competed for a US$100,000 grant to support the development of their solar projects, funded by Access Power and Dutch development bank FMO. Part of the prize, subject to terms and conditions, was pre-qualification for ACF2016.

# European solar market grows 15 percent

IN 2015, European countries connected around 8 GW of solar power systems to electrical networks, according to first estimates by SolarPower Europe, the association of the solar power sector in Europe. Demand for solar power systems in European countries increased by around 15 percent year-on-year, compared to 6.95 GW of new grid-connected solar power capacity in 2014.

"It is good to see the European solar power sector again on the growth path in 2015," says James Watson, CEO of SolarPower Europe. Peaking in 2011, demand for solar power installations in Europe declined for 3 consecutive years. Europe's solar growth in 2015, however, is primarily based on the strong UK market, demand for solar systems in most other countries stayed flat or declined. Watson added, "Solar needs clear signals from policy makers in Europe to be able to contribute to achieving the climate goals agreed in Paris. With solar being competitive for residential and commercial applications in most European countries today, investors need a secure political framework for generation, self-consumption and storage of solar energy."
Annual global grid-connected solar rose by over 25 percent to more than 50 GW in 2015, from 40.1 GW in 2014.

SolarPower Europe is unique in comparison to other market analysts, because it examines grid-connected solar systems rather than product shipments or installations.
Final numbers for 2015 will be presented in a new report in March. Estimates for 2016, including market forecasts until 2020, will be published in SolarPower Europe's 'Global Market Outlook for Solar Power 2016 - 2020,' which will be launched at Intersolar Europe in June.

# Imec extends collaboration with Total on next generation silicon solar cells

NANOELECTRONICS research centre imec and global energy company Total, have announced that they have extended their collaboration to significantly increase the energy output of PV panels. Imec's industrial affiliation program (IIAP) on next-generation crystalline silicon solar cells is a multi-partner R&D program concentrating on further increasing the conversion efficiency of silicon solar cells and modules, while at the same time reducing industrial manufacturing cost.

Total joined imec's industrial affiliation program (IIAP) on next-generation crystalline silicon solar cells in 2009, which is a multi-partner R&D program bringing together companies along the value chain of solar cell manufacturing.

Within this framework, researchers from Total collaborate with the solar R&D team at imec, including imec experts, solar cell manufacturers, material and equipment suppliers, and academia. Future R&D will build upon research breakthroughs achieved in the previous collaboration, such as 22.5 percent large area two-side contacted n-type PERT solar cells.

Imec and Total will continue with the development of advanced cell architectures aiming at +23 percent bifacial n-type cells, novel low-cost module interconnection concepts, smart modules and techniques to more accurately predict the energy production from solar cell modules under varying weather conditions.

With this, the partners aim to significantly increase the energy output of PV panels, in this way bringing the cost of electricity from solar further down.

"I am pleased that Total has extended its partnership to imec's R&D program on silicon solar cells and am looking forward to building upon the work we have done thus far," said Rudi Cartuyvels, executive vice president of smart systems and energy technology

at imec. "Investing in R&D and innovation, is crucial for companies to prepare for the future and to stay ahead of the competition in a challenging environment such as the PV market. Total's commitment confirms the leading positions of imec's PV research in the global PV and energy market."

# Trina Solar supply modules to 57 MW project in Japan

TRINA SOLAR LIMITED has begun shipping 57.1 MW of solar modules to Toyo Engineering Corporation for use in the Furukawa Mega Solar Project is located in Osaki City, Miyagi Prefecture, Japan.

The delivery of solar modules is scheduled for completion before the end of the third quarter of 2016. The Project, developed by Pacifico Energy Furukawa G.K, is being constructed on an abandoned golf course in Osaki and is expected to be completed and commissioned in the fourth quarter of this year. The clean electricity that the Project will generate will be purchased by Tohoku Electric Power Company to energize the region.

"We are delighted to be selected as an exclusive supplier to Toyo Engineering and Pacifico Energy again for their large-scale solar project," commented Ms. Ye Chen, President of Trina Solar Japan Ltd. "We believe the historic climate pact adopted at COP21 will further bolster the development of solar energy in Japan, as well as other countries around the globe.

Looking ahead, we will continue to reinforce our deployment in the Japanese market while proactively devoting our efforts to prevent global warming through continuously delivering innovative solar products."

£40 million to drive green car revolution across UK cities
Four UK cities have been awarded significant funds to promote green vehicle technology after successfully bidding for a share of a multi-million pot created to support the take-up of plug-in electric cars across the UK.

Transport Secretary Patrick McLoughlin announced the winners of the Go Ultra Low City Scheme, after the successful cities proposed a number of initiatives to support greener vehicles as part of a government competition.

The winning cities will deliver a rollout of cutting edge technology, such as rapid-charging hubs and street lighting that double as charge points, along with a range of innovative proposals that will give plug-in car owners extra local privileges such as access to bus lanes in city centres. Around 25,000 parking spaces will also be opened up for plug-in car owners saving commuters as much as £1,300 a year.

The funding has been awarded to cities which have designed schemes that will help encourage thousands of people to consider switching to a plug-in car. These proposals will support the UK's thriving green vehicle sector, improve air quality in urban hotspots and help the government meet its emission cutting targets.

# Energy storage for solar to be an $8 billion market in 2026

DISTRIBUTED STORAGE for solar systems will be worth $8 billion in 2026 as solar combines with storage in order to continue its remarkable growth, according to Lux Research. Solar-plus-storage is a key necessity for solar to overcome limitations like intermittency and the lack of power after dark.

Energy storage will increase the distributed solar market by 25 GW annually in 2026. Adding storage adds costs, affecting revenue streams and addressable market size, but as installed solar system costs decline – from $3.83/W in 2015 to $1.87/W in 2035 – an attractive economic case will emerge in 2023, leading to strong growth.

"As the solar-plus-storage market matures, interesting developments will unfold on a number of fronts. There will be more vertical integration between the two industries, increased financing options and even a move towards energy-sharing between communities," said Cosmin Laslau, Lux Research Senior Analyst and lead author of the report titled, "Helping Renewables Shine On: Analyzing the New Business Cases Where Batteries Make Sense for Solar Systems."

Lux Research analysts studied the impact on distributed solar of its integration with storage to maintain growth. Among their findings: Solar-storage partnerships begin to emerge. Partnerships between Stem and SunPower, Green Charge Networks and SunEdison, and Sonnen and Sungevity reveal the industry's future.

First Solar even joined a $50 million investment in Younicos, a leader in grid-scale energy storage integration.

Software is a key differentiator. Leaders like SolarCity and others are offering demand management software that can help integrate storage. Sunverge's system can link to smart devices and electric vehicles, while Sonnenbatterie's software can analyze weather data to optimize solar consumption and storage.

Policy support has big impact. Thanks to policy support, Germany has installed 12,000 solar-plus-batteries systems since 2013 with a recent growth rate of 35 percent. Japan has launched a subsidy program to cover two-thirds of the installation costs for lithium-ion battery systems at 1kWh or larger, while California offers a $1.46/W incentive – and mandates utilities to install 1.3 GW of storage by 2020.

The report, titled "Helping Renewables Shine On: Analyzing the New Business Cases Where Batteries Make Sense for Solar Systems," is part of the Lux Research Solar Intelligence, Energy Storage Intelligence, and Distributed Generation Intelligence services.

# ABB secures contract with to supply 50MW in Jordan

ABB has secured a contract with Martifer Solar to supply 50MW solar capacity in Jordan. The deal covers four solar plants, located near the cities of Ma'an and Mafraq. Jordan imports 96 percentof all its energy at an annual cost of $3.6 billion or 13.5 percentof the country's GDP. The Master Strategy of the Energy Sector in Jordan has set a target of 1,800MW, or 10 percent of the country's energy supply to come from renewable sources in 2020. This strategy calls for 600MW of this new capacity to be provided by solar power.
ABB has helped co-design the plants using the company's equipment as required by the grid operator (NEPCO) with complete solution. The project is scheduled for completion in the first quarter of 2016. Under the agreement, ABB will be responsible for the manufacture, supply, and commissioning of 45 central inverters (ULTRA), 24 36kV compartments on skid (MVCS), Plant Power Controller (PPC), and 36kV delivery stations. In addition, ABB signed a service agreement to train Martifier Solar's operations and maintenance (O&M) technicians on specialized O&M of its inverters.
"ABB is proud to play an important role in helping Jordan reach its ambitious renewable energy targets set for 2020," said Ahmad Alhussein, Local Manager, Discrete Automation and Motion. "These innovative and technologically advanced solar projects are a big first step toward boosting Jordan's energy security and reducing its reliance on imported oil and gas."

Marco Alves, Operations & Maintenance Business Director, Martifer Solar said: "This service agreement established with ABB, including the training of our O&M technicians in operating and maintaining the ABB inverters, is an important milestone for the company and an important step towards proficiency, in line with our global strategy of providing highly reliable O&M services worldwide."

# Solarpack to develop 100 MW PV in India

SOLARPACK has been selected to build six photovoltaic solar plants with a total power of 100 MW DC in the Indian state of Telangana. Solarpack is in a partnership with Think Energy Partners.

TSSPDCL will acquire all the generated electricity through a long term power purchase agreement (PPA) for a period of 25 years. These plants are expected to generate around 160 GWh annually; thus catering to the huge energy requirements of the country.

To achieve the total power awarded, the Consortium will build six plants for a total of 100 MW DC, that will be located in the districts of Mahbubnagar, Medak and Nizamabad in the Indian State of Telangana. The construction will begin during the first half of 2016 and the plants are expected to be in operation at the end of January, 2017. This contract entails, according to Pablo Burgos, CEO of Solarpack, "the entry into a market as important as India´s and demonstrates our experience and growing international presence that permits us to be competitive in the most relevant markets. In addition, we count on the support of Think Energy Partners that is already widely established in the country, to respond to any challenges that may be encountered".

Mr. Burgos also guarantees that "the drive of Solarpack is to bet for company growth and the development of solar energy projects in regions with high development potential". Mr. Ravishankar Tumuluri, Managing Partner of Think Energy Partners, said that "This is just

the beginning and we will continue to work toward bringing more and more experience and solar business into India; thereby catering to India's increasing energy demand.
"Our vision is to become one of the leading solar power developers in India over the next 3-5 years. We will leverage our global presence and local expertise to provide a reliable platform for our partners".

# Tekes awards Valoe EUR4 million loan for back contact technology

VALOE CORPORATION and the Finnish Funding Agency for Technology and Innovation ("Tekes") have agreed on new funding for Valoe. Tekes gives Valoe a subsidised loan of EUR 4 million to further develop photovoltaic modules and to develop solar cells based on the back contact technology.

The loan can amount to max. 70 per cent of the project's total costs which are estimated to be ca. EUR 5.8 million. The loan will be withdrawn in 2016 -2019. The loan period is seven years. Valoe's advances in solar PV-business have been based on the understanding in automation, laser technology and the company's experience in flexible circuits. Further, laser technology is one of the key technologies in the production of the cells based on the back contact technology.

Additionally, Valoe has a deep understanding in physical metallurgy that is one of the key sciences in developing the PV- cells. Together with its strategic partners Valoe plans, in the future, to expand its offering with solar cells based on back contact technology. "The decision of Tekes to fund Valoe's photovoltaic technology based on the next generation back contact is

significant. Valoe has been co-operating closely with Tekes for several years in relation to the development of the nextsolar cells. The decision of Tekes to provide Valoe withmore funding strengthens remarkably Valoe's possibilities to create an ecosystem based on the technology developed by Valoe. I believe that in the near future we will see new initiatives supporting Valoe's understanding that the market share of the back contact modules will grow fast in the next few years", says Iikka Savisalo, Valoe's CEO. The loan arrangement with Tekes has a positive impact on Valoe's financing situation.

Further, the Board of the Directors of the Company wishes to emphasize that there are risks relating to the Company, especially in terms of sufficiency of financing. The Convertible Bond I/2015 and the loan now given by Tekes have enabled the Company to stabilize its short-term and long- term financing remarkably. Also negotiations for deliveries of production technology have made good progress. However, the financing situation of Valoe continues to be tight. The sufficiency of the company's financing and working capital for the next twelve months involves significant risks.

According to the current view of Valoe's management the company continues to need financing until the cash flow from the business operations has turned positive or a long -term financing arrangement has been secured with the planned share issue. The company will have a significant deficit in its working capital until the first delivery of production technology for solar modules will start to generate positive cash flow. If the company does not succeed to secure sufficient financing, the continuity of the company's operation may be jeopardised.

If the company does not receive new orders as fast as it expects or if the market situation gets worse it may take longer time to turn orders into revenue. This would affect significantly the schedule in which cash flow before investments would turn positive. In such a case the company's financing situation would further tighten. Other risks connected to Valoe have been presented in more detail in the Interim Report released on 4 November 2015 and in the Annual Report for 2014.

# Swinerton selects AET ground mount for 30 MW project

APPLIED ENERGY TECHNOLOGIES (AET) has announced that Swinerton Renewable Energy has selected the Rayport-G ECO mounting system for a 30 MW-DC project in North Carolina. AET's engineering team provided substantial support for the system due to the unique site conditions. Extensive custom engineering was required to design the 30 MW-DC project taking into consideration flood plain levels. The site had a variable flood plain height from 2' to 6' based on the terrain of the site. AET performed a detailed analysis to determine final post lengths and post sizes required to maintain a leading edge height that was above the required flood plain height for the project.

AET is recognized industry-wide for its high level of precision, detail and streamlined processes enabling them to support projects of all sizes in varying locations. For this particular project, AET successfully delivered materials for the entire 30 MW-DC project over a six week period in order to meet Swinerton's timeline.

"Swinerton is one of the EPC industry leaders and we are delighted to work with them on another joint project. It is rewarding to have an association with companies who are the best in the business," said Aaron Faust, VP of Business Development for AET. "Our ability to execute on these large utility-scale projects is a validation of both our system and our expertise."

The Rayport-G ECO is strong and durable, having been engineered to withstand the most challenging environmental conditions. It is also light and compact, allowing for high shipping density, significantly reducing freight costs and enabling easier handling on the job site.

"We selected AET not only for their high quality product, but because we knew they would meet our strict deadline and still provide the level of engineering and design support needed for this particular project," said George Hershman, VP and Division Manager of Swinerton Renewable Energy.

# Meyer Burger CHF 22 million in orders

MEYER BURGER TECHNOLOGY has announced the successful conclusion of two important contracts with a combined volume of over CHF 22 million with existing photovoltaic customers in Asia. Meyer Burger also reported unaudited net sales of CHF 323.6 million, incoming orders of CHF 418.9 million for 2015 and order backlog of CHF 257.5 million as of 31 December 2015.

An Asian manufacturer of monocrystalline solar wafers has selected Meyer Burger's high precision water based DW 288 diamond wire cutting technology. In addition, a second contract for the delivery of Meyer Burger's industrially proven MAiA 2.1 equipment with MB PERC technology has been signed with a major solar cell manufacturer in Asia. The order volume of these contracts, which are recorded for January 2016, amounts to over CHF 22 million and delivery of all equipment to both customers is scheduled throughout the first half of 2016.

Meyer Burger reached total incoming orders of CHF 418.9 million in fiscal year 2015, representing an increase of 28.5 percent compared to the previous year period (FY 2014: CHF 326.0 million).

Furthermore, its order backlog was at CHF 257.5 million as of 31 December 2015 which is an increase of 35.5 percent compared to the previous year (31.12.2014: CHF 190.1 million). The strong trend in incoming orders seen during 2015 reflects the improvement in investment behavior by customers and the increased technology demand to further improve solar cell production lines with new and upgrade technologies.

# Concentrator PV technology continues to break new records

THE HIGHEST efficiencies for the direct conversion of sunlight into electricity are reached with concentrator photovoltaic (CPV) systems, and the technology still promises room for improvement. After announcing their world record solar cell two years ago, Fraunhofer ISE now reports that they have just achieved a new highest efficiency on the module level.

A mini-module comprised of four-junction solar cells reached a newly confirmed world record of 43.4 percent. "This value is a new milestone in the history of CPV technology and demonstrates the potential available for industrial implementation," says a pleased Dr. Andreas Bett, Deputy Director of the Institute and Division Director of Materials, Solar Cells and Technology at Fraunhofer ISE.

Multi-junction solar cells are used in concentrator photovoltaics (CPV). This technology is implemented in regions with a high share of direct irradiation to generate renewable electricity at cost-effective prices. In 2014 the researchers in Freiburg, together with their French partners Soitec and CEA Leti, achieved a new world-record efficiency for a four-junction solar cell.

The mini-module holding the new current record is based on this type of multi-junction solar cells in combination with a high-efficiency optic. The details of the technology behind this success will be presented at the upcoming CPV12 International Conference on Concentrator Photovoltaic Systems. This international conference for CPV will be held in Freiburg, Germany from 25-27 April 2016.

# JA Solar awarded 86-MW project in South Africa

JA SOLAR has announced that it has been awarded as the sole supplier for the Orange Solar Project which is to build an 86MW utility-scale solar farm starting 2017.

The ORANGE project is a part of the so-called 4.5th round of the Renewable Energy Independent Power Producer Procurement Program ("REIPPP") launched by the South African government in 2011.

The REIPPP initially planned five rounds of bidding, but has been extended by another two rounds (the 4.5th and 4.75th rounds) in order to meet the high demand for local new energy development from various provinces. Together with two South African partners, Solar Capital (Pty) and Black Enterprise Empowerment ("BEE"), JA Solar successfully won the bidding as the sole module supplier for this Orange project.

The construction of the solar farm will start in 2017 using JA Solar's high efficiency P310W multi-crystalline silicon modules, and is expected to be completed within the same year. Solar Capital (Pty) Ltd, based in Cape Town, is one of the most successful South African PV farm developers.

The company was awarded a 90 MW solar farm project in the first round of the REIPPP and an 86MW PV farm in the second round.

Mr. Paschal Phelan, Chairman of Solar Capital, was very pleased with the success of winning the bidding of another 86 MW project this round, and expressed the strong desire to continue its cooperation with JA Solar in the 4.75th and 5th rounds of bidding. Mr. Jian Xie, President of JA Solar, commented, "We are honored to be awarded the winning bid in this round and are very proud of being the exclusive module supplier for this 86MW project.

This achievement is another testament to the global recognition of JA's products, and is a new milestone in our global market expansion efforts. There are many more such opportunities for JA as Africa continues to develop. With our high-performance PV modules capable of greatly reducing the per-watt cost of electricity, JA is well positioned to provide assistance to South Africa for overcoming its energy shortage as the nation grows."

# First Solar achieve CdTe conversion efficiency record

FIRST SOLAR, INC has announced it has established another world record for cadmium-telluride (CdTe) photovoltaic (PV) research cell conversion efficiency, achieving 22.1 percent efficiency certified at the Newport Corporation's Technology and Applications Center (TAC) PV Lab. The achievement confirms that First Solar is on pace with its established research cell roadmap, and validates CdTe's growing competitive advantage over multi-crystalline silicon technology and other commercial thin film PV.

The record-setting research cell was constructed at the company's Perrysburg, Ohio manufacturing factory and Research & Development Centre using processes and materials suitable for commercial-scale manufacturing.

In addition to the Newport TAC Lab certification, the record has been documented in the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) "Best Research Cell Efficiencies" reference chart.
This is the ninth substantial update to CdTe record efficiency since 2011, firmly establishing a sustained trend of rapid performance improvements that significantly outstrips all other commercial technologies.
"We are tracking very closely to a technology roadmap we presented in 2013 and revised upward in March 2014", said Raffi Garabedian, First Solar's Chief Technology Officer. "At that time, we said we'd hit a 22 percent research cell efficiency milestone by the end of 2015. We've delivered on that promise. The accomplishment validates our continued confidence in CdTe as a superior PV material that combines cost effectiveness, reliability and high performance. In recent years and based on our research cell progress, we've improved the efficiency and energy density of our mass produced commercial PV modules at a rate at least three times faster than our multi-crystalline Si competitors. We fully expect to further separate ourselves from the pack in coming years."
Garabedian noted that First Solar's lead manufacturing lines were producing PV modules with 16.9 percent conversion efficiency in 4Q 2015, and that the research cell efficiency accomplishment serves as a powerful driver for integrating performance improvement into the real-world manufacturing environment.

# REC Silicon to close Silane IV unit in USA

REC SILICON ASA (REC Silicon) has reported fourth quarter revenues of USD 74.9 million, compared to USD 87.5 million in the previous quarter.
The corresponding EBITDA during the fourth quarter was a loss of USD 29.6 million compared to a loss of USD 14.1 million for the previous quarter. The decrease in revenue and EBITDA can be attributed to lower sales volumes, the recognition of USD 7 million in bad debt expense and approximately USD 6.1 million of write down of finished inventories to estimated net realizable values during the fourth quarter.

Fourth quarter total polysilicon production volumes were 3,022 MT, or 2 percent over guidance of 2,980 MT. FBR production was 2,321 MT, exceeding guidance of 2,220 MT, and semiconductor production was 288 MT, compared to guidance of 300 MT. FBR cash cost was $16.50/kg for the quarter, compared to guidance of $17.10/kg. Silicon gas sales volumes were 709 MT, slightly above guidance of 700 MT. However, silicon gas sales prices were 2 percent lower than the previous quarter.

REC Silicon will also recognize an impairment of USD 151.5 million, due to anticipated lower future prices caused by the uncertainty from the solar trade war between the US and China and the impact of Moses Lake production curtailments and the oversupply in the polysilicon industry.

Due to ongoing negative effects from the trade war between the US and China, the company has been prevented from accessing the Chinese market during the fourth quarter, which has resulted in lower sales than previously anticipated.

As a result, fourth quarter polysilicon sales volumes were 2,740 MT, compared to guidance of 4,855 MT, and finished goods inventory decreased by 131 MT, compared to guidance of 1,700 MT of inventory depletion.

Additionally, average sales prices for solar grade polysilicon declined by 4 percent compared to the previous quarter. In order to reduce existing inventory levels and maintain a healthy cash position, given the current market conditions in the ongoing solar trade war, the company will shut down the Silane IV unit and remaining FBR production in Moses Lake.

Production is currently expected to be shut-down from February until June of this year, dependent on the ongoing negotiations towards a resolution in the solar trade war and the general market development outside China.

The company intends to perform equipment inspections and preventative maintenance on Silane IV while the unit is shut-down and will utilize current employees to perform this inspection and maintenance work.

Additionally, also on account of existing inventory levels, Silane III, which has been out of production since July 2015 and was previously expected to resume production in January 2016, is also expected to remain out of production until there is a resolution to the solar trade war. The company will continue to limit capital expenditures to critical maintenance.

# Trina Solar acquires dutch cell factory

TRINA SOLAR Netherlands, has completed the acquisition of all the assets from Solland Solar, a solar cell manufacturing company with approximately 200 MW solar cell manufacturing capacity located in Heerlen, the Netherlands.

Trina Solar Netherlands acquired all of the manufacturing machines, equipment, stocks, office inventory, and real estate etc. from Solland Solar. Trina Solar will commence operations at the facility in the coming weeks.

“We are delighted with the successful completion of the transaction and believe that the acquisition enables us to expand the global manufacturing footprint of Trina Solar in an efficient manner,” commented Mr. Jifan Gao, Chairman and CEO of Trina Solar. “This investment will be one of the components of our ongoing global expansion strategy. In particular, this new cell facility in Europe, along with our in-house manufacturing capacity in Thailand and other overseas capacities allows us to leverage our global resources so that we can further expand our presence and enhance our competitive edge in overseas markets, especially the U.S. and Europe. We are also pleased to be investing in the Netherlands PV sector, in which we believe we can help create job opportunities for the local area, and support economic development in the region.”

# £40 million to drive green cars across UK

FOUR UK cities have been awarded significant funds to promote green vehicle technology after successfully bidding for a share of a multi-million pot created to support the take-up of plug-in electric cars across the UK.

Transport Secretary Patrick McLoughlin announced the winners of the Go Ultra Low City Scheme, after the successful cities proposed a number of initiatives to support greener vehicles as part of a government competition.

The winning cities will deliver a rollout of cutting edge technology, such as rapid-charging hubs and street lighting that double as charge points, along with a range of innovative proposals that will give plug-in car owners extra local privileges such as access to bus lanes in city centres.

# E.ON to partner with SOLARWATT to develop electricity storage systems

EFFECTIVE immediately E.ON will develop its own electricity storage system in partnership with Dresden-based SOLARWATT GmbH, which last year successfully launched an award-winning electricity storage system called MyReserve. The first E.ON models will be rolled out in Germany in a few months and will be available in increasingly larger numbers going forward.

The storage devices will be easy to install and, thanks to their modular design, easy to expand to increase capacity at any time. They will efficiently store electricity generated by a home solar system and therefore help customers permanently reduce their electricity costs. The storage system will come with an energy app visualizing the production and consumption for the customer.

"An increasing number of our customers wants to become more energy autonomous. Together with SOLARWATT we can offer them a complete solution that fits their individual needs," E.ON Management Board member Bernhard Reutersberg said. "We aim to become a leading provider of electricity storage systems in Germany and to continually expand our palette of intelligent solutions for our customers."

For several years now, SOLARWATT has marketed intelligent, complete solar systems that enable residential and small-business customers to generate their own electricity and heat. "Our cooperative arrangement with E.ON is an important milestone for SOLARWATT. Earning the trust of Germany's largest energy supplier indicates the success of our product innovation, which has taken us from being a manufacturer of solar modules to being a provider of system solutions," SOLARWATT principal owner Stefan Quandt said. Managing Director Detlef Neuhaus added that "we're very proud that our smart, economical energy systems and high-quality products gave E.ON the confidence to forge a partnership with us."

The cooperative arrangement with SOLARWATT is another example of E.ON's resolute focus on the new energy world, which is characterized by renewables, distributed generation, energy efficiency, microgrids, and increasingly autonomous and proactive customers. The potential for electricity storage devices in Germany is enormous. In just a few years nearly 100 percent of solar arrays may be sold with a storage device. In addition, the country's more than 1.5 million existing solar arrays offer huge potential for retrofitting with storage devices. A big power station generates electricity around the clock. But a solar panel's output varies with the amount of sunshine. It typically reaches its highest level on cloudless days around noon, when the sun is at its zenith.

By contrast, families typically consume the most electricity in the morning and the evening. An electricity storage device bridges this gap by storing electricity when it is produced and discharging it when families need it to power lights, appliances, and home entertainment systems. Storage devices make renewable energy more flexible and reduce the amount of electricity that customers have to import from the grid, thereby reducing their energy costs.

# Heraeus establishes regional product modification lab in japan

HERAEUS PHOTOVOLTAICS, supplier of metallization solutions to the PV industry, has announced the launch of a regional Product Modification Lab (PML) in Tokyo. This move strengthens the existing framework of Heraeus' regional research and development centers. By expanding product modification capabilities in Japan, Heraeus will solidify its strong commitment to the Japanese PV market and will be able to more efficiently manage customer requirements.

Japan represents an important market for Heraeus Photovoltaics. It represents over 8 percent of the worldwide supply of solar cell manufacturing and 18 percent of global PV installation. As markets in Asia continue to grow and Heraeus customers' technologies evolve rapidly, the network of regional product

innovation abilities is a cornerstone for the company to further explore the photovoltaic markets. "Our regional PML reinforces our strong commitment to Japan as high technology market, adding to our strength as reliable supplier of high quality products," states Dr. Weiming Zhang, Senior Vice President Innovation, Heraeus Photovoltaics.

Another factor in this investment is to encourage customer collaboration and accelerate R&D innovation in key regions. Dr. Zhang added, "By establishing our PMLs close to the markets, we are able to understand changes in our customers' needs constantly and provide them with superior products in shortest response time." As part of this distributed approach, all Product Modification Labs work closely with the Heraeus Photovoltaic global R&D Center in the U.S.A. to ensure that the customer requirements are reflected in the development of products with highest efficiency and reliability. Japan marks the third Heraeus regional PML to open in Asia in the last12 months. It complements the installation of two regional PML's, one in Shanghai, one in Taiwan, in early 2015.

# EU PVSEC 2016

## European Photovoltaic Solar Energy Conference and Exhibition

**The Innovation Platform for the global PV Solar Sector**


EU PVSEC 2015

**Conference Programme available, register now!**
**Early Bird Deadline: 30 April 2016**

**20 - 24 JUNE 2016**

**MUNICH, GERMANY**

**ICM - International Congress Center Munich**

Co-located with inter solar EUROPE

**www.photovoltaic-conference.com**

# New approaches for **hybrid solar cells**

Manufacturers around the world are on the lookout for light-weight and robust materials to use in portable solar cells. The thin but robust germanium hybrid layers provide a real alternative.

USING a new procedure researchers at the Technical University of Munich (TUM) and the Ludwig Maximillians University of Munich (LMU) can now produce extremely thin and robust, yet highly porous semiconductor layers. A very promising material – for small, light-weight, flexible solar cells, for example, or electrodes improving the performance of rechargeable batteries.

The coating on the wafer that Professor Thomas Fässler, chair of Inorganic Chemistry with a Focus on Novel Materials at TU Munich, holds in his hands glitters like an opal. And it has amazing properties: It is hard as a crystal, exceptionally thin and – since it is highly porous – light as a feather.

By integrating suitable organic polymers into the pores of the material, the scientists can custom tailor the electrical properties of the ensuing hybrid material. The design not only saves space, it also creates large interface surfaces that improve overall effectiveness.

"You can imagine our raw material as a porous scaffold with a structure akin to a honeycomb. The walls comprise inorganic, semiconducting germanium, which can produce and store electric charges. Since the honeycomb walls are extremely thin, charges can flow along short paths," explains Fässler.

## The new design: bottom-up instead of top-down

But, to transform brittle, hard germanium into a flexible and porous layer the researchers had to apply a few tricks. Traditionally, etching processes are used to structure the surface of germanium. However, this top-down approach is difficult to control on an atomic level.

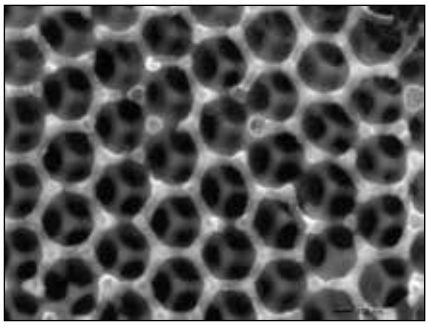
The new procedure solves this problem.
Together with his team, Fässler established a synthesis methodology to fabricate the desired structures very precisely and reproducibly.
The raw material is germanium with atoms arranged in clusters of nine. Since these clusters are electrically charged, they repel each other as long as they are dissolved. Netting only takes place when the solvent is evaporated.

This can be easily achieved by applying heat of 500°C or it can be chemically induced, by adding germanium chloride, for example. By using other chlorides like phosphorous chloride the germanium structures can be easily doped.

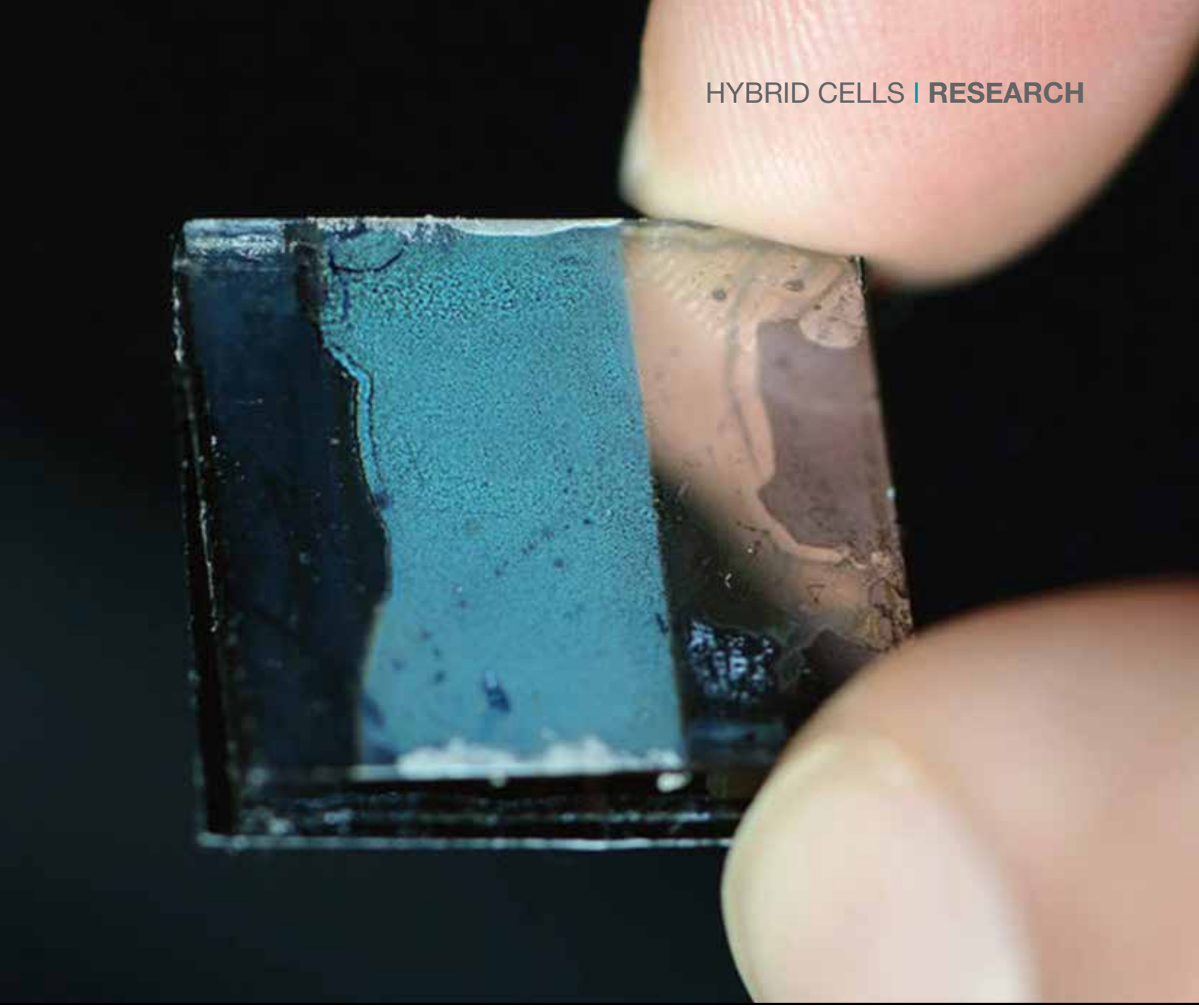
This allows the researchers to directly adjust the properties of the resulting nanomaterials in a very targeted manner.

## Tiny synthetic beads as nanotemplates

To give the germanium clusters the desired porous structure, the LMU researcher Dr. Dina Fattakhova-Rohlfing has developed a methodology to enable nanostructuring: Tiny



Electronmicroscopical image of the germanium-structure after removal of the polymer templates



polymer beads form three-dimensional templates in an initial step.

In the next step, the germanium-cluster solution fills the gaps between the beads. As soon as stable germanium networks have formed on the surface of the tiny beads, the templates are removed by applying heat. What remains is the highly porous nanofilm. The deployed polymer beads have a diameter of 50 to 200 nanometers and form an opal structure. The germanium scaffold that emerges on the surface acts as a negative mold – an inverse opal structure is formed. Thus, the nanolayers glitter like an opal.

"The porous germanium alone has unique optical and electrical properties that many energy relevant applications can profit from," says LMU researcher Dr. Dina Fattakhova-Rohlfing, who, in collaboration with Fässler, developed the material. "Beyond that, we can fill the pores with a wide variety of functional materials, thereby creating a broad range of novel hybrid materials."

## Nanolayers pave the road to portable photovoltaic solutions

"When combined with polymers, porous germanium structures are suitable for the development of a new generation of stable, extremely light-weight and flexible solar cells that can charge mobile phones, cameras and laptops while on the road," explains the physicist Peter Müller-Buschbaum, professor of functional materials at TU Munich.

Manufacturers around the world are on the lookout for light-weight and robust materials to use in portable solar cells. To date they have used primarily organic compounds, which are sensitive and have relatively short lifetimes. Heat and light decompose the polymers and cause the performance to degrade. Here, the thin but robust germanium hybrid layers provide a real alternative.

Nanolayers for new battery systems

Next, the researchers want to use the new technology to manufacture highly porous silicon layers. The layers are currently being tested as anodes for rechargeable batteries. They could conceivably replace the graphite layers currently used in batteries to improve their capacity.

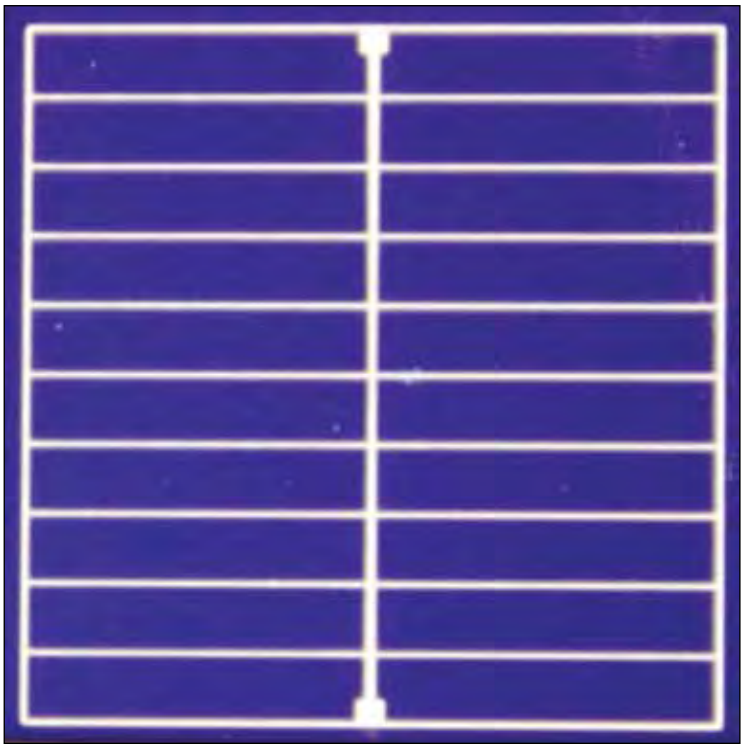
The research was funded by the "Solar Technologies Go Hybrid" program of the Bavarian State Ministry of Science, in the context of the excellence cluster "Nanosystems Initiative Munich (NIM), the German Research Foundation (DFG) and the Center for Nanosciences (CeNS).

# Simplifying solar cells with a new mix of materials

## Berkeley Lab-led Research Team Creates a High-efficiency Device in 7 Steps

AN INTERNATIONAL RESEARCH TEAM has simplified the steps to create highly efficient silicon solar cells by applying a new mix of materials to a standard design. Arrays of solar cells are used in solar panels to convert sunlight to electricity. The special blend of materials – which could also prove useful in semiconductor components – eliminates the need for a process known as doping that steers the device's properties by introducing foreign atoms to its electrical contacts. This doping process adds complexity to the device and can degrade its performance.

"The solar cell industry is driven by the need to reduce costs and increase performance," said James Bullock, the lead author of the study, published in Nature Energy. Bullock participated in the study as a visiting researcher at the U.S. Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) and UC Berkeley.



A photo of the DASH (dopant free asymmetric heterocontact) solar cell developed through an international collaboration.
(Photo credit: James Bullock/Berkeley Lab, UC Berkeley, ANU)

"If you look at the architecture of the solar cell we made, it is very simple," said Bullock, of Australian National University (ANU). "That simplicity can translate to reduced cost."

Other scientists from Berkeley Lab, UC Berkeley, ANU and The Swiss Federal Institute of Technology of Lausanne (EPFL) also participated in the study. Bullock added, "Conventional silicon solar cells use a process called impurity doping, which does bring about a number of limitations that are making further progress increasingly difficult."

Most of today's solar cells use crystalline silicon wafers. The wafer itself, and sometimes the layers deposited on the wafer, are doped with atoms that either have electrons to spare when they bond with silicon atoms, or alternatively generate electron deficiencies, or "holes." In both cases, this doping enhances electrical conductivity.

In these devices, two types of dopant atoms are required at the solar cell's electrical contacts to regulate how the electrons and holes travel in a solar cell so that sunlight is efficiently converted to electrical current that flows out of the cell. Crystalline silicon-based solar cells with doped contacts can exceed 20 percent efficiency – meaning more than 20 percent of the sun's energy is converted to electricity. A dopant-free silicon cell had not previously exceeded 14 percent efficiency. The new study, though, demonstrated a dopant-free silicon cell, referred to as a DASH cell (dopant free asymmetric heterocontact), with an average efficiency above 19 percent. This increased efficiency is a product of the new materials and a simple coating process for layers on the top and bottom of the device. Researchers showed it's possible to

create their solar cell in just seven steps. In this study, the research team used a crystalline silicon core (or wafer) and applied layers of dopant-free type of silicon called amorphous silicon.
Then, they applied ultrathin coatings of a material called molybdenum oxide, also known as moly oxide, at the sun-facing side of the solar cell, and lithium fluoride at the bottom surface. The two layers, having thicknesses of tens of nanometres, act as dopant-free contacts for holes and electrons, respectively.
"Moly oxide and lithium fluoride have properties that make them ideal for dopant-free electrical contacts," said Ali Javey, program leader of Electronic Materials at Berkeley Lab and a professor of Electrical Engineering and Computer Sciences at UC Berkeley. Both materials are transparent, and they have complementary electronic structures that are well-suited for solar cells.

"They were previously explored for other types of devices, but they were not carefully explored by the crystalline silicon solar cell community," said Javey, the lead senior author of the study. Javey noted that his group had discovered the utility of moly oxide as an efficient hole contact for crystalline silicon solar cells a couple of years ago. "It has a lot of defects, and these defects are critical and important for the arising properties. These are good defects," he said.

Stefaan de Wolf, another author who is team leader for crystalline silicon research at EPFL in Neuchâtel, Switzerland, said, "We have adapted the technology in our solar cell manufacturing platform at EPFL and found out that these moly oxide layers work extremely well when optimized and used in combination with thin amorphous layer of silicon on crystalline wafers. They allow amazing variations of our standard approach."

In the study, the team identified lithium fluoride as a good candidate for electron contacts to crystalline silicon coated with a thin amorphous layer. That layer complements the moly oxide layer for hole contacts. The team used a room-temperature technique called thermal evaporation to deposit the layers of lithium fluoride and moly oxide for the new solar cell. There are many other materials that the research teams hopes to test to see if they can improve the cell's efficiency. Javey said there is also promise for adapting the material mix used in the solar cell study to improve the performance of semiconductor transistors. "There's a critical need to reduce the contact resistance in transistors so we're trying to see if this can help."



> "Most of today's solar cells use crystalline silicon wafers. The wafer itself, and sometimes the layers deposited on the wafer, are doped with atoms that either have electrons to spare when they bond with silicon atoms, or alternatively generate electron deficiencies, or "holes." In both cases, this doping enhances electrical conductivity"

**Further reading**
Some off the work in this study was performed at The Molecular Foundry, a DOE Office of Science User Facility at Berkeley Lab.

This work was supported by the DOE Office of Science, Bay Area Photovoltaics Consortium (BAPVC); the Joint Center for Artificial Photosynthesis, a DOE Energy Innovation Hub; Office fédéral de l'énergie (OFEN); the Australian Renewable Energy Agency (ARENA) and the CSEM PV-centre.

Nature Energy, Jan. 25, 2016 (10.1038/nenergy.2015.31)

# Chemically storing solar power

A photo-electrochemical cell has been developed at TU Wien (Vienna). It can chemically store the energy of ultraviolet light even at high temperatures.

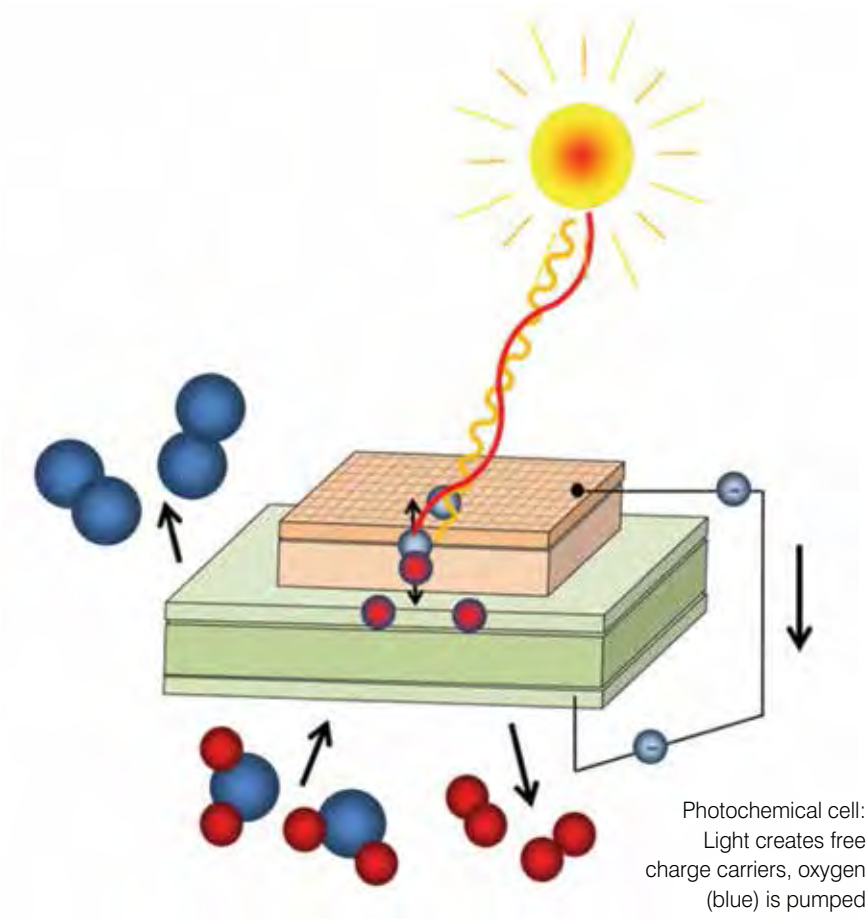
NATURE SHOWS US how it is done: Plants can absorb sunlight and store its energy chemically. Imitating this on large industrial scale, however, is difficult. Photovoltaics convert sunlight to electricity, but at high temperatures, the efficiency of solar cells decreases. Electrical energy can be used to produce hydrogen, which can then be stored – but the energy efficiency of this process is limited.

Scientists at TU Wien (Vienna) have now developed a new concept: By combining highly specialised new materials, they have managed to combine high temperature photovoltaics with an electrochemical cell. Ultraviolet light can be directly used to pump oxygen ions through a solid oxide electrolyte. The energy of the UV light is stored chemically. In the future, this method could also be used to split water into hydrogen and oxygen.

Special Materials for High Temperatures
As a student at TU Wien, Georg Brunauer started pondering possible combinations of photovoltaics and electrochemical storage. The feasibility of such a system depends crucially on whether it is able to work at high temperatures. “This would allow us to concentrate sunlight with mirrors and build large-scale plants with a high rate of efficiency”, says Brunauer. Common photovoltaic cells, however, only work well up to 100°C. In a solar concentrator plant, much higher temperatures would be reached.

While working on his doctoral thesis, Brunauer managed to put his ideas into practice. The key to success was an unusual choice of materials. Instead of the ordinary silicon based photovoltaics, special metal oxides - so-called perovskites - were used. By combining several different metal oxides, Brunauer managed to assemble a cell which combines photovoltaics and electrochemistry. Several research partners at TU Wien contributed to the project. Georg Brunauer is a member of Prof. Karl Ponweiser’s research team at the Institute for Energy Systems and Thermodynamics, Prof. Jürgen Fleig’s group (Chemical Technologies and Analytics) and the Institute for Atomic and Subatomic physics were involved as well.

Creating Voltage and Pumping Ions
“Our cell consists of two different parts – a photoelectric part on top and an electrochemical part below”, says Georg



Photochemical cell: Light creates free charge carriers, oxygen (blue) is pumped through a membrane

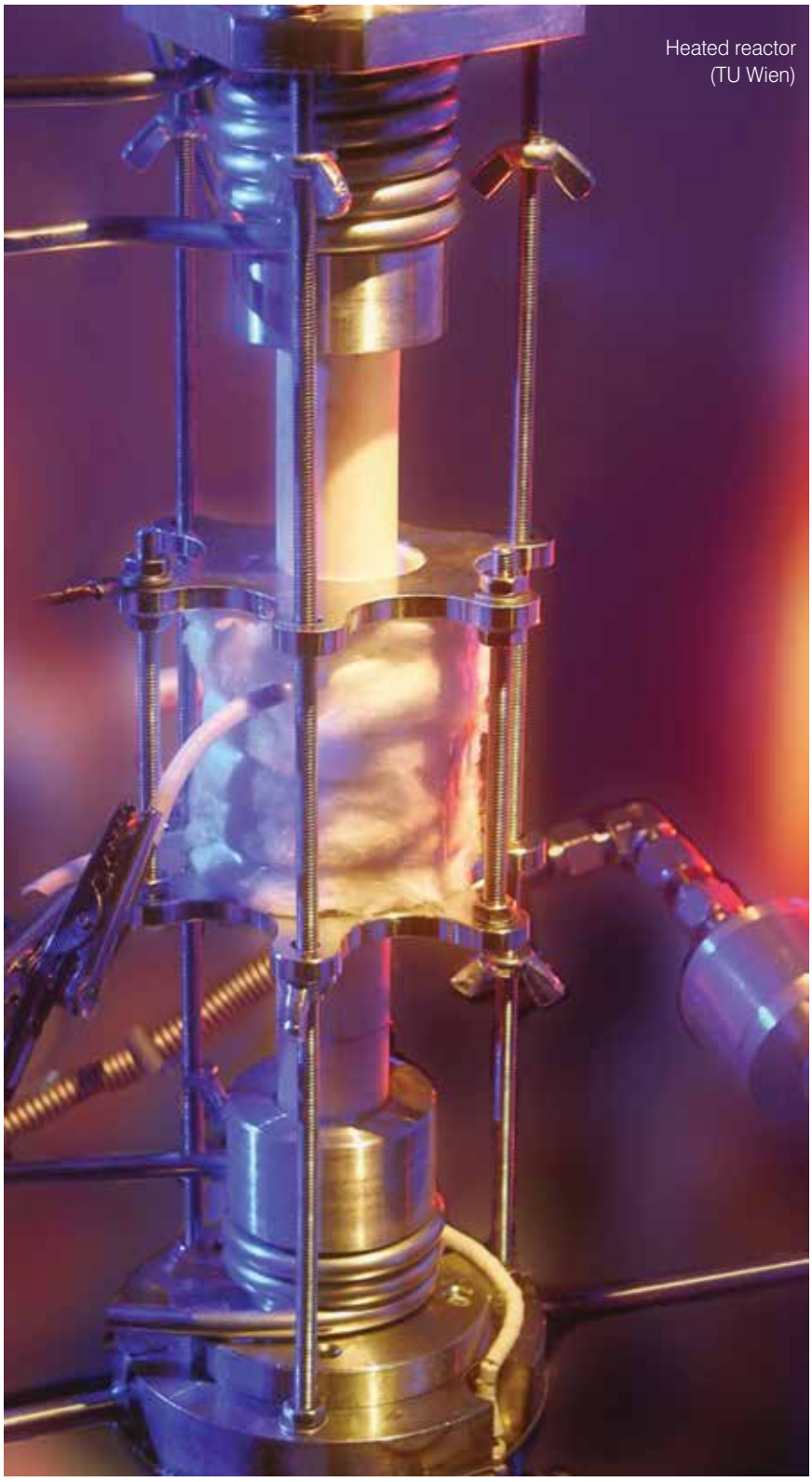
Brunauer. “In the upper layer, ultraviolet light creates free charge carriers, just like in a standard solar cell.” The electrons in this layer are immediately removed and travel to the bottom layer of the electrochemical cell. Once there, these electrons are used to ionize oxygen to negative oxygen ions, which can then travel through a membrane in the electrochemical part of the cell.

“This is the crucial photoelectrochemical step, which we hope will lead to the possibility of splitting water and producing hydrogen”, says Brunauer. In its first evolution step, the cell works as a UV-light driven oxygen pump. It yields an open-current voltage of up to 920 millivolts at a temperature of 400°C.

The photoelectrochemical cell has now been presented in the journal “Advanced Functional Materials”, but the research project continues. “We want to understand the origin of these effects by carrying out a few more experiments, and we hope that we will be able to improve our materials even further”, says Brunauer. If the electrical power can be increased a slightly, the cell will be able to split water into oxygen and hydrogen. “This goal is within reach, now that we have shown that the cell is working”, says Georg Brunauer. The concept is not only useful for the production of hydrogen, as it could also split carbon dioxide into carbon monoxide. The produced energy carried in the form of hydrogen and carbon monoxide can be used to synthesize fuels.

To make the leap from the university lab to an industrial prototype, Georg Brunauer has founded the startup company NOVAPECC. Together with TU Wien, he has filed several patents; Brunauer was supported by the University’s Research and Transfer support, by the startup-support programme INITS and the Austrian Research Promotion Agency (FFG).





Heated reactor (TU Wien)

Stephan Pröller (l.) and Dr. Eva M. Herzig in their laboratory. Here they investigate the processes that take place on the molecular scale during the production of organic solar cells. (Photo: Uli Benz / TUM)

# X-rays reveal details of plastic solar cell production

Plastic solar cells are light, easy to install, and readily produced using a printer. Nevertheless, the processes that take place on the molecular scale during the production of organic solar cells are not yet entirely clear. Researchers from the Technical University of Munich (TUM) have now managed to observe these processes in real time. Their findings could help to improve the efficiency of organic solar cells.

THE SOLAR MODULES that can be seen on the roofs of many houses mainly consist of the semiconductor silicon. They are heavy and consequently costly to secure on roofs. Moreover, they do not blend in very well with their surroundings. Organic solar cells, which consist of organic molecules like plastic bags or cling film, are an alternative to these conventional solar cells. Organic solar cells are soluble and can therefore be produced using a printer. Since they are very thin and light weight the installation of this thin light converting device in a variety of different locations is feasible, furthermore, the colour and shape of the solar cells can also be adjusted. One of the current disadvantages is, however: The efficiency of organic photovoltaics has not yet reached that of silicon solar cells.

## Processes at the nano level

One of the key parameters for harvesting more energy from the flexible solar cells is the arrangement of the molecular components of the material. This is important for the energy conversion because, as in the case of the “classic” solar cell, free electrons must be produced. To do this, organic solar cells need two types of material, one that donates electrons and another one that accepts them. The interface between these materials must be as large as possible to convert light into electricity. Up to now, it was not known exactly how the molecules align with each other during the printing process and how the crystals they form grow during the drying process. Like the pigments in printer ink, the molecules are initially contained in a solution.

“In order to be able to control the arrangement of the components, we need to understand what happens at the molecular level during the drying process,” explains Dr. Eva M. Herzig from the Munich School of Engineering (MSE) at TUM. To resolve such small structures inside a drying film with adequate time resolution presents an experimental challenge.

## X-ray give insight into the process

Working in cooperation with the Lawrence Berkeley National Laboratory in the USA, Stephan Pröller,

doctoral candidate at MSE, used X-rays to make the molecules and their processes visible during the printing of a plastic film. He identified different phases that unfold during the drying of the film. Initially the solvent evaporates while the other materials stay in solution. This leads to an increase in the concentration of the plastic molecules in the wet film until the electron donor starts crystallizing.

At the same time the electron acceptor starts to form aggregates. A fast crystallization process follows, pushing the aggregates of the electron acceptor closer together. At this stage the distance between the interfaces of the two materials is defined, which is closely related to efficiency. To systematically improve the solar cells, this step in the printing process needs to be controlled. In the last stage optimizing processes within the individual materials are taking place, like the optimization of the packing of the crystals.

"The production speed also plays an important role," explains Pröller. Although this pattern is preserved with faster drying processes, the aggregates and crystals formed by the materials influence the remainder of the structure formation so that slower structure formation has a more positive impact on the final efficiency.

The researchers would now like to use their insights into the processes to gain specific control over the arrangement of the materials using other parameters. These results could then be transferred to industrial production and help to optimize it.

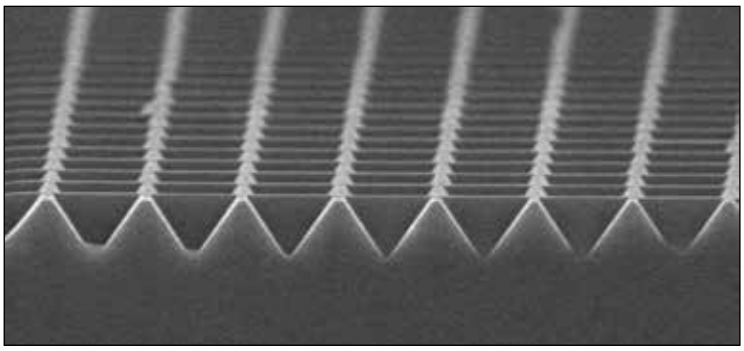
Findings published in the specialist journal Advanced Energy Materials,

# Nanopatterning doubles c-Si pv cell efficiency

A consortium of European researchers and industry partners has succeeded in developing novel nanopatterning structures for enhancing light gathering efficiency in c-Si PV cells. The results show great promise in developing new generations of higher efficiency thin film photovoltaics.

IN A PROJECT begun three years ago, researchers and industry partners in Belgium, France and Sweden set out to demonstrate whether nano-scale patterning on ultrathin, c-Si photovoltaic cells could enhance the devices' light gathering ability and by so doing, enhance electron collection efficiency.

The group set its sights on improving thin film devices since manufacturing steps and processes used to make these classes of PV cells are generally considered less resource intensive and less toxic than processes used to create conventional PV cells. While efficiency in standard mono- and multi-crystalline PV cells has already topped 20 percent in commercial products, today's thin film PV efficiency is typically far less. Enhancements sought in the FP7 project PhotoNVoltaics could make thin film technology more attractive to manufacturers and consumers alike. The research partners achieved many of their goals, including an efficiency in test devices more than double that of non-patterned cells. While acknowledging that work remains to commercialize processes, improve cost structures and ultimately boost efficiency even farther, the consortium's achievements are very significant for the future of thin film technologies. Results of this collaboration are recounted in the following article prepared by imec researchers (Belgium).



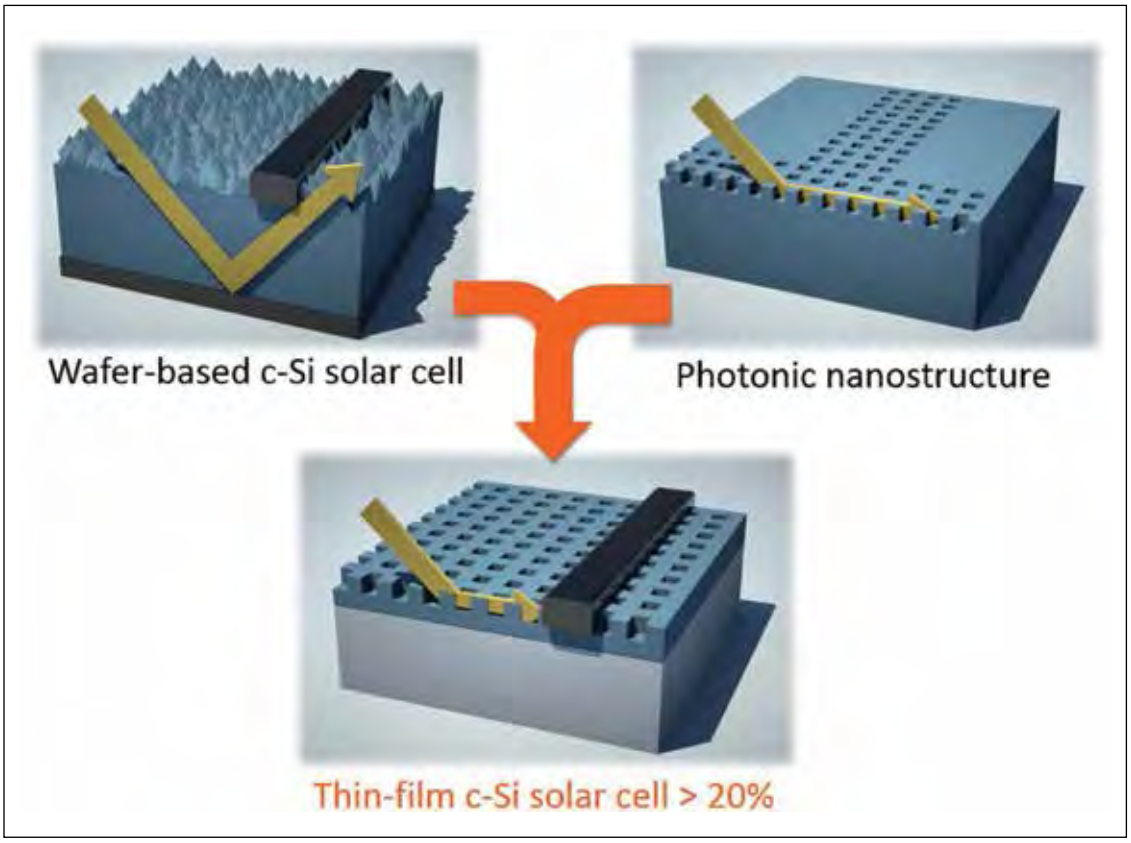
Inverted nanopyramids after wet etching. The pyramid tips are spaced by 800 nm.

## PhotoNVoltaics: Guidelines for a highly efficient nanopatterned crystalline Si solar cell

Since November 2012, seven European teams from diverse fields (photovoltaics, photonics and nanolithography) have worked enthusiastically on the FP7 PhotoNVoltaics project. They identified the conditions for a disruptive solar cell generation that integrates advanced light trapping schemes into thin-film crystalline silicon (c-Si) solar cells. In tight interaction loops between models and experiments, they learned how to capture the light efficiently, which photonic nanostructures work best as front-side textures, and how can these structures be efficiently integrated into the c-Si solar cell. Now that the project has come to an end, the project partners have set forth all the guidelines of how to make these highly efficient thin-film c-Si solar cells, and identified routes for low-cost integration.

## Efficient light trapping

For many years, c-Si solar cells have been considered the workhorse of the photovoltaic industry. Silicon is an earth-abundant, non-toxic and stable material, and the technology for fabricating c-Si based solar cells is well established. Crystalline Si has, however, one intrinsic drawback: it absorbs light rather weakly, especially the lower-



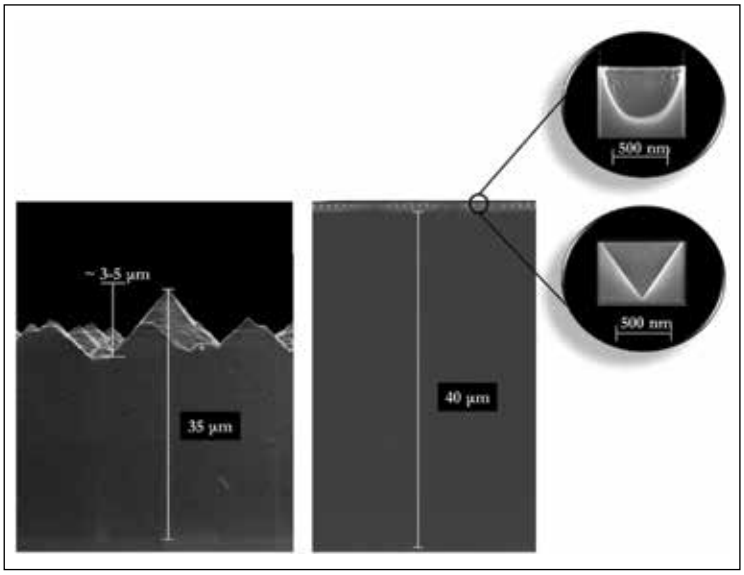

The goal of the PhotoNVoltaics project.

energy photons in the near-infrared spectrum. This challenges the development of thinner c-Si solar cells, which would be more cost effective and more energy efficient to produce. A promising approach to overcome this hurdle is to develop an efficient way of trapping these (low-energy) photons, for example by nanotexturing silicon at sunlight wavelength scale. Many studies indeed indicate that a significantly higher photon absorption may be achieved compared to today's micron-scale texturing, especially for absorber thicknesses below 100 micrometer.

That was the starting point of PhotoNVoltaics, a European FP7 project that took-off three years ago. The aim of the project was to learn which nanotexture geometries are optically optimal and how to integrate them into real c-silicon (c-Si) thin film solar cells. PhotoNVoltaics is a Future Emerging Technologies (FET) project. In other words, it was a high-risk project with an ambitious target and a long-term objective. The integration of nanopatterns into c-Si is especially challenging. The patterns may introduce electrical defects and may undergo optical degradation in later process steps. A higher photon absorption therefore does not necessarily translate into a higher electron collection. To outline the conditions for a successful integration, the project brought together seven partners from three different fields (photovoltaics, photonics and nanolithography) and from three different worlds (R&D, academia and industry). Imec was the project coordinator and also responsible for the fabrication and development of ultrathin mono- and poly-crystalline films and of solar cells with photonic nanostructures.

## Inverted nanopyramids

In standard industrial c-Si solar cells, which are 150 to 200 micrometers thick, random upright pyramids at the micron-scale are being used as front-side textures. This is not necessarily the most optimal pattern when used in c-Si thinner than 100 micrometers. For these thicknesses, various simulations of (non-) periodic nanopatterns have indicated that a significantly higher photon absorption may be achieved compared to micron-scale texturing. To find the most beneficial nanopattern morphology, the consortium looked into various nanotextures, with different dimensions, shapes and patterns. Tight interaction loops of modelling and experiments have pointed towards inverted nanopyramids with smooth sidewalls as the

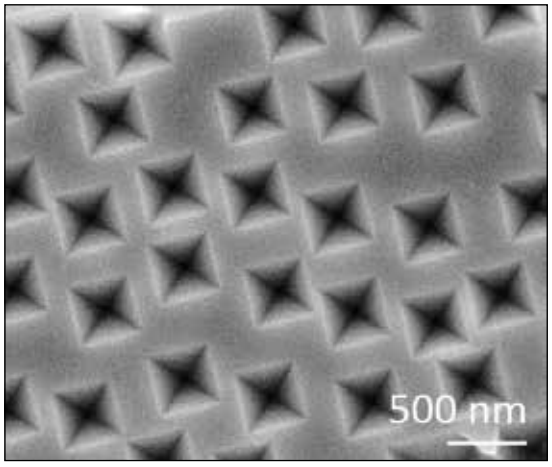



(Left) Micron-scale front-texturing vs. (right) nano-scale texturing, with dry-etched parabolic holes (top inset) or wet-etched inverted pyramids (bottom inset).

best pattern profile. They are the best choice for both the optical and the electrical performance of the cell. Another key question was related to the periodicity of the patterns: should a periodic texturing or random texturing be applied? The project partners have used different types of models to compare between order and disorder. They found that a controlled disruption of the periodicity is beneficial. This is good news for industrial fabrication since it means there is a higher tolerance on pattern accuracy. The degree of disorder should however not be too large. Beyond order vs. disorder, the most important parameter is the filling fraction, i.e., the ratio of nanopatterned over flat surface area. A high filling fraction is essential, since it optimizes the in-coupling of all incoming photons inside the silicon film. In practice, a high fill fraction translates into adjacent holes.

## Fabrication techniques

The project approach for the fabrication of nanopatterns was to consider techniques that not only lead to excellent light absorption, but that may be potentially applied to the PV industry at the same time. For the patterning, the consortium could rely on three different lithography techniques: laser-interference lithography, nano-imprint lithography and hole-mask colloidal lithography. The technical as well as economical aspects of these techniques were studied. While nano-imprint lithography is the most mature technology, hole-mask colloidal lithography allows to experimentally control the disorder and can be applied to rough surfaces. As a bottom-up nanofabrication method, it can provide tunable pseudo-periodic structures, with a good range of hole diameters and average pitches. Laser-interference lithography, on the other hand, can only deliver ordered structures, but it is a versatile technique enabling rather simple pattern pitch and diameter tuning. For these three techniques, it would be necessary to identify the conditions for integration into the PV industry. For example, it may be necessary to reduce the cost and consumption of consumables, and to design higher throughput equipment.

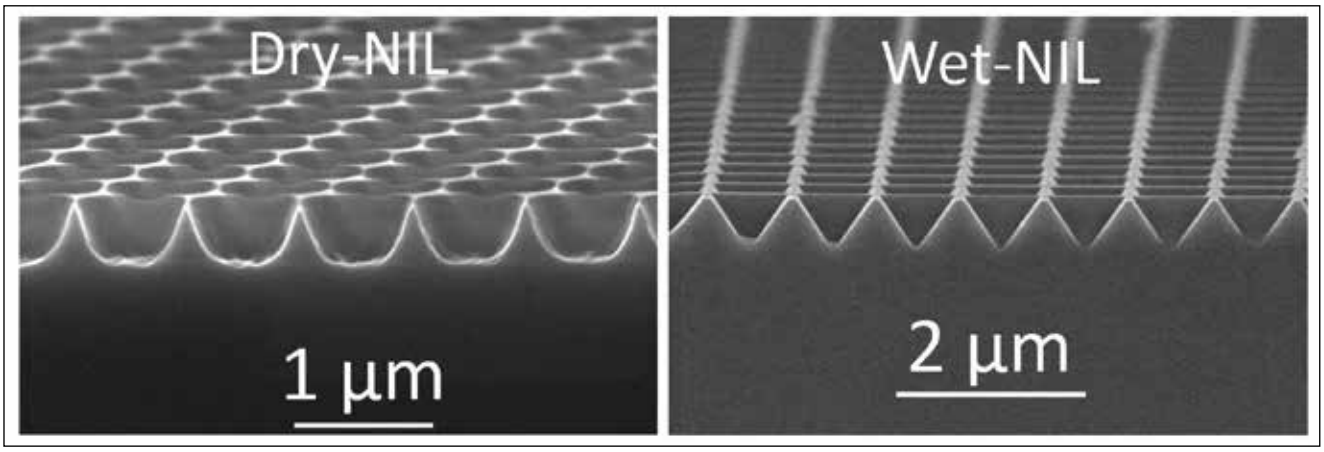



Experimentally introduced disorder via hole-mask colloidal lithography

The lithography technique has to be combined with an etching step to transfer the pattern into the silicon surface. The project partners compared different dry-etching and wet-etching techniques, and assessed their impact on the morphology and on the electrical properties of the cells. They found that dry-etching can reduce significantly the electrical quality of the material. It can damage the sample surface, which translates into a poor surface passivation. Wet etching is therefore the preferred option. It generates smooth inverted nanopyramids.

## Guidelines for integration

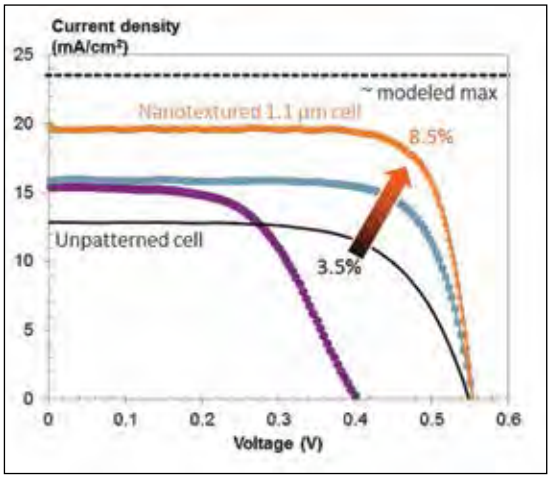
As a main outcome of the PhotoNVoltaics project, the project partners have identified the conditions for a successful cell integration. They extracted the guidelines for an efficient integration of nanophotonic textures into thin-film crystalline silicon solar cells. By following these guidelines, highly efficient nanotextured c-Si solar cells can be fabricated. Integrating the nanotextures is very challenging, as the nanopattern profile can affect the morphology of the materials that are to be deposited above, and as it can impact the metal contacts and the surface passivation. Key questions for a successful integration are therefore related to the pattern dimensions, the parasitic optical losses, the contacting, the film thickness, the etch profile and the surface passivation. The partners developed a set of powerful tools for modelling realistic solar cells with a very broad range of patterns. To complete the solar cell stack optimization, a powerful genetic algorithm




(Left) Dry etching vs. (right) wet etching of the nanopatterns.

was developed, allowing to optimize all parameters at the same time. The modelling teams worked in close collaboration with the nanopatterning and solar cells teams. To fabricate thin-film c-Si solar cells, the consortium could rely on a wide panel of materials, with thicknesses ranging from 1 to 40 micrometre, with high-temperature and low-temperature growth approaches, with a layer transfer from a wafer or with direct growth on a foreign material.

Throughout the project, a progressive improvement of the solar cells performances was achieved. The consortium demonstrated cells with enhanced light trapping, without compromising on the electrical performance of the cells. Unfortunately, high efficiency cells could not be achieved in the time frame of the project. Handling issues, specific to thin-film c-Si solar cells, will first have to be solved. As soon as such a cell process is available, the guidelines will enable the fabrication of good functioning nanotextured thin-film c-Si solar cells. In particular, cells with thickness of a few tens of micrometer could absorb enough light to reach efficiencies above 20 percent. These cells will compete with current wafer-based Si solar cells in terms of efficiency. In terms of cost, guidelines for low-cost integration have been identified.




Successful integration of a nanophotonic structure into a 1.1 micrometer c-Si cell. The efficiencies are the highest achieved for this c-Si thickness. This ultra-thin cell is however too thin to be competitive.



**Further reading**

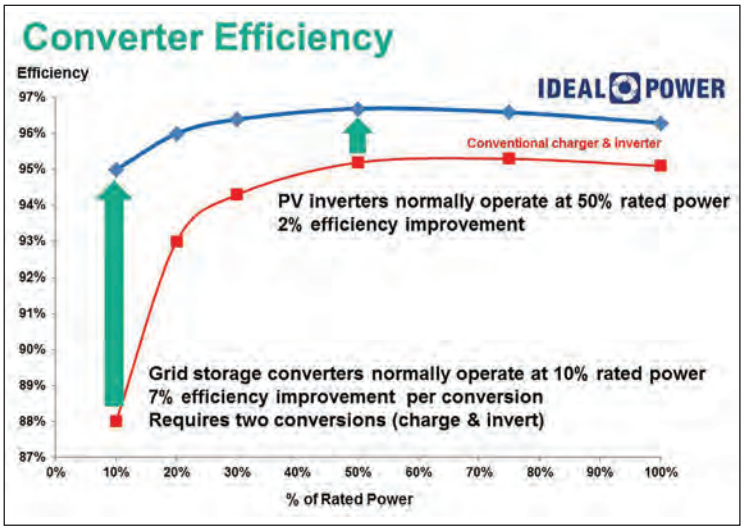
The project PhotoNVoltaics (Nanophotonics for ultra-thin crystalline silicon photovoltaics) has received funding from the European Commission under grant agreement No 309127. The seven project partners represent the industrial world (Obducat Technologies AB (Sweden) and TOTAL (France)), research (imec (Belgium), Centre National de la Recherche Scientifique - Institut des Nanotechnologies de Lyon (France) and Centre National de la Recherche Scientifique - Laboratoire de Physique des Interfaces et des Couches Minces (France)) and academia (University of Namur (Belgium) and Chalmers University of Technology (Sweden)).

Imec collaborates in many projects (EU, ESA and IWT) on which we work in close collaboration with industrial and academic partners. On our website, you can view the projects that are currently running. You can browse this information by research domain. And on April 30, 2016, imec participates in Europe Day (Dutch website), where we will put some of our European projects in the spotlight.

# Effective energy storage **goes beyond batteries**

While batteries tend to dominate energy storage conversations they are only one element driving efficiency and cost. New power conversion solutions are critical to improving real-world ROI. By: John Merritt, Director of Applications Engineering for Ideal Power.

THE ENERGY STORAGE INDUSTRY has been experiencing tremendous growth, with numerous established companies now entering the market. Many in the industry are bullish on significant cost reductions in lithium-ion batteries In the near future; it's expected that lower costs and improved ROI will open new geographic markets and a broader suite of customer-sited, as well as utility-scale energy storage applications. However, batteries represent only one piece of the cost puzzle. Often overlooked are the Balance-of-Systems (BoS) components which, given the expected battery cost declines, would typically consume an ever-increasing share of total system costs. A new power conversion topology called Power Packet Switching Architecture™ (PPSA) reverses such cost trends, driving down installed and operating costs while also opening up new value and revenue streams for energy storage systems.




Lower First Costs, Lower Installed Costs, and Higher Efficiency Deliver Tangible Economic Benefits

Conventional Power Conversion Systems are based on technology that has been largely the same for more than five decades. Such systems are large, noisy, inefficient and utilize failure-prone power components and cooling systems. PPSA-based systems eliminate the use of these components, as well as bulky isolation transformers, offering significant size, weight and efficiency advantages.

The technology also eliminates the need for electrolytic capacitors, large line reactors and filter circuits, further improving system reliability and minimizing the use of raw earth materials such as copper and iron. The result is a lightweight power conversion system that is manufactured with lower material costs and is not as vulnerable to price fluctuations of commodity materials in global markets.

Smaller, lighter systems dramatically reduce installed costs due to simplified logistics, installation and deployment. Power conversion systems using PPSA are less than a quarter the size and weight of conventional transformer-based systems, resulting in much lower shipping costs, and limited use of motorized materials-handling equipment such as a crane or forklift.

No dedicated concrete pad is required, and the systems can be moved into place by two technicians with a hand truck or appliance dolly. For example, the weight of a typical dual-port 125kW PPSA-based system is 425 pounds, compared to 2,000 pounds or

greater for conventional solutions with similar power nameplate ratings. Lastly, PPSA-based systems deliver 10 percent or more in annual OPEX savings due to reduced energy use and simplified Operations and Maintenance (O&M) procedures. Systems using PPSA technology also operate quietly and unobtrusively, a huge benefit for many applications sited behind the meter.

## Integrating renewables

When integrating renewable sources such as wind and solar with energy storage, traditional power converters utilize a multi-step/multi-trip power conversion process which further compromises system efficiency and power throughput, resulting in typical PV-to-storage-to-grid conversion efficiencies of 88 percent or less, depending on power levels. Multi-port PPSA technology replaces the multi-step/multi-trip conversion process and eliminates the isolation transformer losses, improving the PV-to-storage-to-grid conversion efficiencies by five percent or more. These multiport converters also have integrated algorithms to support PV smoothing and PV firming. These "Smart Inverter" features are viewed as essential to stabilize distribution feeders in Hawaii and parts of California, where today, high-penetration levels of PV have created grid stability problems.

## Application flexibility provides multiple value streams

The flexibility of energy storage to perform more than one application creates multiple value streams for the customer, creating more favorable payback scenarios. Peak demand management is an obvious application for energy storage today in areas like California, Hawaii and New York, where demand charges represent a significant portion of energy costs, particularly for commercial and industrial customers whose heavy intermittent loads often occur during late afternoon and early evening. Unfortunately, rooftop solar does little to mitigate such demand charges, which can represent 35 to 40 percent of the customer's monthly utility bill. Incorporating renewable generation like PV with storage further maximizes the value of a battery storage system by allowing the sun to charge the battery during off-peak and mid-peak hours such as 8:00 AM to 4:00 PM. Multi-port PPSA-based power conversion systems integrate PV with battery storage using a single multi-port converter rather than a dedicated PV inverter for the system and a separate dedicated battery converter for the energy storage components, dramatically simplifying systems control overhead. In fact, many utilities appear to be eliminating or minimizing "NET Metering" (using the grid as a battery), as an option for exporting PV energy during periods of low building energy use, making multi-port PV + storage far more attractive than PV-only solutions. Hawaii Electric (HECO), among others, is rumored to be eliminating NET Metering altogether.

Lastly, PPSA-based converters can generally provide Power Factor and Volt/VAR support for commercial and industrial sites with large inductive loads such as motors, refrigeration and HVAC equipment. Offsetting Power Factor charges will deliver monthly energy savings to the building owner/operator, who are often billed for "Low Power Factor" on a monthly basis.

## Grid resiliency

Diesel generators are often used as backup for commercial and industrial facilities in the event of a grid outage. In most cases, existing rooftop solar is not incorporated as a part of facility backup

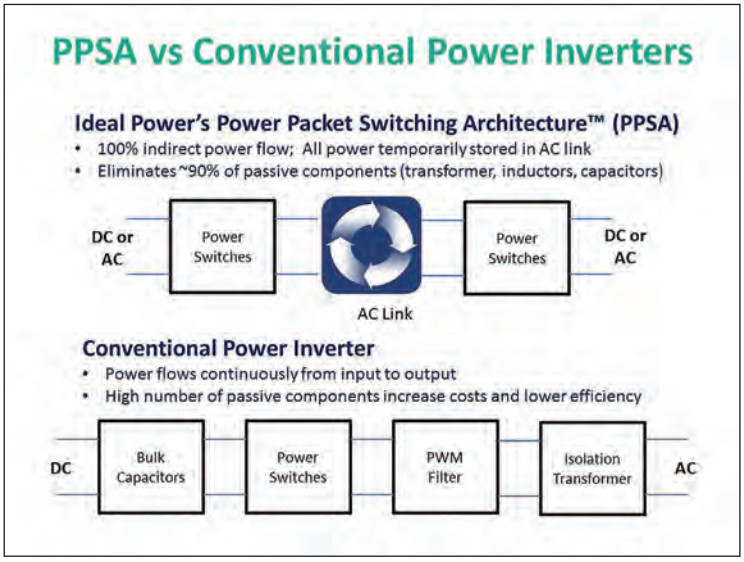
“While decreasing battery costs are making energy storage more economically feasible and companies are racing to secure a place in the stationary battery market landscape, cost reductions of lithium-ion will only go so far toward improving the economics of energy storage. Now and into the future, the industry will need to look beyond batteries in order to maximize the value of energy storage”

scenarios, due to fundamental inverter technology limitations and existing safety standards. As Hurricane Sandy demonstrated, 99 percent of the solar systems in New York and New Jersey remained dormant, providing no backup power during the weeks of grid outages experienced in the region.

Next generation Battery + PV, and Battery-only PPSA converters, when coupled with intelligent controls and appropriate transfer switches, can safely deliver mission-critical power during sustained grid outages and may be integrated with existing diesel generators, dramatically reducing fuel use and ensuring that critical power disruption during emergency events is minimized.

## Microgrids

In developing countries, as well as island nations, diesel gensets are often the primary source of power where the local grid is unreliable or altogether unavailable. These generators are typically oversized and operate at a low average load, making them highly inefficient with regards to fuel use. Light loading also impacts generator maintenance and reliability; many generators have a service life of 5 years or less. The end result is high energy costs to the end consumer ($0.50 to $0.75 per kWh is not atypical).




As with the Grid Resiliency example above, these diesel generators can be integrated with energy storage or, for even greater savings, energy storage + PV. Such hybrid microgrids based on PPSA converter technology, dramatically reduce fuel use, while also ensuring the generator is loaded appropriately, lowering system maintenance costs. Island nations with strong solar resources combined with high fuel costs are an ideal candidate for Storage + PV based microgrids. ROI's of less than two years for such systems is not uncommon.

Lastly, not all microgrids are identical; some operate completely independently of a local grid, some operate in tandem with the local grid (when available), and then operate autonomously during grid outages. Depending on local grid standards, the grid frequency is 60Hz or 50Hz, and grid voltages also vary by locale and geography. PPSA technology supports all of these world standards in a single power conversion system platform, simplifying the design, deployment and maintenance of all anticipated microgrid applications.

While decreasing battery costs are making energy storage more economically feasible and companies are racing to secure a place in the stationary battery market landscape, cost reductions of lithium-ion will only go so far toward improving the economics of energy storage. Now and into the future, the industry will need to look beyond batteries in order to maximize the value of energy storage.

# High Throughput Production Equipment for Laser Processing of Crystalline Solar Cells

- Powerful Laser Structuring of PERC Solar Cells
- Half Cell Cutting with TLS-Dicing™ to Increase PV Module Power


3D MICROMAC

3D-Micromac AG
Phone: +49 371 40043 0

Technologie-Campus 8
E-Mail: info@3d-micromac.com

D-09126 Chemnitz, Germany
Web: http://3d-micromac.com

# inter solar EUROPE

connecting solar business

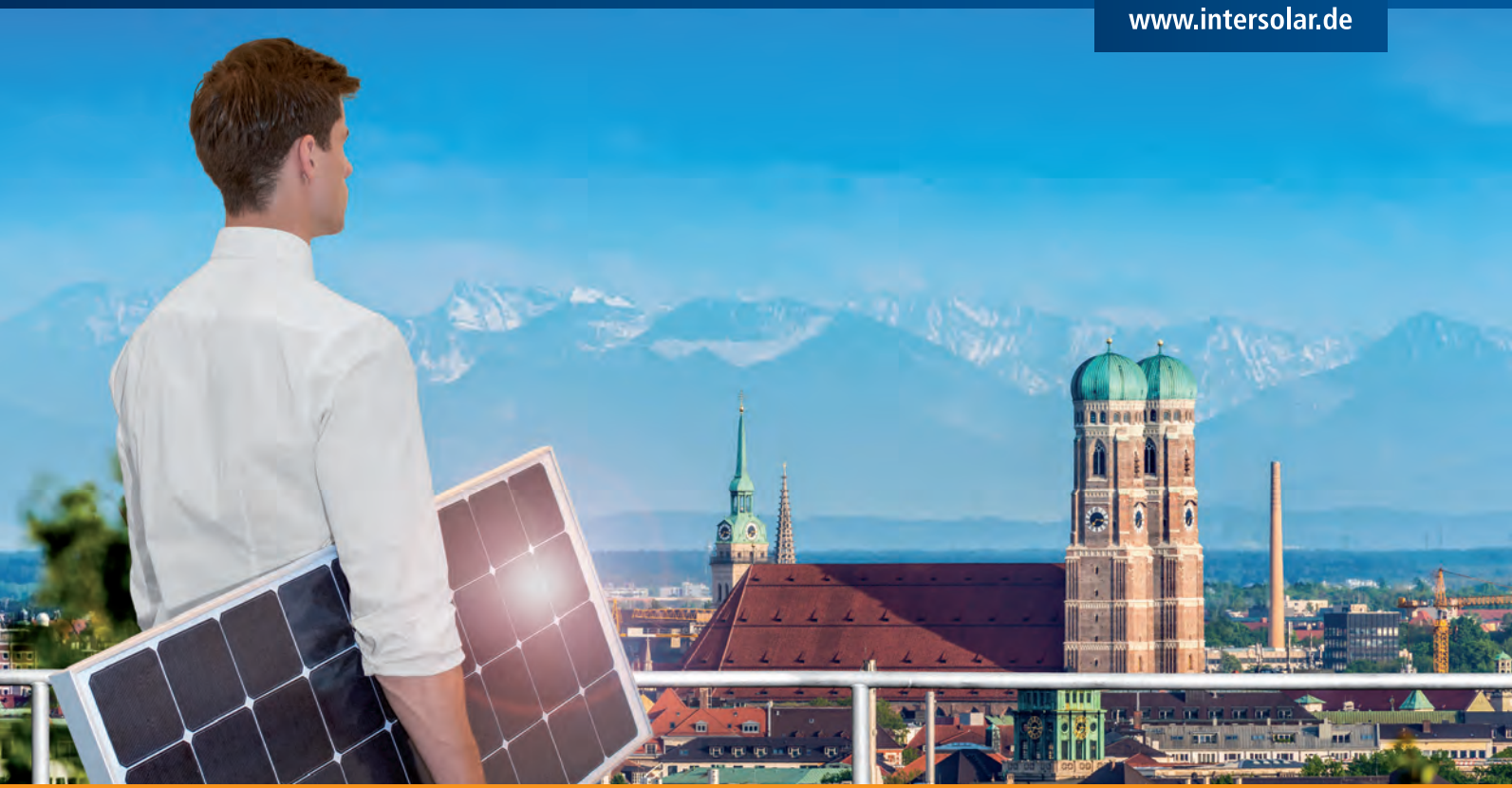
25 YEARS OF INTERSOLAR
1991–2016

## The World's Leading Exhibition for the Solar Industry
## Messe München, Germany

- The unique meeting point for the global solar industry
- Success guaranteed: 1,000 exhibitors – 40,000 visitors – 165 countries
- A dynamic marketplace with a global reach

**JUNE 22–24 2016**

**www.intersolar.de**



co-located with

ees EUROPE | EU PVSEC | AUTOMATICA OPTIMIZE YOUR PRODUCTION

Top information for your visit in Munich, Germany!

# Bringing clean electricity to remote communities in emerging markets

INTASAVE Energy believe they have a model that will provide clean, reliable and affordable electricity to off-grid communities in developing regions, where larger solar installations are simply not viable. By Arran de Moubray, Head of Renewable Energy, INTASAVE Energy

A MAJOR PROBLEM for many small and remote communities in Africa and across the globe is the ability to access reliable and/or affordable electricity. According to the World Bank, only 23 percent of the Kenyan population has direct access to electricity as the country's national grid is not only unreliable, but it is also extremely expensive to buy into. What's more, in 2010 only five percent, or about 1.7 million, of the 34 million Kenyans in rural areas had access to any form of energy at all.

Solar energy has long been a solution for bringing electricity to rural areas, with various projects installed in the last few years with varying degrees of success. However, the main difficulty has always been finding a model that is affordable, easy to maintain and scalable to meet the growing energy needs of these rural communities as they develop.
With this in mind, we at INTASAVE Energy believe we have the solution to this problem, by introducing a model that will provide clean, reliable and affordable electricity to off-grid communities in developing regions, where larger solar installations are simply not viable.

## Say it with a SONG

INTASAVE Energy has developed its Solar Nano-Grid (SONG) to not only provide a "quick fix" for immediate electricity needs but also deliver a long-term sustainable, scalable and affordable solution that allows communities to grow their energy usage at their own pace.

Many villages in Sub-Saharan Africa are located in remote areas, with small independent communities of around 50-100 houses in reasonably close proximity. The standard solar home systems (SHS) that are available are standalone and limited to supplying a fixed amount of energy to one single consumer household. And this is where our solution differs. Rather than relying on having solar panels on each household, a single SONG can supply an entire community of around 50 households from one central hub at 20Wp per household - enough to power three light bulbs and a phone charger, for example.

The solar hub contains traditional lead-acid cells that store the power collected from the solar panels. Household energy is then supplied via portable battery packs that are housed in the central hub. These battery packs, a cutting-edge design using recycled lithium-ion batteries, a unique battery management system and microcontroller developed for use in the field, can be taken to be used in homes each night and returned for re-charging in the morning.

This 'hub' model also enables another crucial aspect of the SONGs model – the provision of collective community power. Excess power generated at the central location can be effectively utilised elsewhere, meeting the communities' commercial, social or agro-industrial needs and any other micro-enterprises

they may be involved in, including water pumps, refrigeration units and egg incubators, and even for commercial micro-enterprises such as hair salons and mobile phone charging businesses.

This community aspect is especially powerful, far outweighing alternative models of solar energy for alleviating problems associated with poverty and a lack of access to electricity. For example, any SHS excess power generated from bright sunshine or long hours of sunlight cannot be used elsewhere, and is therefore entirely wasted. What's more, a SHS cannot serve an entire community by supporting small-scale economic activities that require power because it is built to serve individual households rather than the community as a whole.

The SONG system architecture is also modular, which means it can easily be extended over time in keeping with the growing aspirations and needs of the community or individual households. What's more, new photovoltaic (PV) panels can be installed and the existing nano-grids can then be interconnected to form a larger, more powerful system, or be connected to other new grids.

By providing clean energy this way, SONGs can improve quality of life, empower women, improve health, increase children's educational attainment, and boost the local economy.

## Cost savings and quality of life benefits

SONGs provide energy at very competitive costs compared to the kerosene or diesel equivalents and compared to SHS solutions. Other alternatives such as minigrids (systems of between 50kW and 1MW) and micro-grids (5kW to 50kW) have high up-front costs. This means they are out of the reach of the majority of the small remote communities SONGs are targeting.
In addition to these cost savings, households benefit from numerous health, environmental and educational factors.

To date many households in these communities have relied on kerosene and diesel for the energy required to run their enterprises or as the fuel in lamps for lighting, which is proven to be extremely harmful to their health and wellbeing. For example, children are often forced to do their homework by kerosene lamp.

As a result, one of the top reasons for clinic visits is fume inhalation or fumes affecting eyes. By using SONGs, communities can eliminate their exposure to health risks to lungs and eyes, reducing recorded respiratory disorders and deaths associated with indoor air pollution.
With energy from the SONGs available for community activities, this also means that maternal health can be improved, owing to the reduced physical labour demands caused by new practices such as water pumping, corn-husking and maize-milling. What's more, communities are now able to use refrigeration to store medicine, vaccines and milk for themselves – something that until now had not been possible.

In terms of education, children from electrified households are able to gain an average of two additional years of 'educational achievement' by comparison to those from non-electrified households. Households can also benefit from far greater access to radio, television, ICT and mobile telephones.

## Our unique proposition

INTASAVE Energy works closely with the Energy and Power Group (EPG) of the University of Oxford, Loughborough University and the United International University Bangladesh to design SONGs to most effectively meet the needs of communities in Kenya and other emerging markets and developing countries. One of the core innovations behind SONGs is ionQube technology, developed in tandem with the EPG at Oxford, which enables the portable battery packs used in SONGs.

Lithium-ion cells are the most common type of rechargeable battery used in consumer electronics today. Their ubiquity is due to the fact that not only do they possess high energy density

**Arran de Moubray**
*Head of Renewable Energy, INTASAVE Energy*

Arran De Moubray has over 20 years' experience in the construction and renewable energy sectors. Prior to working with INTASAVE, Arran worked as an advisor to governments and to a number of listed companies on renewable energy projects, and led the fundraising for a number of clean tech companies in the US, Africa and EU. Arran is currently working on the SONG programme for rural electrification in Africa and Asia, and exploring different technologies from solar to anaerobic digestion.

but they also have a slow loss of charge when not in use, making them ideal for portable devices, with two to three times the energy storage capacity of their lead acid battery equivalent. However, the batteries themselves rarely reach the end of their full lifespan. Usually the devices they are used in stop being able to draw power even though usable energy remains in the cell. This can be caused by hardware limitations or even by faulty software, but what happens to these batteries when they outlive their usefulness?

Today, these batteries are usually discarded or recycled, but around 50 percent of waste Lithium-ion batteries are actually still usable. The ionQube is a solution that allows industry standard 18650 lithium-ion batteries to be 'upcycled' into a rechargeable and reusable power source that can be used for low carbon energy storage. The ionQube design isolates the useful cells and recombines them into the ionQube.

As the ionQube is chemistry agnostic, it can accept any Lithium-ion battery and because it has cell-level management it can easily combine cells of varying capacities where traditional battery packs cannot. In addition, for the first installation in Kenya, each ionQube is equipped with a small microcontroller, which acts as the battery pack's 'brain'. The microcontroller is used to detect the type of battery installed and is able to manage each one individually to extend the life of the battery pack as a whole. The electronics of the ionQube are designed to be long lasting, with the battery cells replaceable by the user. Therefore, not only do users avoid having to pay large amounts of money to replace their entire system, it is entirely scalable so that multiple ionQubes can be connected together to increase both capacity and power. In addition to battery management, the microcontroller also saves data on how the ionQube is being used.

The data from each SONG solar-hub is then shared via a GSM uplink. This information is then used by the SONG team to determine how many ionQubes are needed in certain situations – for example understanding the relationship between the number of people in a household to the number of ionQubes needed to fulfil their energy needs. This intelligent understanding of end user profiles and consumer behaviour allows INTASAVE to extend the opportunities for system optimisation and to better specify the system requirements for future rollouts.

Accurate usage data allows scheduling of energy and power to most efficiently use the solar panels and hub batteries to provide the energy and power required. In addition, it either validates or disproves information gathered through community consultations, ensuring that SONG deployments are built on tried and tested developments rather than assumptions based on consultation results. At the battery level, INTASAVE can also ensure the batteries are matched to the usage patterns they will be subjected to in the field, delivering optimal performance in each pack.

## Lemolo B and Echareria in Kenya – these are just the beginning

Kenya has been chosen as the starting point in Africa for implementing the SONG programme due to its solar conditions, with an average of 5kWh/m²/day available throughout the country. The first SONGs deployments are currently taking place in Lemolo B, a community of approximately 250 people, and in Echareria, as well as other communities in Africa, South America and eventually, the rest of the world.

Projects like our SONGs in Kenya will bring power and new business opportunities to remote communities across the world. Linking clusters of about 50 families in rural communities to small-scale, communal solar power not only delivers power to households and communities - it lifts people out of poverty. The INTASAVE Energy team strongly believes that it is through the combination of new technologies and creative minds that we can help bring clean, sustainable electricity to any community around the world.



# intersolar

connecting solar business | NORTH AMERICA

25 1991–2016 YEARS OF INTERSOLAR

## North America's Most-Attended Solar Event

## Moscone Center, San Francisco

- Hear it here first! Be part of the first major U.S. solar event in 2016
- Join 18,000 peers, visit 550 exhibitors, attend 60 sessions & workshops
- Gain insight: PV, energy storage, smart renewable energy & solar heating/cooling

**JULY 12–14 2016**

**www.intersolar.us**

co-located with

ees® NORTH AMERICA

SEMICON® WEST

Register now!

# Schneider in the Gulf

Benoit Dubarle, President, Gulf Countries and Pakistan, at Schneider Electric reports on the success story to date.

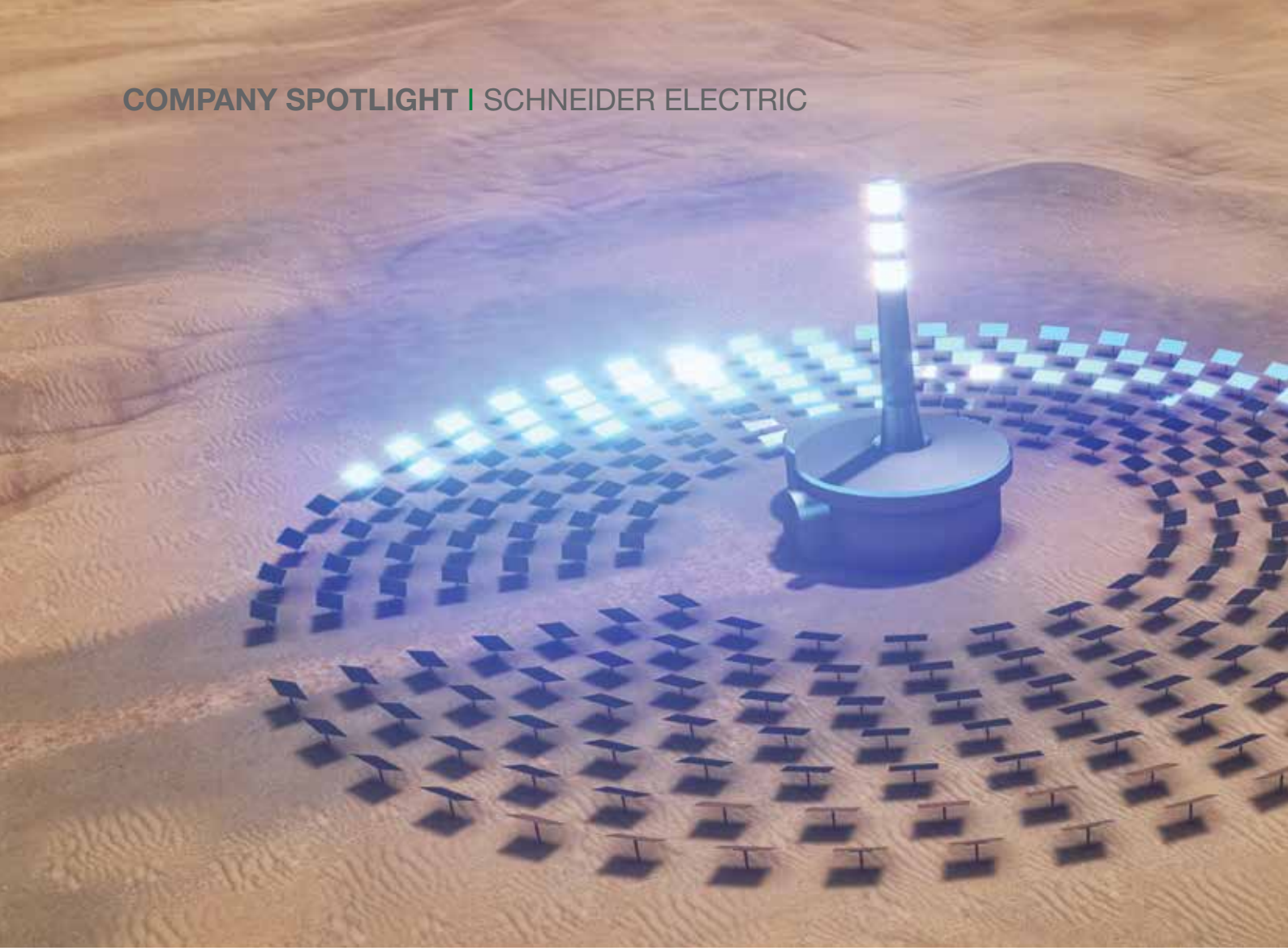
SCHNEIDER ELECTRIC is a global expert in energy management and automation. Providing efficient and sustainable solutions to several industries and verticals in over 100 countries, Schneider Electric recorded €25 billion in revenues in 2014.The company's strong network includes its 170,000 employees, trusted business and channel partners, engineers and researchers who are constantly innovating with cutting-edge science, all towards the aim of addressing the world's pressing energy issues. Through connected and diverse technologies, the company is committed to reshaping industries, transforming cities and enriching lives.

By 2020, more than 50 billion devices worldwide will be connected to each other. This revolutionary level of interaction isn't just changing the way people communicate, but how we experience – and manage – our environments. Now dubbed the 'Internet of Things' (IoT), we exist among massive amounts of data which is capable of providing knowledge, convenience and innovation.

To unlock this experience for individuals, homes, corporations and the planet, Schneider Electric unveiled a new brand strategy in September 2015. Titled 'Life is ON,' this approach will leverage Schneider Electric's knowledge in the operational technologies (OT) which controls society's most important processes and embed it with the most advanced IT. In other words, Schneider Electric has the software and hardware to break down the big data from IoT into useful and timely analytics. It is built on four main brand attributes - Connectivity, Sustainability, Efficiency and Reliability and Safety.

Schneider Electric's comprehensive solutions help customers maximize uptime of their systems by ensuring efficient and reliable distribution of power, all the way from the utility, through transmission networks, to the plug that feeds power to their equipment components.

- **IoT for cities:** Data analytics processed by IoT enables citizens and companies to save time and cut costs. Such OT technology can also enable two-way communications between the city and the public
- **IoT for Data Centers:** Schneider Electric's real-time DCIM solutions and lifecycle predictive maintenance and modernization services, help businesses manage the connectivity revolution
- **IoT for Industry:** Schneider Electric solutions analyse all the plant floor operational data, integrate it with external data, and put it into context to enable better, faster plant



management decisions

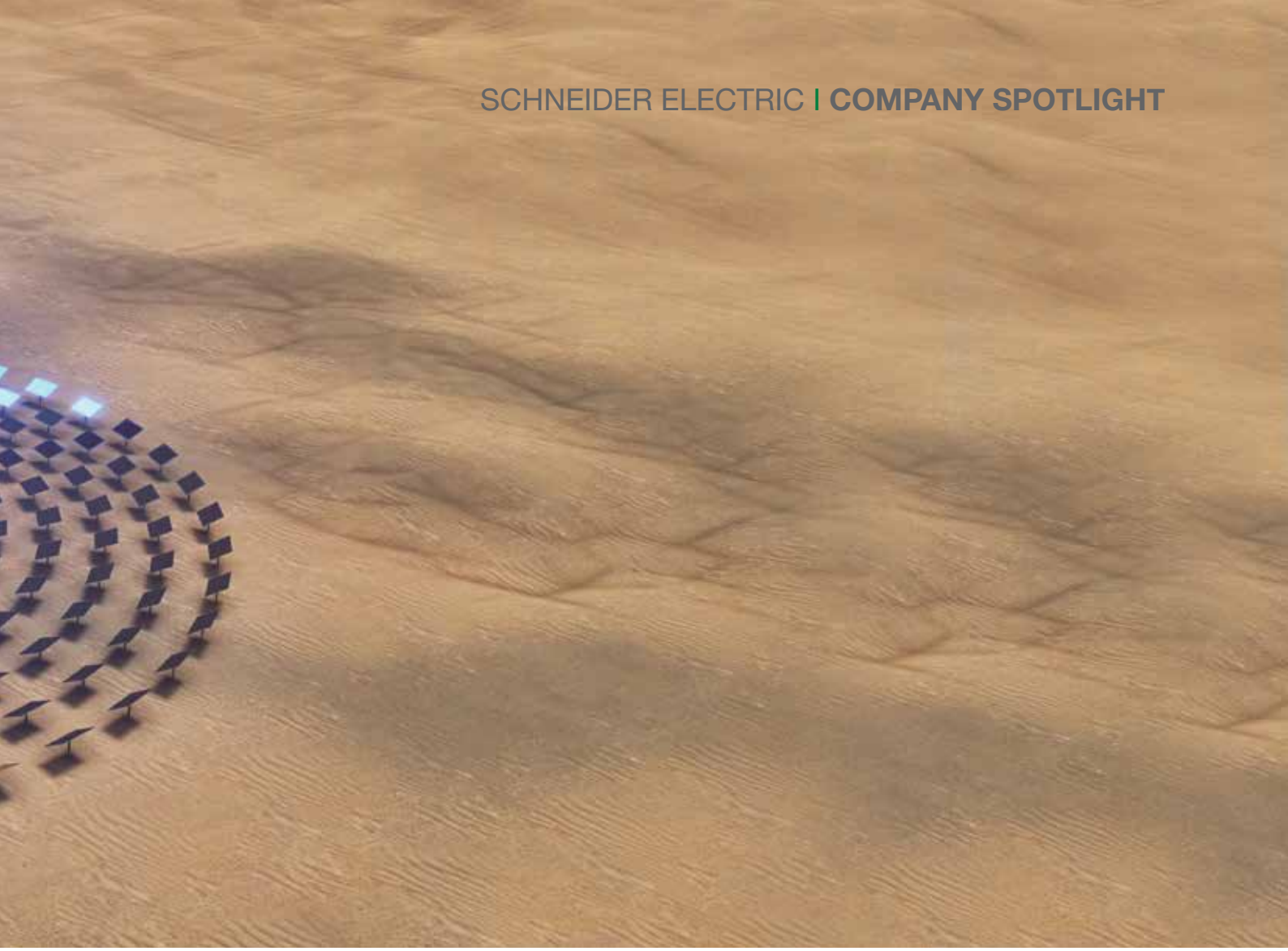
- **IoT for Homes:** Highly automated and integrated management solutions enable quick and easy personalization of home control settings - they also facilitate energy management as components of the home can be remotely monitored and managed
- **IoT for Smart Grids:** IoT allows utility network operators to lower energy spend and helps grid operators to enable a more decentralized and 2-way grid and renewable energy in inventive ways for Smart Grid realization
- **IoT for Buildings:** Building management systems connect lighting, HVAC, access control, space management, blinds, sensors and control systems. Consumers are empowered to be more sustainable and manage energy more efficiently.

IoT also greatly contributes to sustainability. Through machine-to-machine communication and data accumulation, consumers can effectively manage or mitigate carbon emissions – by managing traffic more efficiently, our lighting or energy usage, and preventing scenarios where energy is wasted. Schneider Electric facilitates transactional IT channels with aggressive, quick-impact conservation measures and retrofit projects that guarantee savings and performance. PRESENCE & WORK IN THE GULF FOR MORE THAN 30 YEARS, Schneider Electric has served the Gulf market by providing integrated solutions in energy management, making energy safe, reliable, efficient, productive and green. The company now has over 15 sites, including a regional distribution centre, a training centre for MENA region, a manufacturing factory plant and Middle East Regional Execution Centre. Schneider Electric is aligned with the GCC government's vision to be smarter, innovative and more sustainable. By customizing our smart solutions to the region's needs and embedding our technologies with Internet of Things (IoT), we are confident that we will be able to grow our operations while contributing to the region's burgeoning infrastructure, utilities and O&G industries. The GCC presents Schneider Electric with an abundance of growing opportunities to reiterate their market leadership in smart infrastructure, energy efficiency, water management, datacentre technology and mobility solutions. Leadership in the Gulf region is keen to leverage advanced technology to create an urban ecosystem which is friendlier to and for its people.

Governments and private sector enterprises are welcoming Schneider Electric's global expertise, highly valued R&D and decades of experience in order to achieve the next step of development and urban efficiency across the GCC. As such, Dubai, which is the regional headquarters, has also been named one of company's four central business hubs - the others being Paris, Hong Kong and Boston.

## Smart solutions

Schneider Electric has many smart solutions that help create the cities of the future. Its integrated 'Smart City' solutions from Smart Energy, Smart



Mobility, Smart Water, Smart Public Services, and Smart Integration help in various aspects of traffic and parking, safety, lighting, waste management, and energy management. These solutions no longer operate in silos, instead integrate seamlessly and run cohesively enabling clients to save up to 30 per cent in energy consumption, including a 15 per cent reduction in water use.

Over 170 years of experience and growth has given Schneider Electric a unique perspective on how to connect the best of technologies and people. The company has established a unique 'Centre of Excellence' in Spain, which harnesses the conglomerate's extensive know-how, experience and success in working with over 200 cities in smart management projects worldwide.

Aiming to encourage the research and development (R&D) of smart solutions with the engagement of more than 40 investigators, the Centre seeks to develop new business models that meet contemporary urban efficiency and sustainability standards. The cities of Abu Dhabi and Dubai are among the key focus areas for Schneider Electric's Center of Excellence. Masdar City, in particular, has been identified as one of the early beneficiaries of the center's solutions in smart city management.

## Growth

Through the acquisitions of companies including APC, Uniflair, Clipsal and Xantrex, Schneider Electric has gained new markets in UPS (uninterruptible power supply), movement control and building automation and security. In recent years, the company has built a leading position in the development of Smart Grid and mission-critical infrastructure through its acquisition of distribution specialist Areva T&D and leading software provider Telvent.

Schneider Electric's most recent major acquisition in 2014 was Invensys, a global automation leader with a comprehensive network and strong software capabilities.

The acquisition has boosted Schneider Electric's ability to provide energy efficient solutions that combine power and automation.

## Sustainability is at the core of schneider electric's offerings

We have put sustainability at the core of our strategy by helping people do more with less. We help to create shared value with all our stakeholders. We enable our customers to do more with less wherever we can help them being more efficient. On the other hand, we help the 1.3 billion people who do not have access to electricity to get access to reliable, affordable and clean energy. That's our vision of sustainable growth: profitable and responsible.

Our sustainability approach relies on three fundamentals -- we engage our people, starting from the top (15 per cent of Schneider Electric's executive committee members have their bonus based on CSR components); we measure our commitment through a unique tool, the Planet and Society Barometer, which sums up our main priorities in terms of sustainability; and, our eventual commitment is to get recognized, especially by marking a presence in the world ethical stock indexes.

It is estimated that 1.3 billion people have no access to energy around the world. In order to provide energy access to people at the base of the pyramid, Schneider Electric launched a BipBop programme which aims to eradicate fuel poverty and aid social development. This business model aims to connect 1 million households to electricity and train 30,000 people in energy management. The company is achieving this through strategic collaborations and investments in developing countries.

Schneider Electric has worked with several private and governmental authorities in Qatar, such as Qatar Petroleum, Kahramaa, Lussail, Qatar Foundation, GSAS, where our systems help end users conserve resources, achieve LEED certification, and provide a platform to drive measured organizational behaviours with respect to sustainability, and their contribution to the environment, and reduction of CO2, using our Energy Operations TM and Resource Advisor TM softwares.

Schneider Electric was placed 9th in the Corporate Knights 'Global 100 most sustainable corporations in the world' ranking. In order to track its sustainability, Schneider Electric has developed the Planet and Society Barometer index, which has six indicators to measure and track internal utilization of energy resources. The company scored 5.6/10 at the end of 2015, exceeding its year-end target of 4.5/10 and demonstrating our ongoing commitment to three pillars of sustainable development- Planet, Profit and People.

Awareness is also a crucial part of the transition towards adopting smarter and greener solutions in your daily life. Schneider Electric is thereby committed to providing education and technical know-how on energy management to industry professionals through their free online, non-proprietary platform known as 'Energy University.'

This program is available in 13 languages to professionals in 185 countries and includes 200 courses on topics such as energy efficiency, building controls & automation, lighting, HVAC, data centres, industrial systems, electric systems, healthcare. The platform recorded 500,000 registered participants in 2015.

## Solar solutions

The UAE seeks to increase its target for power generation from clean energy to 30 per cent by 2030 – out of which 25 per cent will be sourced from nuclear and solar energy. A bulk of renewable energy power generation in the country comes primarily from solar power. In fact, UAE's energy minister Suhail Al Mazrouei noted that the "economics of solar power had been improving rapidly in recent years," with the record-setting bid at the end of 2014 for a 100MW solar power plant at US$5.98 per kilowatt hour.

At a time when renewable energy has become the industry buzzword, only to be enhanced by commitments made in 2015's COP21, solar energy has a key role to play. As commodity prices have fallen, the region requires cost efficient and reliable power generation techniques for its rising levels of industrial and infrastructure activity. Schneider Electric provides reliable products for the solar power conversation chain and photovoltaic systems. Our comprehensive solutions range from DC connection to AC grid integration. We contribute to substations, power plants, commercial and residential buildings with solutions such as PV Box, Conext CL, Conext XW inverter and charger solutions. We also have commercial solar power systems for centralized and decentralized grid-tie, self-consumption, off grid solar and back-up power. Our off-grid systems are cost-efficient and keeps users independent from external energy supplies.

Our solar business unit has been involved with provided solar solutions to enable rural electrification in remote communities in Indonesia, Myanmar and India. These are beneficial as they help avoid utility peak usage and provides a reliable back-up power option. It also promotes the economy of rural communities and improves the quality of life.

In 2015, Schneider Electric was listed as an approved PV Inverter Manufacturer for Dubai Electricity and Water Authority (DEWA). With this technology, anyone will be able to buy, install and get approval to connect their solar system to the grid when installed by a certified solar EPC. In the long-run, home and building owners will save on electricity bills, increase the value of their property, reduce their carbon footprint, and collectively contribute to a smarter and cleaner future.

In this way, excess energy will be fed back to the local grid, assisting the city with its sustainability commitments.

# POWER GENERATION EGYPT PROJECTS

POWERED BY PROJECT EGYPT

**28 - 29 March 2016,** Cairo, Egypt

Under The Patronage Of:

NREA

EgyptERA

Implementing strategies to finance, construct and operate conventional and renewable energy plants in Egypt

## 5 EASY WAYS TO REGISTER

+971 4 361 4001

+971 4 361 4554

www.powerprojectsegypt.com

opportunities@acm-events.com

Advanced Conferences & Meetings
FZ-LLC, P.O.Box: 478842, UAE

**Special Offer For** Solar Power MANAGEMENT A GLOBAL BUSINESS JOURNAL **Readers**

Register now and quote PGPEM16 and get a **10%** discount

## KEY THEMES TO BE DISCUSSED

- Update on Egypt's 2030 energy strategy
- Outlook for conventional power generation and update on the liberalisation process
- Gas and coal-fired power generation projects and opportunities
- Gas turbine, clean coal and renewable energy technologies
- Energy efficiency targets and initiatives for Egypt's energy sector
- The latest renewable energy developments in Egypt and prospect

Media Partner: Solar Power MANAGEMENT A GLOBAL BUSINESS JOURNAL

Organized by: acm

www.powerprojectsegypt.com

# MOROCCO PROJECTS

## Solar | Wind | Hydro

**4-5 April 2016**
**Rabat, Morocco**

**Special offer to** Solar Power **readers. Quote MSWHM16 and get 10% discount.**

Addressing strategies and opportunities for the successful procurement and construction of solar, wind and hydro projects in Morocco.

**www.moroccoswhprojects.com**

**Advanced Conferences and Meetings FZ-LLC**
T: + 971 43614001 I F: +971 4 361 4554 I Email: opportunities@acm-events.com

# Delivering long term solutions to the Philippines' energy needs

POWER & ELECTRICITY WORLD PHILIPPINES 2016

THE SOLAR SHOW PHILIPPINES 2016

So far as energy is concerned, the Philippines is a land of opportunity.

As one of Asia's fastest growing economies, the country is yearning for effective solutions to help its power infrastructure keep pace with the change.

**Power & Electricity World Philippines** has been designed to fulfil that need. We bring together those searching for solutions with businesses offering the right services and products.

**The Solar Show Philippines** is designed to unite the entire solar industry from across Philippines and beyond to share ideas and experiences, and crucially, to cement relationships and forge business opportunities.

Drawing experts from the Philippines and further afield, this event covers all major challenges and opportunities current in the market today, offering unparalleled insight and helping you to get ahead.

## 18–19 MAY 2016

SMX Convention Center
Manila, Philippines

## 20% DISCOUNT OFF CONFERENCE PASSES

**Quote FQSR when you register online**

**BOOK NOW AT www.terrapinn.com/powerphilippines**

## 80% OF EXHIBITION STANDS SOLD OUT

**For remaining sponsorship and exhibition opportunities, contact Andre Laury at andre.laury@terrapinn.com or +65 6322 2760 for more details.**

## Leading Speakers

**Allard M. Nooy**
Chief Executive Officer
**InfraCo Asia Development**
Singapore

**Reynaldo Umali**
Chairman, Committee on Energy, **House of Representatives**
Philippines

**Carlos P. Gatmaitan**
Chief Executive Officer & President
**PNOC Renewables Corporation**
Philippines

**Deon James**
Chief Executive Officer
**Dagupan Electric Corporation**
Philippines

**Emma Imperial**
President
**Imperial Homes**
Philippines

**Rufino Bomasang**
Chairman
**Otto Energy**
& Former Undersecretary
**Department of Energy,** Philippines

**Ather Sajid**
Non-Executive Chairman
**EOil & Gas**
Philippines

**Eric Francia**
Managing Director
**Ayala Corporation**
& Chief Executive Officer, **Ayala Energy & Infrastructure Group,** Philippines

**Neeraj Bhat**
Managing Director
**AES**
Philippines

**Edgare Kerkwiik**
Managing Director,
**Asia Green Capital**
Singapore

**Geoffrey Tan**
Managing Director, Asia Pacific, **Overseas Investment Coorporation**
Thailand

**William Hsu**
Managing Partner
**Sustainergy Capital**
Hong Kong

**Gavin Barfield**
Chief Technology Advisor
**Meralco**
Philippines

**Ernesto Pantangco**
Executive Vice President & Director, **Energy Development Corporation**
Executive Vice President, **First Gen Corporation**
Philipppines

**Joseph Nocos**
Vice President for Business Development
**Alsons Energy Development Corporation**
Philippines

**Jesse Ang**
Principal Investment Officer, IFC PPP Transaction Advisory Asia Pacific
**International Finance Corporation**
Philippines

**Ruth Yu Owen**
President
**PhilCarbon**
Philippines

**Loren Legarda**
Senator
**Senate of the Philippines**
Philippines

***and many more...***

**WWW.TERRAPINN.COM/POWERPHILIPPINES**

# New silicon manufacturing approach cuts costs

The PV industry thrives on innovation, yet manufacturing polysilicon has not undergone significant process changes in decades. Silicor Materials aims to make its mark by cutting time and materials costs through its new solar silicon process. Terry Jester, Chairman and CEO, Silicor Materials explains.

UNLIKE MOST SEGMENTS of the PV supply chain, polysilicon production has not experienced transformative innovation since the 1960s. The vast majority of the solar industry's polysilicon has been produced using the Siemens process, which results in electronic-grade (EG) silicon best suited for use in the semiconductor industry. However, a new method produces silicon that can be used for high-efficiency solar panels. This method uses two-phase changes instead of the four required for EG silicon; it is dramatically less energy intensive than the Siemens process and avoids the use of toxic materials like silane gases.

## Where are we today?

2015 was the biggest year on record for the solar PV industry, and 2016 is promising to be even bigger. In addition to favorable government mandates and increased awareness of climate change, a major contributor to solar's momentum is the falling cost of photovoltaic (PV) equipment. While lower prices benefit end-users and the solar industry as a whole, these ever-falling figures have proven to hold unintended consequences for the manufacturers at the heart of the supply chain. The cost of the individual components that make up modules has simply not fallen at the same rate as module prices, leaving producers struggling to operate on shrinking profit margins.

## Improving the PV supply chain

Although prices have dropped in recent years, silicon is still the single most expensive component in the entire PV supply chain. This is because for more than 50 years, the solar industry has relied primarily on one method to produce its polysilicon: the Siemens process. Currently responsible for approximately 90 percent of polysilicon production, the Siemens process was designed to produce extremely pure electronic-grade (EG) silicon that is well suited for use in consumer electronics semiconductors. However, because the level of purity required for solar silicon is much lower—just 99.9999 percent, versus the 99.9999999 percent purity needed for EG silicon—implementing the energy-intensive Siemens process has proven to be an inefficient and high-cost burden on solar manufacturers. Rising solar demand coupled with the pressure on manufacturers to improve their pricing structures is only exacerbating this challenge.

Today, Silicor Materials is working to bring that price back down by engineering a next-generation process for solar silicon production. Silicor Materials produces lower-cost, environmentally friendly silicon designed specifically for the solar industry.

## The silicor process

To appreciate the value of this new process, it is first important to understand the steps required for EG silicon production. The Siemens process is a chemical method that encompasses a total of four

Solar silicon involves the smelting of aluminum and silicon to naturally draw out impurities. The process yields resalable aluminum byproducts.

“After a selective international scouting mission to site its plant, Silicor Materials found its home in Grundartangi, Iceland. Although an unlikely candidate on the surface, Iceland is a perfect match for Silicor’s operations for a number of reasons, including a shared commitment to environmentally conscious operations”

phase changes: solid-to-liquid, liquid-to-gas, gas-to-liquid and liquid-to-solid. The energy required to accomplish this is considerable—up to 125 kWh to produce a single kilogram of EG silicon. The need to manage four phase changes demands that Siemens-type production facilities be capital intensive. In Europe alone, approximately 30 percent of the cost of silicon stems from electricity expenses. Additionally, the Siemens method involves the use of potentially hazardous substances like silane gas and creates a number of byproducts like silicon tetrachloride that must be carefully monitored, managed and disposed.

By contrast, Silicor uses molten aluminum to dissolve the raw silicon, doing so at far lower temperatures than other silicon producers. The aluminum naturally draws out the impurities in the metallurgical silicon, and as a result, the product undergoes only two phase changes—solid-to-liquid, and liquid back to solid—and uses just 10-25 kWh per kilogram of material produced.

The Silicor process does not use high-risk substances and creates zero hazardous byproducts. Instead, the process yields two aluminum-based byproducts: an aluminum alloy and polyaluminum chloride, which can be sold for use in industries ranging from automotive and aerospace to wastewater treatment.

## Building a clean future for solar silicon

To date, pilot-scale production of Silicor’s solar silicon has yielded enough material to power more than 20 million PV cells in projects worldwide. Silicor is now expanding that operation considerably with its first commercial-scale production plant. The facility, which has a nameplate capacity of 16,000 metric tons annually, will place Silicor among the world’s six largest producers by volume. The plant is expected to be operational in late 2018. After a selective international scouting mission to site its plant, Silicor Materials found its home in Grundartangi, Iceland. Although an unlikely candidate on the surface, Iceland is a perfect match for Silicor’s operations for a number of reasons, including a shared commitment to environmentally conscious operations. The country is home to an abundance of both hydropower and geothermal power, enabling Silicor to source 100 percent of its electricity needs from clean, renewable sources. Iceland is also a major hub for world-class aluminum partners, addressing feedstock and off-take needs without complicated transportation logistics—or the emissions associated with them.

To further reduce its environmental impact, Silicor recently announced a plan to achieve carbon neutrality at its Iceland site. With support from the Icelandic Forestry Association and the Icelandic Environment Association, the company will fund the planting of more than 26,000 trees across Iceland. This measure will offset approximately 2,800 tons of CO2 annually, which covers both the entirety of Silicor’s process and the transportation logistics of manufacturing, shipping and receiving at the facility.

Silicor’s technology represents one of the first major upstream PV innovations in recent years, but it is only one part of the solution. There is ample opportunity for the industry to optimize its technologies and processes, especially during this period of intense growth. Together, industry players can achieve meaningful cost reduction across the solar supply chain—and do it with an eye toward environmental stewardship. Silicor Materials is proud to be leading this charge.



**About the Author**
Terry Jester is a 35-year veteran of the solar industry with extensive leadership experience in the manufacturing and engineering of photovoltaics. She joined Silicor Materials in 2010 following her active involvement in the company as entrepreneur in residence at Hudson Clean Energy. Ms. Jester has managed large solar operations and held engineering positions for SoloPower, SunPower, SolarWorld, Siemens, Arco and Shell. She holds a degree in Mechanical Engineering from California State University Northridge.

A metals-based process for silicon production requires only two phase changes: solid to liquid and liquid to solid.

# SOLAR PANELS

## Faster acoustic inspection

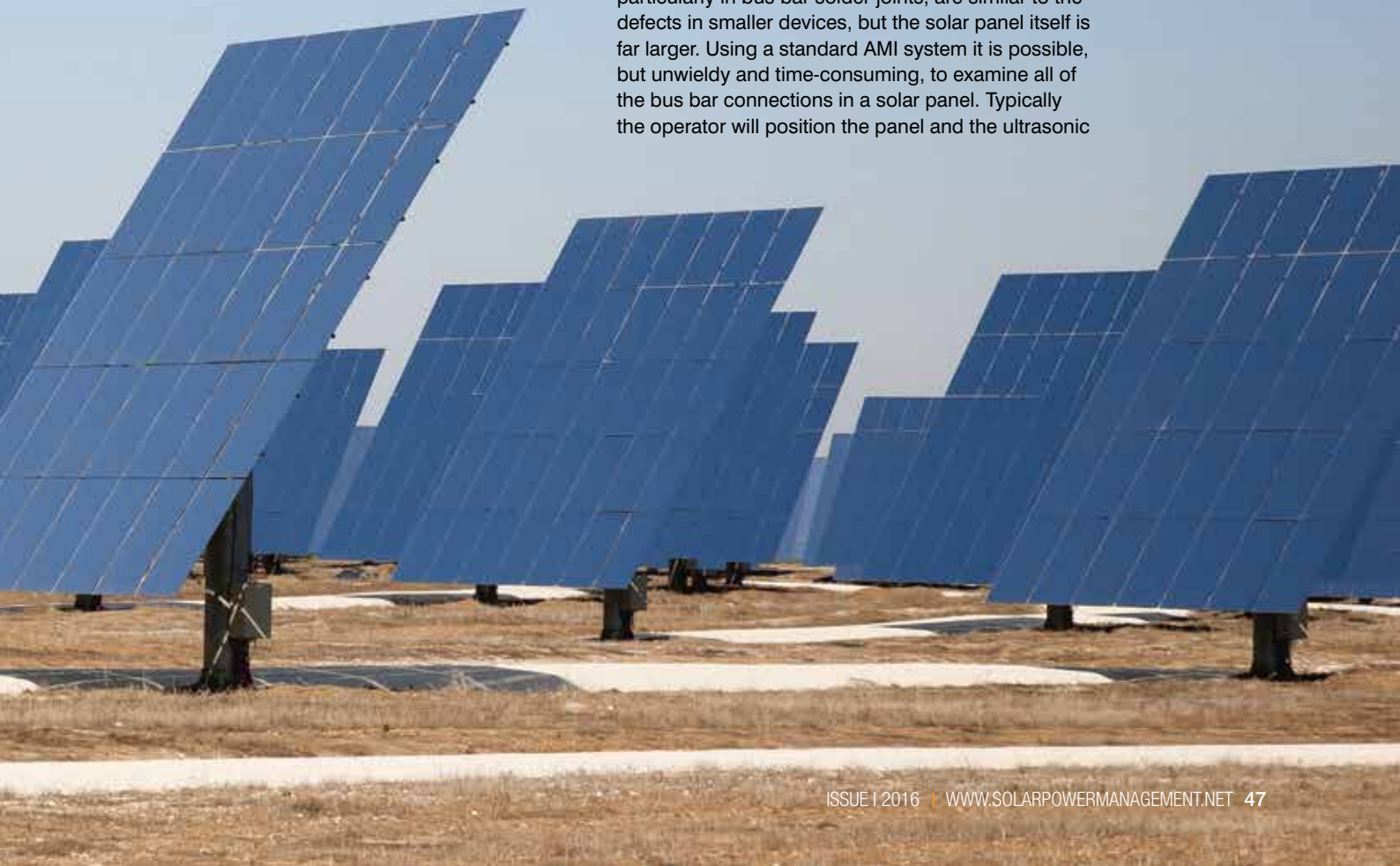
By maximizing the scan area and developing innovative software, it is possible to significantly increased both the speed and the efficiency of the inspection process. Tom Adams, consultant, at Sonoscan, Inc explains.

THE STRUCTURAL DEFECTS that solar panels are inspected for include cracks in the silicon, delaminations between the silicon and the silicone adhesive, delaminations, broken traces, and others. Any of these structural defects can diminish the performance and lifespan of a solar panel.

Some of the most critical and most frequent structural defects involve the solder that joins the bus bar to the silicon cells. These defects include non-bonds or partial bonds (which may be caused by surface contamination on the silicon) between the solder and the cell, as well as voids (air bubbles) in the solder. The defects may have all sorts of configurations, but are undesirable because they shrink the area of contact between the cell and the bus bar, and because physical and thermal stresses during service are likely to shrink the area of contact even more. Eventually the contact is broken. In the best case, only the single cell is lost; in the worst case, the entire panel goes dead. These structural defects are not visible optically but are easily seen by acoustic micro imaging tools. They are typically too thin to be imaged by x-ray.

Ideally a solar panel will go into service and operate with high efficiency for its expected lifetime. Structural defects involving the solder joints can seriously compromise this performance. A cold joint, where the solder is in place but not bonded at all to the solar cell, may be intermittent and may or may not be detected by electrical testing. But when a solder joint is only partly bonded or harbors voids, the bus bar can lose contact with the solar cell gradually until it abruptly fails. In order to eliminate problem solder bonds, a manufacturer can perform acoustic imaging of the panel during assembly. Rework can often be performed to ensure normal operation in service.

Countless devices, modules and assemblies aside from solar panels run the risk of sudden field failure caused by loss of electrical contact between two elements. Most of these items are smaller than a solar panel in their x-y dimensions, and fit nicely onto the scanning stage of most acoustic micro imaging (AMI) tools. The defects in solar panels, and particularly in bus bar solder joints, are similar to the defects in smaller devices, but the solar panel itself is far larger. Using a standard AMI system it is possible, but unwieldy and time-consuming, to examine all of the bus bar connections in a solar panel. Typically the operator will position the panel and the ultrasonic



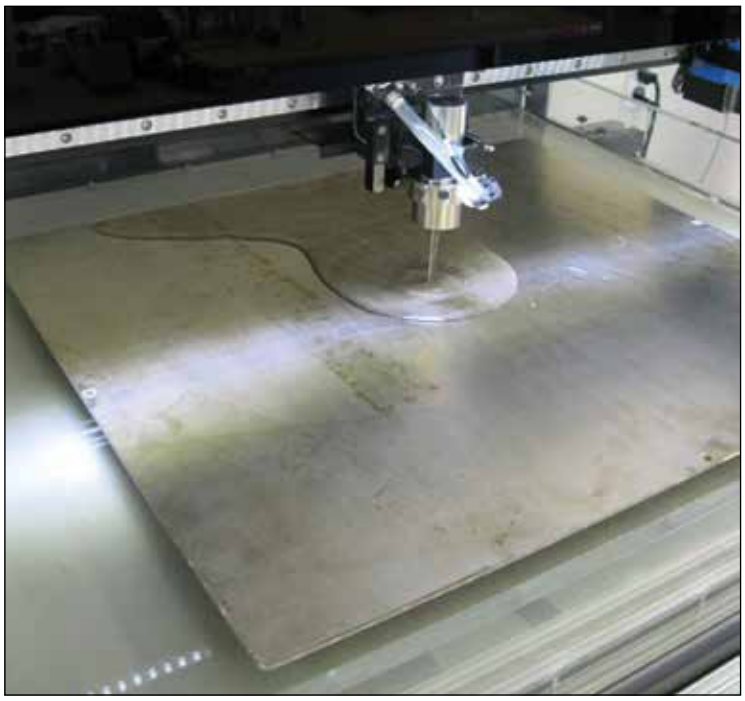


Figure 1: Sonoscan's oversized scan area, here at work on a very large unpopulated PC board, speeds the inspection of solar panels.

transducer will scan one small area to produce an acoustic image. The operator will then reposition the panel to scan the next small area, and so on until the entire area of the panel has been scanned. This method is effective but tedious.

Sonoscan also developed a C-SAM AMI tool that has a much larger scan area (0.6096 m x 0.6096 m) than other laboratory, semi-automated or automated AMI tools. It is shown scanning the bottom side of a large pc board (solar panels being proprietary) in Figure 1. Some solar panels can be imaged in their entirety in one scan, without repositioning the panel. Even panels measuring up to 1m x 3m require relatively few scans. Because there are many fewer interruptions of the scanning process to reposition the solar panel, inspection is much faster. To further speed the inspection process, Sonoscan has developed software that can accommodate scanning to the geometry of the panel. The layered structure of the panel may have defects such as cracks or delaminations in the silicon and other materials, but such defects are both less common than and less lethal than bus bar defects. The new software therefore scans only the bus bars, looking for anomalies and defects in the bonds between the bus bar and cells. This selectivity greatly reduces scan time and the area that must be scanned, and means that even very large solar panels can be inspected for the most dangerous features in the shortest possible time.

The concept of scanning only the most relevant regions of a sample is used by Sonoscan in non-solar applications as well. An AMI system having a smaller scan area, for example, may be scanning a JEDEC-style tray that contains only a few large parts. Time may be saved if each of the few parts is scanned individually, without scanning the regions of the tray that contain no parts. The two major types of solar cells are both imaged acoustically in panel form, but not at the same stage of production. Thin film solar cell panels have no backside material that will block the transmission of ultrasound, and the common anomalies and defects occur on the backside. Thin film panels are typically imaged just after busing.

Traditional glass solar cell panels differ in that a strengthening material is placed on the backside of the panel. The material covers the whole area of the backside and prevents ultrasound from reaching and imaging the solar cells. A reflective coating makes imaging from the frontside impractical. For these reasons, traditional panels are imaged from the back side just before the strengthening material is applied.

During the acoustic imaging process, the AMI tool's transducer is coupled to the panel's surface by a column of water that rides with the transducer. The transducer scans across the width of the bus bar at a given point, moves fractionally, and scans back across the bus bar. The transducer moves back and forth across the bus bar at relatively high speed. Thousands of times a second, it sends a pulse

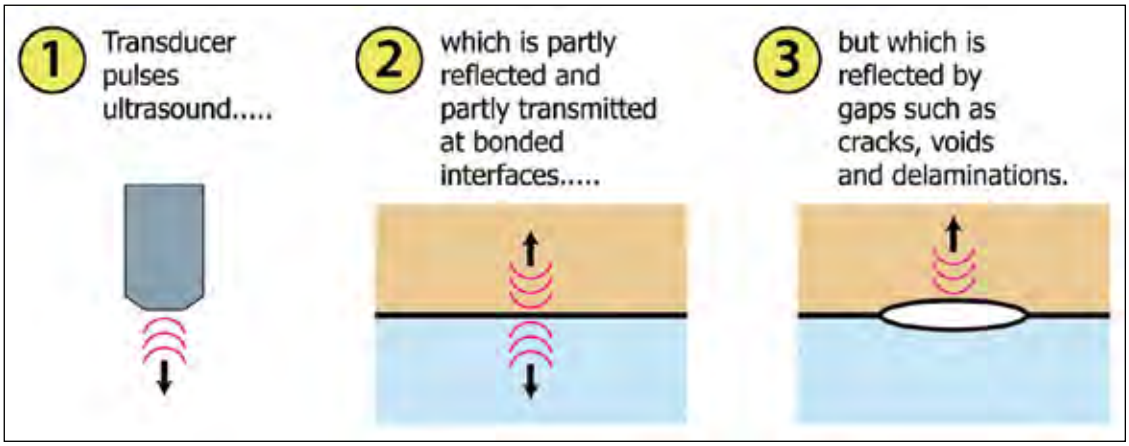



Figure 2: Well bonded interfaces both reflect and transmit an ultrasonic pulse, while a gap - even one as thin as 100Å - reflects essentially all of the ultrasound.

of ultrasound into the panel and receives return echoes having various amplitudes. The transducer typically has a long focal length and pulses 230 MHz ultrasound to achieve the highest spatial resolution in the acoustic images.

Well bonded material interfaces in the bus bar attachment reflect a portion of the ultrasound; another portion crosses the interface and travels deeper into the sample. A well bonded bus bar will therefore send back moderate-amplitude echoes that will appear gray in a monochromatic acoustic image. But any material gap, even if it is as thin as 100Å, will send back a maximum-amplitude echo that will be displayed as bright white in the acoustic image (Figure 2). The near-total reflection of the pulsed ultrasound is caused by the interface between a solid material and the air or another gas in the gap. Bright white features in acoustic image of the bus bars are non-bonds, voids, delaminations or other types of gaps. Their location and size are evaluated to determine how great a threat they pose to long-term performance.

Figure 3 is the acoustic image of one junction box, where the bus bar is soldered to the solar cell. The depth imaged was the glass-to-silicon interface. Imaging revealed two areas of concern:

- The bond between the bus bar and the silicon. Only the right and left regions of the bus bar display the medium gray tone that is indicative of successful bonding. There are significant regions (blue arrows) whose white color indicates that they are delaminated or non-bonded. In the center of the bus bar weld only small regions are well bonded (the medium gray seen at the left and right extremities) and there are numerous small delaminations. These anomalies may be the result of thermal interaction between the bus bar and the bond pad during assembly.
- The bond pad. Most of the area of the oval bond pad seems to be well bonded (evenly gray), but the outer edges of the bond pad are white - delaminated or non-bonded. Although these regions are relatively small, they are likely to expand in area until the bond itself is compromised. The bond pad is also surrounded by small more or less circular features that are likely to be voids.

Figure 3 is representative of the sorts of defects that need to be found during acoustic inspection of solar panels. By maximizing the scan area and developing innovative software, Sonoscan has significantly increased both the speed and the efficiency of the inspection process.



> “Traditional glass solar cell panels differ in that a strengthening material is placed on the backside of the panel. The material covers the whole area of the backside and prevents ultrasound from reaching and imaging the solar cells. A reflective coating makes imaging from the frontside impractical”

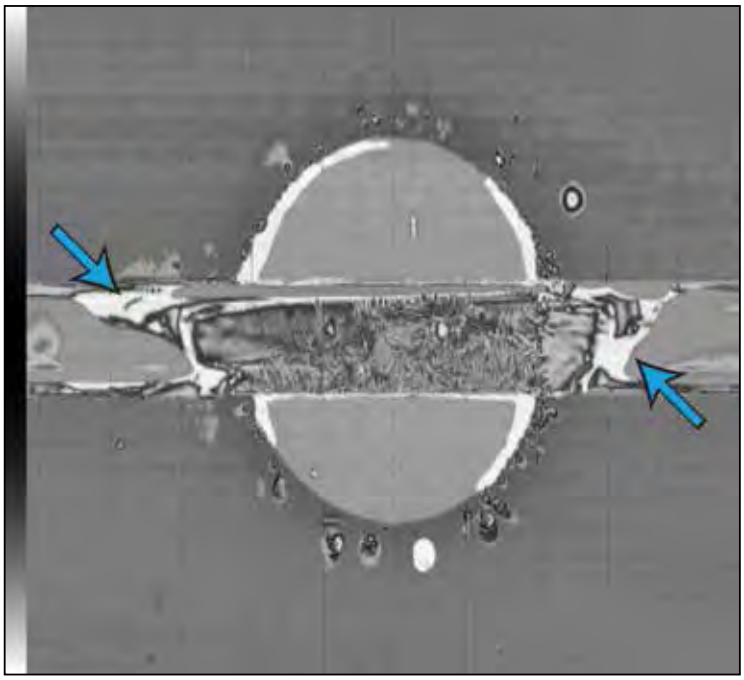


Figure 3: White areas in the acoustic image of a junction box are delaminated. Evenly gray areas are bonded.

# PV Taiwan
## shines with solar innovations

The PV Taiwan 2015 exhibition in Taipei spotlighted the industry's latest work to boost cell efficiency, make storage more affordable and instill confidence in the long-term future of solar power. Mark Andrews brings the latest technology highlights.

PV TAIWAN brought together the industry's leading solar cell designers and manufacturers in Taipei, celebrating the industry's continuing growth while addressing the need for improvement in product quality and long-term durability.

The exhibition and conference (14-16 October) is in its 9th year. More than 120 exhibiting companies in 365 booth at the Nangang Exhibition Centre saw more than 9,300 visitors. Most attendees came from Taiwan and neighboring China, Singapore, Hong Kong, the United States, Germany and other countries across Europe and Asia.

Taiwan's Bureau of Energy and Ministry of Economic Affairs take the needs of its industrial base very seriously. To that end they have established product assessment criteria and certification for PV products, with awards for cells and modules that not only meet standards of the IEC, but also 13 separate safety requirements and 18 performance tests and do so while maintaining high efficiency: 20 percent or more for monocrystalline cells and at least 18.5 percent for multicrystalline devices. Companies winning 2015 'Taiwan Excellent PV Awards' included AU Optronics, Neo Solar Power Corporation, TSEC Corporation and WINAICO.

Taiwan's photovoltaic industry is expected to report NT$184.8 billion in 2015 sales revenue (about $6.1 billion USD) according to the Taiwan External Trade Development Council (TAITRA) and SEMI. Even though the market has slowed in some parts of the world where subsidies have been cut, the overall solar market continues to grow at double-digit rates. This expansion is envied by the wider semiconductor industry where growth is expected to remain flat or increase about 1 percent in 2015.

A survey conducted by Solar Power Europe (formerly EPIA) shows that in 2014, solar installations increased significantly in Japan, China and the U.S. Global PV installations exceeded 40GW last year, and are expected to reach 58 GW in 2015 (about 30 percent growth), followed by further expansion to 85 GW generating capacity per year by 2020.

Solar's growth spurt is what brought many suppliers and manufacturers to the PV Taiwan marketplace including Heraeus Photovoltaics that announced it was expanding its presence in the Republic of China

(ROC) by adding local manufacture of front-side metallization pastes to its existing product line.

Making the announcement in a ribbon cutting ceremony on the tradeshow floor was a delegation of senior executives including Andreas Liebheit, President of Heraeus Photovoltaics Global Business Unit; Dr. P. H. Chang, CEO of Motech Industries, Inc., Chairman of the SEMI Taiwan PV Committee and the TPVIA; and Dr. Sam Hong, CEO of Neo Solar Power Corp. Heraeus expects manufacture of front-side pastes to begin in its expanded Taiwanese facility by the end of 2015.

Liebheit met with Solar + Power Management magazine prior to the official ceremony to discuss the company's history in Taiwan and operations across Asia. Liebheit said the manufacture of high quality solar cells and modules as well as new research and development work was driving his company's expansion in Taiwan.

"In order for us to offer customization and shorten lead times for customers, it is vital to have a strong operational presence where our customers are, and Taiwan has grown to become an important market for us," Liebheit said.

Quality, shorter lead times, increased ruggedness and longer in-service lifetimes were recurring themes expressed by companies at the event. Major Taiwanese manufacturers acknowledged that long-term market success meant delivering quality, not just low costs.

More manufacturers are working towards end-to-end supply chain management strategies as well as relationships with installers and trade groups to encourage feedback and continual product improvement. PV Taiwan exhibitors included a wide range manufacturers and suppliers. While many had new product announcements, most device details pointed toward continuing advances towards greater efficiency and serviceable lifetimes.

GinTung Energy Corporation, founded as Apollo Solar Energy Co. in 2005, offers a wide range of mono- and multicrystalline cells. Module efficiency is on par with industry averages between 15 and 18 percent. Its existing product line is popular across local and international markets. But what caught many visitors' attention were plans to release its new 'Lightwave' panel line early in 2016, with full production expected in third quarter.

> "GinTung Sales and Marketing Division Manager Cyrus Wong said that the new Lightwave panels will be 50 percent lighter than current models (glass sealed cells in aluminum frames) that average about 19 KG per module. Lightwave modules will tip the scale at only 9 KG"


GinTung Sales and Marketing Division Manager Cyrus Wong said that the new Lightwave panels will be 50 percent lighter than current models (glass sealed cells in aluminum frames) that average about 19 KG per module. Lightwave modules will tip the scale at only 9 KG. Wong said the company believes that this revolutionary leap in weight reduction will impact future residential installation the most since residences tend to have more weight-related concerns than commercial structures. But no matter the location, cutting weight in half while maintaining performance will give both end-use customers and retailers a new product worthy of consideration.

Like many larger manufacturers at PV Taiwan, Neo Solar Power Corp. has been in the PV cell and module business since 2005. Starting with PV cells, they grew capabilities to embrace all aspects of manufacturing end-use products; they now also partner with installers so they have contact with the product from start to finish. They also support community, grid-scale projects around the world including the largest airport installation to date (32 MW), that was completed recently in Indianapolis, Indiana (USA). They also supported a 42 MW plant in Manchester, England—their largest project so far. The Manchester plant will produce enough electricity for about 17,000 homes.

Neo Solar Power Corp. has been in the PV cell and module business since 2005. Starting with PV cells, they grew capabilities to embrace all aspects of manufacturing end-use products

Vendors supplying manufacturers with wide selections of process tools included Symtek Automation Asia (SAA), a European automation expert that has extended its product line to include machinery for handling PV wafers and cells. Tobias Rapp, PV Division Vice President, said the company sees great opportunity for the future growth across Asia.

Rapp indicated that one of the interesting transitions he is seeing across the industry is the move from manually handling PV cells throughout various processing steps to fully-automated systems. When the PV industry was just gaining traction in Taiwan and China, transferring cells from one machine to another was often done by hand. The workers were highly skilled and rarely broke cells. The problem his company noticed was that this highly skilled and careful work force saw opportunity as the industry grew, and a sizeable percentage of the workforce might move from plant to plant seeking higher wages. Rapp said his sales pitch is to empower plant operators with a process tool solution that won't move up the street, doesn't take time off and is ready whenever the plant operator needs to change production parameters.

Sino Green Energy (SGE) was one exhibitor that had more of a challenge displaying its product than most because unlike others, SGE doesn't manufacture PV products, it builds solar-based distributed electric cooperatives in Taiwan. Although currently operating 230 sites across the island nation, it doesn't plan to export its management technology outside the ROC—at least for now. What is does bring to the market is a savvy efficiency enhancement approach that delivers results it claims are better than any other generating company.

SGE President Eric Wang explained that his company found that programs to monitor and affect solar generating efficiency was lacking. SGE hired


the engineering expertise to create its own software that now maximizes efficiency. During the summer of 2015, Wang said SGE's capacity was 3.91 kWp while other solar plants in the same area were averaging 3.19 kWp. While Wang did not speculate about his company's plans to export their management software, achieving an 18 percent increase in usable generating capacity is no small feat in an industry that gets excited about even single point efficiency gains.

AU Optronics (BenQ Group subsidiary) was another stand-out company that combined PV cell and module manufacturing with a line of storage solutions that scale from residential needs up to commercial and micro-grid applications. AUO was also one of the few companies also involved in smelting polysilicon ingots. They offer a wide range of module choices, from 16 to 20 percent efficiency, and a company history dating to 1996. AUO is also listed on the Dow Jones Sustainability World Index and was the first Taiwanese manufacturer to receive a LEED Platinum Certification.

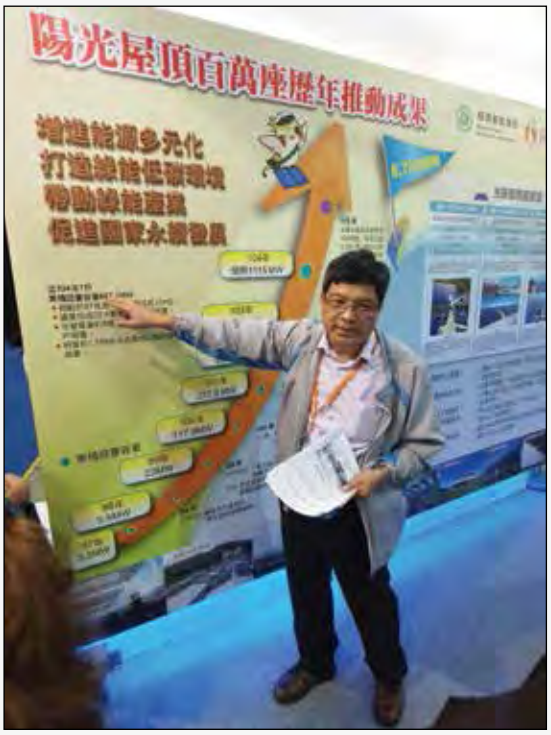
Taking solar in another direction entirely was Aplus Energy Company that manufactures crystalline solar modules laminated to coated steel roofing panels to eliminate the need for rack systems. Their panels can be installed with no penetration of existing roof structures. Roof panels can also be constructed of polycarbonate, further reducing weight loads. The panels have obvious weight advantages, require little to no racking, and provide unusually high wind and precipitation resistance due to their flush-mount characteristics. PV cell efficiency is currently rated at 17.6 percent, and panels are guaranteed to perform at 90 percent capacity for 10 years and 20 years at 80 percent capacity.

Industry analysts, financers and investors anticipate further worldwide growth of solar generating capacity. By mid-century, renewable energy will dominate electric power generation. Innovation continues to push photovoltaic cells to greater levels of reliability and long-term quality.

Taiwanese PV companies are bringing products to every major solar market, and continue to grow either through direct connections with retailers or wholesalers. While the competitiveness of Taiwanese and Chinese solar manufacturers has led to 'anti-dumping' regulations, manufacturers have responded by creating local assembly and testing facilities in large markets, which also brought them into closer connection with end users and retailers.

Solar energy is truly an international industry. Design and manufacturing can be found in Taiwan, China, Japan, Singapore, the Americas and Europe; expansion further into Africa, India, the Middle East and Oceania is expected as well. Although fossil-fueled electricity generation still provides most of the world's power, more than 70 percent of new generating capacity added in the last year came through renewable energy. Taiwanese manufacturers continue to play a leadership role in this rapidly evolving industry and will offer exciting new products in 2016 and beyond.






Solar energy is truly an international industry. Design and manufacturing can be found in Taiwan, China, Japan, Singapore, the Americas and Europe; expansion further into Africa, India, the Middle East and Oceania is expected as well

azymuth

# Desert sand can store solar energy

The Masdar Institute proves desert has storage potential

MASDAR INSTITUTE researchers have successfully demonstrated that desert sand from the UAE could be used in concentrated solar power (CSP) facilities to store thermal energy up to 1000°C. The research project called 'Sandstock' has been seeking to develop a sustainable and low-cost gravity-fed solar receiver and storage system, using sand particles as the heat collector, heat transfer and thermal energy storage media.

Desert sand from the UAE can now be considered a possible thermal energy storage (TES) material. Its thermal stability, specific heat capacity, and tendency to agglomerate have been studied at high temperatures.

Dr. Behjat Al Yousuf, Interim Provost, Masdar Institute, said, "The research success of the Sandstock project illustrates the strength of our research and its local relevance. With the launch of the MISP in November, we have further broadened the scope of our solar energy research and we believe more success will follow in the months ahead."

A research paper on the findings developed under the guidance of Dr. Nicolas Calvet, Assistant Professor, Department of Mechanical and Materials Engineering, was presented by PhD student Miguel Diago at the 21st Solar Power and Chemical Energy Systems (SolarPACES 2015) Conference in South Africa. The paper was co-authored by alumni Alberto Crespo Iniesta, Dr. Thomas Delclos, Dr. Tariq Shamim, Professor of Mechanical and Materials Engineering at Masdar Institute, and Dr. Audrey Soum-Glaude (French National Center for Scientific Research PROMES CNRS Laboratory).

Replacing the typical heat storage materials used in TES systems -- synthetic oil and molten salts -- with inexpensive sand can increase plant efficiency due to the increased working temperature of the storage material and therefore reduce costs. A TES system based on such a local and natural material like sand also represents a new sustainable energy approach that is relevant for the economic development of Abu Dhabi's future energy systems.

The analyses showed that it is possible to use desert sand as a TES material up to 800-1000°C. The sand chemical composition has been analyzed with the X-ray fluorescence (XRF) and X-ray diffraction (XRD) techniques, which reveal the dominance of quartz and carbonate materials. The sand's radiant energy reflectiveness was also measured before and after a thermal cycle, as it may be possible to use the desert sand not only as a TES material but also as a direct solar absorber under concentrated solar flux.

Dr Nicolas Calvet said: "The availability of this material in desert environments such as the UAE allows for significant cost reductions in novel CSP plants, which may use it both as TES material and solar absorber. The success of the Sandstock project reflects that usability and practical benefits of the UAE desert sand."

In parallel to sand characterization, a laboratory scale prototype was tested with a small solar furnace at the laboratory of PROMES CNRS 1 MW solar furnace in Odeillo, France. Masdar Institute alumnus Alberto Crespo Iniesta was in charge of the design, construction, and experiment.
The next step of the project is to test an improved prototype at the pre-commercial scale at the Masdar Institute Solar Platform (MISP) using the beam down concentrator, potentially in collaboration with an industrial partner.

# SNEC 2016 PV POWER EXPO

Dialogue & Conference & Exhibition

## SNEC 10th (2016) International Photovoltaic Power Generation Conference & Exhibition

Gather worldwide PV industry leaders and enterprises.
Grasp the newest trends in PV technologies and the PV industry.
Build international co-operation and trade platforms for the PV industry.
Attract tens of thousands of powerful buyers.

www.snec.org.cn

Welcome to Shanghai

**May 24-26 2016**

SNEIA Shanghai New Energy Industry Association

**Shanghai New International Expo Center**
(2345 Longyang Road, Pudong District, Shanghai, China)

| 180,000m² | 1,800+ | 5,000+ | 150,000 |
|---|---|---|---|
| Exhibition Space | Exhibitors | Professionals | Visits |

Shanghai, China Tel: +86-21-64276991
+86-21-33561099
For exhibition:info@snec.org.cn
For conference:office@snec.org.cn

California, USA Tel: +1-510-219-6103
For exhibition: Petersnec@gmail.com

# Ireland plans renewable energy transition by 2050

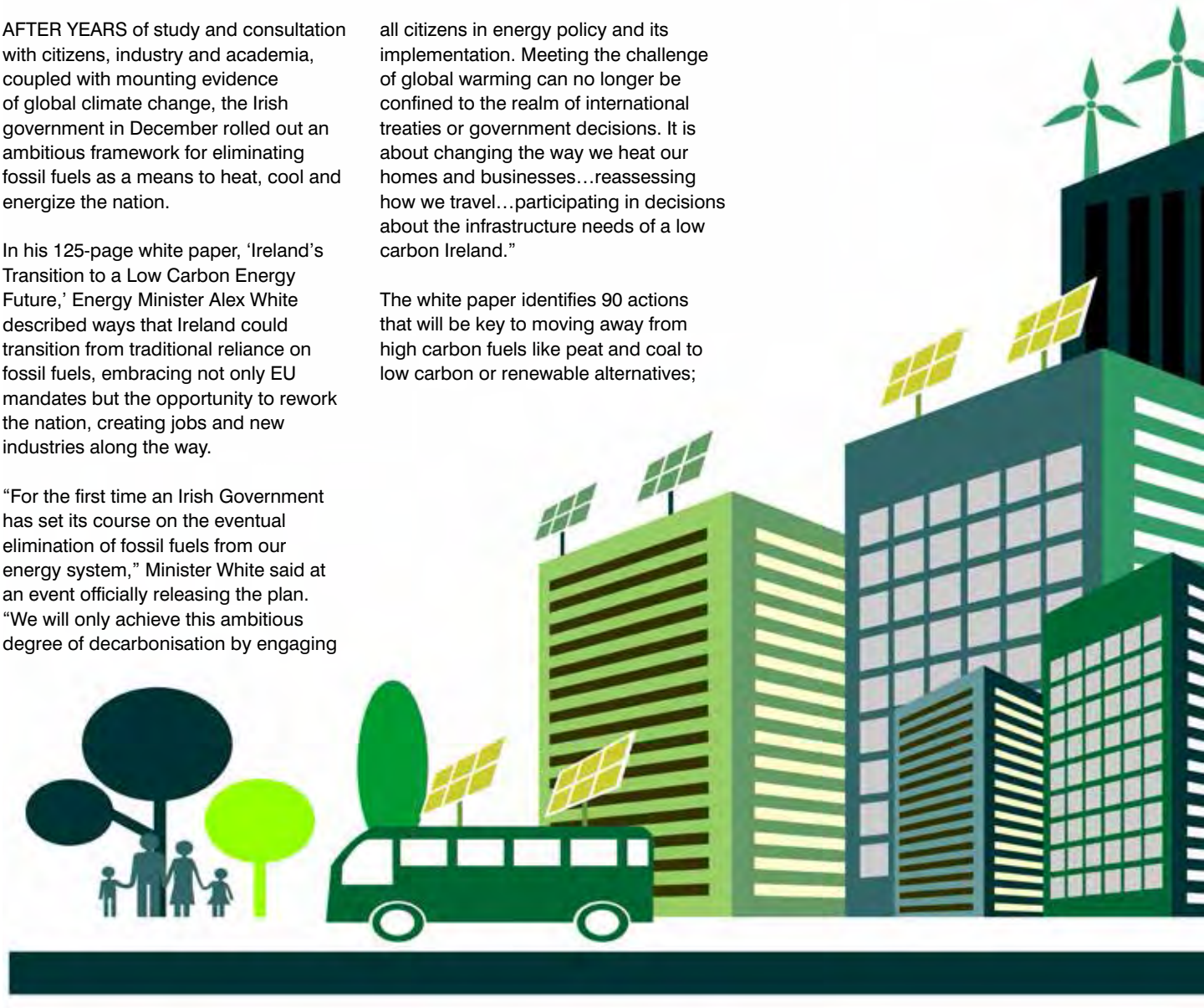
The Irish government has announced a framework for cutting carbon emissions up to 95 percent by 2050, radically altering its energy future. Renewable and low carbon resources will replace Ireland's long-standing reliance on coal, peat and oil for heating and electricity generation.

AFTER YEARS of study and consultation with citizens, industry and academia, coupled with mounting evidence of global climate change, the Irish government in December rolled out an ambitious framework for eliminating fossil fuels as a means to heat, cool and energize the nation.

In his 125-page white paper, 'Ireland's Transition to a Low Carbon Energy Future,' Energy Minister Alex White described ways that Ireland could transition from traditional reliance on fossil fuels, embracing not only EU mandates but the opportunity to rework the nation, creating jobs and new industries along the way.

"For the first time an Irish Government has set its course on the eventual elimination of fossil fuels from our energy system," Minister White said at an event officially releasing the plan. "We will only achieve this ambitious degree of decarbonisation by engaging all citizens in energy policy and its implementation. Meeting the challenge of global warming can no longer be confined to the realm of international treaties or government decisions. It is about changing the way we heat our homes and businesses…reassessing how we travel…participating in decisions about the infrastructure needs of a low carbon Ireland."

The white paper identifies 90 actions that will be key to moving away from high carbon fuels like peat and coal to low carbon or renewable alternatives;



fossil fuels will largely be replaced by renewable energy sources by 2050 under the plan. The ultimate goal of eliminating greenhouse gas (GHG) emissions from the nation's energy economy is set for 2100 when energy derived from fossil fuels should fall to "zero or below," the minister said.

Work on the new Irish framework for a renewable energy future has been proceeding since Ireland's last energy white paper was published in 2007. The new framework focuses on current and medium-length plans through 2030, leaving room for technological advances, public interaction, and regular progress assessments to guide the plan toward its ultimate goals in 2050 and beyond. This new energy plan builds on the Department of Communications, Energy and Natural Resources (DCENR) publication of a Green Paper on Irish energy policy in 2014.

From the outset government leaders acknowledged that fundamental change—even when desirable—is never easy. Their efforts were driven by the prospects of facing runaway global warming and direct consequences for Ireland, other EU member states and the entire world, they stated. The technology already exists to affect positive change in many ways. They expressed a conviction that growing research into alternative energy will address issues such as grid-scale energy storage and combining distributed power with decentralized energy systems much the same way as other global efforts have reduced the cost of solar energy dramatically since 2006. With the technology that exists today, and new innovations that are logically expected, the Irish leadership said its 2050 goals are not only achievable, but may be met even more quickly than is foreseeable today.

Outlining key elements of the plan, the Irish Energy Ministry white paper describes actions and detailed processes needed to enable Ireland's transformation to a low carbon future. They believe this can be achieved by:

- Substantially changing the behaviour of citizens, industry and government
- Becoming more energy efficient
- Generating electricity from renewable sources of which Ireland has a plentiful indigenous supply
- Moving to lower emissions fuels (e.g. away from peat and coal to natural gas), and ultimately away from fossil fuels altogether
- Increasing the use of electricity and bioenergy to heat homes and fuel transportation
- Increasing the Biofuels Obligation and improving take-up of zero and low carbon vehicles powered by electricity and natural gas
- Supporting the wide scale deployment of renewable heat in the business, public and residential sectors
- Adopting new renewable energy technologies as they emerge

The role Irish citizens will need to play in realizing the plan's key objectives was a frequent point discussed in the Energy Ministry's framework plan. Although six pages specifically speak about the need for citizen engagement, consultations between government and citizens saw some type of reference throughout the white paper. Barely a page goes

by without comments concerning interaction between government and its constituencies.

## The Aran example

Taking charge of their energy future is nothing new to the Aran Islands whose residents participated in a number of projects designed to create energy independence by 2022. Like much of the Irish coastline, the Arans have great potential for off-shore wind generation, but given the cost and grid connection issues of sea borne turbines, islanders focused on means that could benefit daily life without massive government programs. They created pilot energy co-ops, retrofitted homes and businesses for higher energy efficiency and took part in the trial use of electric vehicles (EVs) for public transport. A large portion of the Arans' 1,247 residents ultimately participated in various projects that resulted in a 78 percent reduction in transportation energy costs and a 68 percent reduction in energy imports, along with many other benefits. Results such as these were characterized by government officials as indicative of what Ireland can do to take charge of its unique energy requirements without increasing energy costs, compromising daily life or forfeiting business opportunities.

## Becoming active energy consumers

Unless someone is actively engaged in the business of energy, the paper describes most Irish citizens as 'passive' consumers like almost everyone else across the globe. To achieve success the government envisions citizens changing from passive to 'active' energy consumers: persons who look for ways their lives can be made better by understanding proposed transitional energy practices and then taking charge of their own energy futures.

Ireland is not unique in its present day energy consumption practices. In most parts of the world the generation of electrical power, home and business heating/cooling all depend to some degree on government entities or utilities. These paradigms of energy generation came into existence more than a century ago when centralized power generation developed because of electricity's potential to transform daily living. The Ministry's white paper envisions an Ireland in which everyone not only knows how much energy their home or business utilizes, but works to actively conserve energy while embracing new technologies enabling independence.

## A renewable foundation

Ireland is already committed to renewable energy. At the time its white paper was published, the government noted that Ireland obtained nearly 23 percent of its energy from renewable resources, with most of that coming through wind energy.

Solar (either thermal or photovoltaic [PV] power) is currently playing a minority role in the Irish energy economy. Solar is outpaced by contributions from inland wind electricity generation, hydroelectric and geothermal power. But as the government white paper concludes, the dramatic cost reduction in PV power over the last 10 years has translated into cost parity or near parity with fossil fuel generation. In looking at levelized cost of electricity (LCOE) comparisons, PV power is already cost-effective in many locations. In Germany, for example, solar energy (most of it PV,) accounts for anywhere between 20 percent and 50 percent of the country's electricity needs, depending on the time of year and other variables. The upside potential for solar in Ireland is very great.

## Summary

Ireland's transition to a renewable energy future has been charted by its Energy Ministry within a framework of global concerns for reducing GHGs and thereby reducing the threat of global warming. But beyond esoteric concerns for collective world welfare, the plan also charts a course that shows energy independence has real benefits beyond those highlighted in the recent Paris Climate Accord.

Taking charge of a nation's energy future empowers everyone from citizens to industry to international business with confidence that local energy supplies are securely held within Ireland's borders. Modernization of the electricity grid, cooperation with Ireland's neighbors and the international community provides a basis for future business and economic growth that benefits everyone. By taking charge now, Ireland can say with confidence that it is creating its own future with independence from foreign interests. Although its plan is ambitious, Ireland is demonstrating real commitment; this should help every citizen see his or her role in a low carbon energy future as something they can take charge of starting today.



# PV costs could fall 50 percent by 2030

KIC InnoEnergy predict that photovoltaic (PV) energy costs could fall as much as 50 percent by 2030. Their online Delphos modeling tool is designed to aid industry and finance in evaluating how diverse factors will impact future energy ecosystems.

Solar + Power Management recently spoke with Emilien Simonot, KIC InnoEnergy's Renewable Energy Technology Officer about his organization's new Delphos modeling tool. Using the software – available free to anyone who registers – enabled KIC InnoEnergy to predicts that solar energy innovations in conventional c-Si cells, their high-efficiency variants and thin film technology could reduce PV costs as much as 50 percent in the next 15 years. KIC describes the new tool as an important step in helping analysts, investors, academia and manufacturers understand how the levelized cost of electricity (LCOE) will likely be impacted by more than 30 forms of PV innovation and other energy generation systems.

**Q** THE IMPACT of new technology – especially when it affects global energy needs – can be a contentious subject. Incumbent energy producers have a perspective, while technology innovators have another view of how their solutions may affect supply, distribution and cost. What motivated KIC InnoEnergy to develop its new Delphos modeling tool?

**A** Incumbents have in fact been traditionally at the forefront of knowledge and innovation in their respective sectors. However, the past 20 years have seen an increase of "cheap capacity" through computing, prototyping and the internet which have produced the emergence of a highly dynamic "innovation ecosystem." Incumbents are certainly affected by disruptive ideas and radically new business models, but at the same time they closely monitor new, fast growing and dynamic sources of innovation in processes, services or products. This process of integrating innovative solutions to already existing businesses is a challenge, not least in streamlining the integration process so that once an innovation of high value has been identified, it is adopted quicker.

KIC InnoEnergy is here to support this process, ensuring availability of resources, to push ideas forward. But also by bringing thought leadership to help existing players identify opportunities in the energy ecosystem - Delphos is one part of the strategy. It is the toolbox that KIC InnoEnergy is making available to determine the value of an innovative product, service or process. The Delphos modelling tool works in four renewable energy technologies – PV, Wind (onshore and offshore) and Solar Thermal Electricity. It assesses the impact of an innovation on the Levelised Cost of Energy (LCOE), one of the key parameters to help decision makers understand the business case for a given innovation.

**Q** Is the Delphos tool designed primarily for renewable energy manufacturers, incumbents, researchers, trade groups or some combination?

**A** We identified three main targets for the Delphos tool: SMEs and research organisations in renewable energy. They are usually specialised and working in very specific sub-sectors of the industry and so can often miss the full picture of the technology they are working on. Delphos brings them a credible set of data and robust modelling capacity that allows them to better understand the impact of their innovations on the value chain and how it could solve existing needs. Strategically, Delphos can be used to support a business model definition and to demonstrate value proposition from the cost perspective.

The larger players may have their own expertise in evaluating the impact that concrete innovation could have on their processes. In this case, Delphos provides basic impact analysis and can be used as a reference tool to support collaboration strategies with third party partners. Some more applications might be found in the financing or public sector as Delphos provides a common ground to discuss impact analyses and can serve as support from the strategic management to help programme definition, right down to the operative management at the project or investment level.

**Q** How does the Delphos tool compare to other modeling instruments now available? For example: the role of more than 30 technological innovations is mentioned – Is this unique to Delphos?

**A** There are no other existing tools like Delphos that combine both a pre-established set of data (including cost structures of power plants and the estimated impact of innovation) with such a robust modeling capacity. The main alternatives available to the market are tailored to consulting services. In-house developments are also possible but are time-consuming and require a big effort to secure reliable data.

**Q** One of the most challenging aspects of predicting the future of any technology is the large number of variables beyond the purely technological that can impact how a product or family of devices may mature and interact with other technologies. How does KIC InnoEnergy plan to handle changes that materialize over the next 3 to 15 years?

**A** Knowledge grows every day and technology changes fast. This is why the value of publishing a report on the technological impact on cost only lies in giving a fixed picture at a certain moment in time, based on a specific expert vision.

The results presented in a report might get outdated quickly but this is where Delphos really enters into the game. Delphos offers methodology support so you can modify your assumptions and adapt them to what your own experience tells you.

**Q** In the report, "Future renewable energy costs: solar photovoltaics," the conclusion mentions that while purely technical improvements in polysilicon materials, manufacturing and efficiency enhancements are widely recognized as driving lower LCOE, other factors (though small) could significantly impact its success. One example was better PV plant output forecasting and the potential to significantly increase the value of PV electricity relative to overall power grid integration. Could you elaborate?

**A** As the PV installed capacity keeps growing, the penetration of PV electricity in our energy mixes will increase. This brings with it the challenges of integrating PV electricity into our power systems. Production forecasting is a key element of this as it provides reliable information to the power system and market operators. This allows them to manage grids and markets in the safest conditions and at the lowest cost. Another key element in this equation is energy storage that provides regulation capacity, even if it was not part of our study.

**Q** One aspect of PV energy production that will impact how well renewables integrate with legacy generation is storage. While on-site storage for self-consumption is becoming more affordable, it is still expensive. There are also the larger, grid-scale issues tied to storing power during peak generation phases, levelising needs, and so forth. How does the Delphos modeling tool look at storage issues?

**A** Currently Delphos does not look at storage, but KIC InnoEnergy is eager to extend the model into this area. With that in mind any serious players or researchers interested in the storage sector industry are welcome to join this initiative!

> Several initiatives are on track to jump from labs and pilot lines to industrial scale but the lack of coordinated support on issues like risk investment (both private and public) coupled with a lack of regulatory stability is preventing them from developing properly

**Q** Does the Delphos tool take into consideration technologies that are in their relative infancy now, such as perovskites? Since perovskites are rapidly evolving, how might developments here impact long-range projections for lower LCOE?

**A** Delphos focuses on commercially available technologies which with respect to PV, translates into mainstream technologies (crystalline silicone & thin film). "Commercially available" means that it is technically possible to use such technology in volume, and that they have been sufficiently prototyped and demonstrated to have a reasonable prospect of sale into a commercial scale project. Typically, perovskites and organic PV (for example) have not reached this stage yet.

**Q** Another point made in the report indicates that market confidence will need to remain high and relatively continual in order to keep capex investments sustainable in a market where it appears that average module selling prices (and margins) will fall over the next 15 years. Can you elaborate on the 'best' conditions the model points to for continued investment and expansion of PV energy capacity?

**A** Each country, each market has its specificities: regulation, solar resource, supply chain optimisation, and so on - which makes it difficult to generalise. In fact, local specificities were not taken into account in our report and, in our assumptions, we referred to global trends as detailed in international studies of reference. Having said that, the importance of long term vision and predictability should be highlighted as it allows to generate a virtuous cycle, notably:

A business case secured for investors, a predictable market, and sustained equipment sales, make investment in upgrading the production facilities more viable and allow for improvement in equipment (higher quality, lower price) all leading to an improved business case for investors. Europe is currently the PV knowledge and technology leader worldwide and home to several reference research institutions. But the lack of an industry to which this technology can be transferred in a commercial way is threatening our leadership. Several initiatives are on track to jump from labs and pilot lines to industrial scale but the lack of coordinated support on issues like risk investment (both private and public) coupled with a lack of regulatory stability is preventing them from developing properly.

**Q** The initial report points to the conclusion that, "… the current massively used conventional crystalline silicon technology is anticipated to be partly replaced in the future by different options such as high efficiency c-Si technology and also by thin film technology…." in part because these technologies are better suited to market requirements that are not as well met by existing tech. Are thin film and c-Si tech efficiencies going to have to improve greatly to achieve this, or will their ability to bring PV to areas that do not now have it drive adoption, or both?

**A** Efficiency is only one part of the equation and definitely not an objective per se from a business perspective. Efficiency improvement is obviously a target, but should always be balanced by the question: at what cost? Efficiencies are of course improving and those results are continuously being transferred to commercial products, which together with the improvement on costs, contribute positively to the reductions in the Levelised Cost of Energy that PV technology has experienced in the past years. In order to reach new markets in new geographical locations, the quality of the hardware is of course key, but other factors also enter into the equation. These include: i) the cost of financing, which can vary greatly according to "country risk" as defined by financing entities, ii) the structure of the supply chain and its degree of optimisation, iii) the connection costs to electricity grids.

**Q** What is the greatest benefit of the Delphos modeling tool? Can you explain how this will benefit manufacturers and investors looking for opportunities in the solar/photovoltaic market?

**A** Delphos' main benefit is that it provides a reference tool to structure the dialogue between PV innovators, OEMs, investors and public programmes. Some of them will use it to define their strategy, others to calculate impact, others to manage their portfolio. It will bring a unique opportunity to use the same fundamental information and methodology, what we call "speaking the same language".

**Q** Is there anything to add that we have not already covered?

**A** This document and the Delphos tool are part of a series of reports on the impact of innovation on the cost of renewable energies, including onshore and offshore wind, as well as solar-thermal electricity. Its objective is to position KIC InnoEnergy as a point of reference in innovation and in innovation impact evaluation. The latter is a new approach that is not widely implemented but can help in decision making at all levels.