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A PV MANAGEMENT MAGAZINE

Australia reviews renewable support

New government with changing agenda has industry on alert

AN ANGEL BUSINESS COMMUNICATIONS PUBLICATION

Issue III 2014
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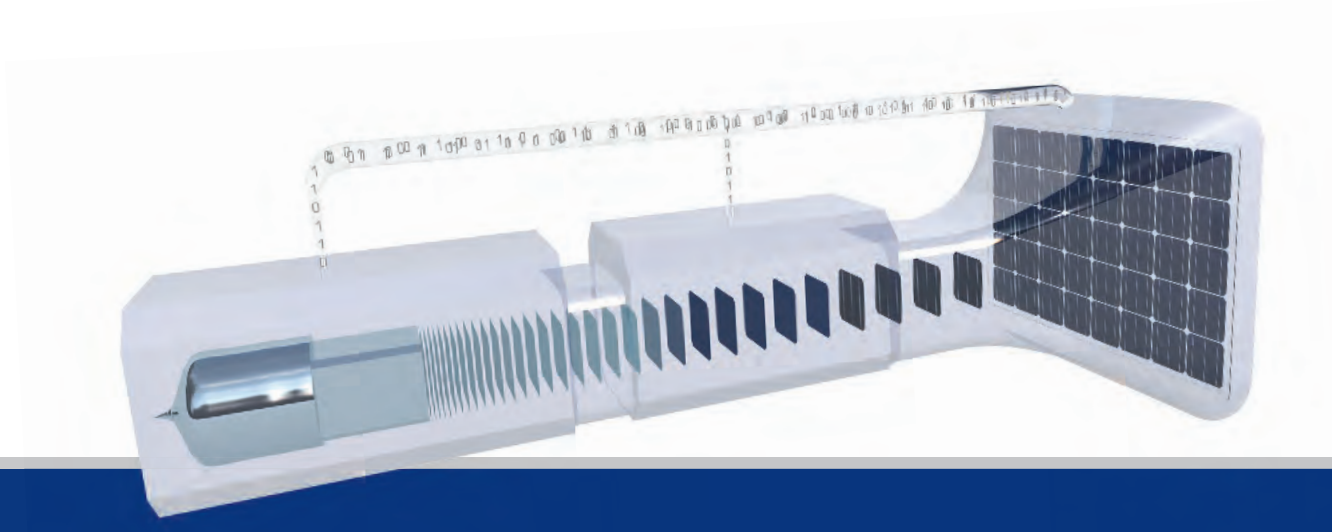

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editor's view

By david ridsdale, editor-in-chief

Solar cross road in spaghetti junction

IT NOW APPEARS EVIDENT that 2014 will be the year that the solar and PV industry returns to growth and addressed the industry oversupply that changed the geographical make-up of PV manufacturers and international solar markets. The impetus has now moved to Asia in both manufacturing and market share. Despite the joy at financial improvements at the top end of the chain, this is not the crossroad that the PV industry currently faces. The financial changes are no more than a cyclical market that will require continual management. A greater change is that the political will that kick started the industry is waning, leading to changing subsidy support and even retrospective changes as governments take stock of the cost of tariff promises when uptake exceeds expectations.

The crossroad the industry finds itself at does not appear as a simple meeting of two roads where a bargains may be struck. This crossroad is a spaghetti junction of external factors and internal choices that sometimes makes it hard to see beyond the need to just stay on the road. Global energy needs are one of the major external factors that often has more impact on the PV industry than can be obviously seen.

There is plenty of speculation in the media about why big energy companies missed the renewable boat and how no-one expected the success of renewables, especially solar. While still only providing a fraction of energy needs, PV technologies have grown at a faster rate than all other energy producing technologies. The subsequent rush to be a part of this growing bonanza led to the recent oversupply that has shaken the industry. The big energy companies did not ignore renewables. In fact most of them had solar programmes in the 1970s through to the 1990s but eventually pulled out as they could not see how to bring the technology to scale.

The German example eventually encouraged other countries to provide support to renewable technology as energy became a greater global issue. The level of growth in Europe was amazing but the cracks were quick to show as Spain developed financial problems keeping up with their promises. Despite this the growth continued around the world and suddenly the industry was bigger than most expected. The big energy companies are interested now and their lobbying power at the top of government also impacts along the energy chain

With so many competing technologies and vested interests in the energy arena the way forward seems complex and confusing. All of this impacts on government policies right along the departmental chain. The growing cost of energy acts as an spur for government action but in tighter times the quicker and cheaper alternative will be pursued unless strong arguments are presented to the alternative. All this leaves the solar and PV industry with a reliance on government support but wanting to be treated as an autonomous industry. The simple crossroad in the spaghetti junction for solar is moving to an industry that does not need subsidies to survive anywhere in the world.

Sometimes the answers are obvious and it's the questions that appear complex.

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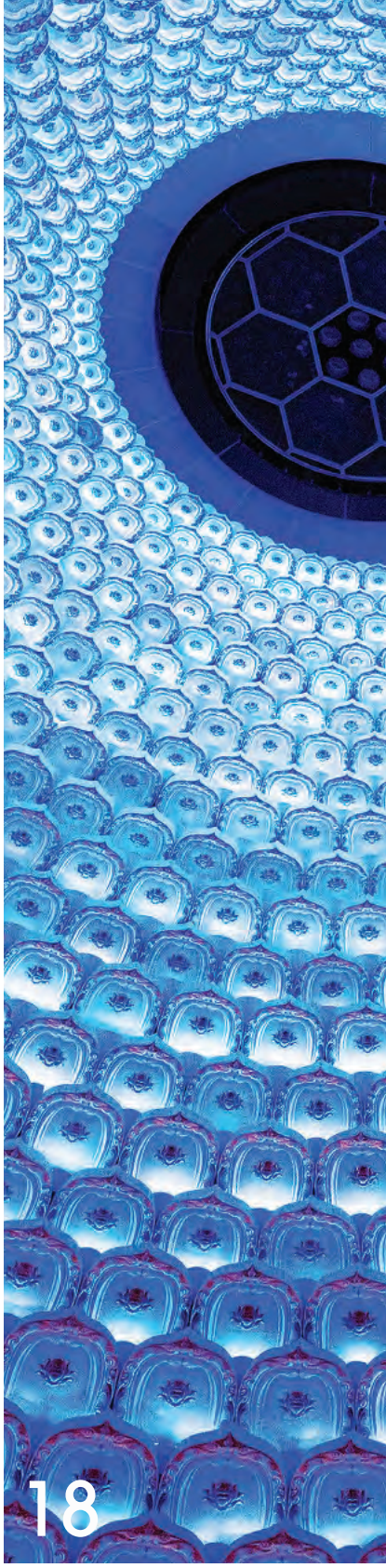
what's inside



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China dominates module statistics with 90.4% output

AFTER PROVING itself as the global solar module production leader in 2013, the Asia-Pacific (APAC) region will continue to hold this position in 2014 with a massive 90.4% of the world's module production, says research and consulting firm GlobalData.

According to Ankit Mathur, GlobalData's Project Manager for Alternative Energy, China led both the demand and supply sides of the global solar photovoltaic (PV) market in 2013, claiming a significant 65% slice. This contrasts highly with the US and Europe, which claimed respective market shares of just 2% and 3%.

Mathur says, "Significant and ongoing growth in solar PV market demand is powering the increase in global module production, which we expect to rise from 40,806 megawatts (MW) in 2013 to 45,170MW this year.

"China will account for a significant 30,000MW of this production in 2014, while Japan and South Korea will follow with 3,700MW and 2,400MW, respectively."

China and Japan have predominantly been known as the hubs for module manufacturing, and the switch in PV demand from Europe to APAC has also resulted in the latter region occupying a giant share of the global crystalline module production market last year. Mathur continues, "China enjoyed a landslide victory in terms of crystalline module production in 2013, after it won a significant 70.4% of the global market.

"The announcement of anti-dumping duties on Chinese module manufacturers, which export solar modules to European markets, has diverted their focus away from exports to increasing sales activities in their own fast-growing domestic market."

The huge rise in solar PV market demand has also reduced global production overcapacity from 151% in 2009 to 62% in 2013, says GlobalData. With this demand expected to grow further in the future, many module manufacturers plan to boost their production capacity in 2014, which will see overcapacity increase again to an estimated 78%.

Australia starts anti dumping case against China

AUSTRALIA'S anti-dumping commission announced on May 14th that they will conduct an anti-dumping investigation on finished and semi-finished Chinese PV module imports. The commission will be investigating whether there are dumping issues for PV modules shipped from China to Australia between July 1, 2012 to December 31, 2013.

In 2013, Australia's PV market capacity was 1GW. Meanwhile, Chinese PV imports to Australia were around 700MW, representing 70% of total module demand in Australia, according to EnergyTrend, a research division of TrendForce. In 2014, Australia's PV capacity is to reach approximately 1.2GW.

The Australian government has gradually cancelled their subsidy plans because they have reached installation target for rooftop systems. In the future, rooftop market growth will have to be stimulated by new business models, such as solar leasing, etc.. On the other hand, Australia has activated Solar Flagships program to stimulate the growth of utility-scale power plant markets.

Here are some of the possible impacts based on analysis by Arthur Hsu, research manager of EnergyTrend.

1. Chinese modules currently account for 70% of total module demand in Australia. Hence, it will challenge local Australian EPC manufacturers' and system investors' costs once the case is established. Australian manufacturers will start to look for alternative solutions and may turn to Japan, Korea, and Taiwan for more options.

2. Although Australia's PV market size is relatively small, the chance for Chinese manufacturers to give up on Australia is slim as Australia remains one of the top-ten export markets for China. In order to avoid the anti-dumping investigation, Chinese manufacturers may outsource to Taiwanese manufacturers for OEM and shipment, benefitting Taiwanese module manufacturers.

TrendForce believes that it will require negotiations and compromises before the final result for Australia's anti-dumping investigation can be determined. It may become a common situation for Chinese manufacturers to deal with anti-dumping and anti-subsidy issues. As such, Taiwanese manufacturers will play an important role within global PV supply and demand in the future. It remains essential for Taiwanese manufacturers to think about avoiding the same thing happen to them while expanding market opportunities.

DuPont slow down impacts silicon thin film market

DUPONT has announced the termination of their silicon thin-film operations by the end of 2014 with a gradual shut down of the silicon thin-film production lines at their subsidiary company.

"Judging from recent price quotes, silicon thin-film price quotes is at US$0.58/watt while silicon module is at US$0.6/watt. Price difference has decreased from the original US$0.1/watt to US$0.02/watt. Therefore, silicon thin-film product no longer holds price competitiveness," said Arthur Hsu, research manager of EnergyTrend. "Meanwhile, silicon module conversion efficiency is around 17.2% while silicon thin-film remains at 8% to 10%. Efficiency gap between the two will continue to increase as silicon module efficiency goes up."

Another reason for the closing of thin-film operations is the slowing of new technology development by equipment manufacturers. In fact, manufacturers were hoping to rely on Tandem technology's commercialization to improve silicon thin-film product efficiency.

However, after acquiring Oerlikon's thin-film business, Tokyo Electron has ended Tandem development, which crushed thin-film manufacturers' final hope.

Polysilicon price slightly dropped 0.13% to US$20.324/kg. Multi-si wafer continued to fall slightly. This recent price arrived at US$1.004/piece, which is a 0.4% dip. Impacted by DuPont's closing of their silicon thin-film production lines, that week's thin-film price decreased below US$0.6/watt to US$0.597/watt, dropping by 1.32%. The prices for other products remained unchanged that week.

Egypt to invest $1 billion into solar

THE EGYPTIAN GOVERNMENT has revealed its plan to invest $1 billion in solar energy projects. During a conference organised by the Chambers of Commerce in Alexandria, the Local and Administrative Development Minister Adel Labib revealed the plan, stating that the solar projects would help create job opportunities for young people in the country, as well as reduce stress on the country's electricity grid.

The country's commitment to go solar is echoed by a recent protocol entered between the government, the New Urban Communities Authority and the Information and Decision Support Centre. Under the agreement, PV arrays will be installed on government buildings to help generate power for lightering and increase the capacity of the electricity network. In February, the former electricity minister Ahmed Emam disclosed the government's target to generate 20% of the country's energy from renewable energy resources by 2020. It is envisaged that 12% of the energy will be created by wind power by that time, and the remaining 8% will be produced by other renewable energy sources.

Other solar projects in Egypt include a solar power in the El Fayoum Governorate's Wadi Al-Rayan wildlife reserve funded by a $500,000 grant from Italy, and a solar PV production line following a contract between Egypt's Arab Renewable Energy Company (ARECO) and Disctech FZCO, an affiliate of Z-One Holding of the United Arab Emirates. The production line is expected to commence in September with an initial capacity of 21MW and reach an annual capacity of 80MW by 2016.

Top module suppliers tipping growth in 2014

THE TOP 20 module suppliers to the solar photovoltaic (PV) industry are guiding an increase in annual shipments of more than 30 percent in 2014, according to the latest NPD Solarbuzz Module Tracker Quarterly report. Leading Chinese module suppliers Trina Solar, Canadian Solar, ReneSola and Jinko Solar are forecasting the most aggressive growth in shipments during 2014, with the upper-end of guidance exceeding 40 percent.

"The top-20 module suppliers to the PV industry account for two-thirds of global shipments, and they provide the leading indicators of industry growth and pricing trends," noted Ray Lian, senior analyst at NPD Solarbuzz. "Assuming the leading suppliers achieve the forecasted growth rates, end-market demand in 2014 will approach 50 gigawatts."

Yingli Green Energy is forecasting the highest shipment volume in 2014, with the upper end of shipments at 4.2 gigawatts (GW). This shipment level would result in Yingli Green Energy heading the annual shipment rankings for PV suppliers for the third consecutive year.

Leading Japanese silicon-based PV module suppliers, Sharp Solar and Kyocera, are forecasting a 15 percent increase in shipments in 2014, reflecting continued strength in the Japanese solar PV market. Sharp Solar and Kyocera command strong market shares, within their markets.

"In addition to benefiting from strong shipment growth in 2014, the top 20 module suppliers are also forecast to increase profit margins," added Lian. "Growth is driven mainly by cost reductions in manufacturing, and lower capital expenditure on new manufacturing plants."

First Solar will only spend a year as top EPC provider

U.S.-BASED FIRST SOLAR delivered on expectations in 2013 to become the leading Engineering, Procurement and Construction (EPC) company in the global photovoltaic (PV) industry, even though it is likely to be surpassed in 2014 by Chinese EPC TBEA SunOasis, according to a new report from IHS Technology.

Global PV Ranking in 2013 of System Integrators, by Installed Capacity

Company	Megawatts		
	2012	2013	2012-13 Change
First Solar	516	1,113	597
TBEA Sun Oasis	250	1,000	750
GD Solar	470	715	245
Shanghai Solar Energy Co., Ltd.	192	550	359
SunEdison	389	505	116

Source: IHS Technology, May 2014

First Solar installed a total of 1.1 gigawatts of solar capacity last year, up from 516 megawatts (MW). In comparison, runner-up TBEA SunOasis installed 1.0GW, up from 250MW, as shown in the attached table. But with SunOasis projected to attain1.5GW of installations this year compared to First Solar's 1.3GW, TBEA SunOasis has the potential to sail to the top among global PV integrators.

These findings are contained in the report, "IHS PV EPC and Project Market Tracker," from the Power & Energy service of IHS.

"After a strong year of installing 22 percent of the non-residential PV capacity in the U.S. and Canada, First Solar remains focused on North America," said Josefin Berg, senior analyst for solar demand at IHS. "Large-scale projects in the U.S. will make up around 93 percent of the 1.3GW worth of additions in 2014."

These projects, Berg said, were acquired in early-stage development and are now being constructed and sold primarily under U.S. investment tax-credit policies. To mitigate the risks that arise from dependence on one market, First Solar is building up a global project pipeline through acquisitions and joint ventures, with the company now also claiming 1GW pipelines each in Latin America and the Middle East.

"After 2015, depending on the evolution of solar support in the United States, First Solar risks slower growth in PV system integration," Berg noted. "And while the development pipeline in emerging countries has given the company a good start, it will be much more challenging to pursue than home-based projects in the U.S."

Meanwhile, TBEA SunOasis is thriving on China's rapidly growing domestic market, and its installations of 1.0GW in 2013 accounted for 10 percent of that country's non-residential PV additions. This year, the power equipment manufacturing group will continue growing its PV systems business, with expected additions to reach as high as 1.5GW. While focusing on utility-scale opportunities in China, TBEA is also involved in power projects in markets such as Pakistan, where it is undertaking the construction of a 100MW PV plant in 2014 and 2015.

"TBEA's global reach as a power equipment provider opens up possibilities for EPC contracts in new PV markets," Berg remarked. "But because the Chinese domestic market will grow by 31 percent this year, TBEA is also set to keep its systems business growth focused on China."

"It is obvious that a large chunk of these pipeline projects will never be built," Berg said. "Developers have to compete for PPAs, grid access, permits, and not least—financing. What is important, however, is that IHS can spot those countries where PV deployment can take off quickly given the right conditions."

With 34GW of announced projects in planning and 5GW under construction, North America boasts the largest PV pipeline. This is due to both the large number of projects involved and the size of the projects proposed. The average size of the projects in the database equates to more than 25MW, with over 80 projects that are 100MW or larger in development.

Latin America, meanwhile, has the largest pipeline of PV projects in comparison to its installed capacity, with nearly 15GW of projects in development. This includes a pipeline of more than 4GW in Brazil and 7.5GW in Chile.

UK government announces large scale solar review

AS EXPECTED the Department of Energy & Climate Change (DECC) announced proposed changes to the array of subsidies and policies for renewable energy in the UK. The thrust of the proposed changes for the solar industry are to reduce support for large scale ground mounted solar arrays in favour of roof tops. This is in line with government discussions over the last few months and is not the terrible event for the solar industry that some sectors of the industry and media are trying to make out.

The DECC announcement states the changes include splitting the current 'degression band' for projects over 50kW under the Feed In Tariffs scheme (FITs) into two: one for standalone, one for non-standalone. In other words, tariffs for building-mounted solar panels would reduce at a slower rate than for ground-mounted solar panels, so giving rooftop-mounted schemes access to more of the financial support available through FITs.

Since 2010 the UK's renewable electricity capacity has doubled; in the same period, over £34 billion of private sector investment has been announced, with the potential to support almost 37,000 jobs. What's more, the scale of growth in the sector has meant that the cost of some renewable technologies, such as onshore wind and solar power, has fallen.

Solar PV is an important part of the UK's energy mix: there is currently 2.7GW of PV capacity in the UK – enough to power 620,000 homes – placing the UK firmly in the global top 10 economies for solar power. This progress is expected to continue, up to a projected deployment of between 10-12GW by 2020.

DECC published the Solar Strategy only a month ago setting out the actions that UK government is taking in partnership with industry to ensure that the solar sector continues to grow. It included a focus on deploying more solar panels on the top of industrial and public sector buildings – a part of the sector that had been deploying at lower levels than we expected. The Solar Strategy highlighted that government was considering the implications of current deployment trends on the budget available for financial incentives to solar PV under the Renewables Obligation (RO) and would consult on any proposals for amendment. Large-scale solar is deploying faster than expected. Industry projections indicate that, by 2017, there could be more solar deployed than is affordable – more than the 2.4-4GW set out in the electricity market reform (EMR) delivery plan.

The changes are occurring as the government manages expectations from the support programmes. With such fast growth comes greater costs than expected. Another part under review is a proposal to close the RO to new solar PV capacity above 5MW from 1st April 2015, across England, Wales and Scotland. Those proposals include grace period arrangements to protect developers who have already made significant financial commitments.

The intention is to keep the RO open for projects under 5MW which are not eligible for the new Contracts for Difference (CfDs). Projects above 5MW will be able to apply for CfDs – part of our world-leading Electricity Market Reform Programme that is marking further progress in its publications.

There will also be a review of community benefits from ownership of renewables projects. The possiblity of increasing the maximum capacity for community anaerobic digestion, hydro onshore wind and solar PV projects from 5MW to 10MW under the FITs scheme is on the table. Also whether more can be done to allow grants to be combined with FITs payments for community projects up to 5MW. This delivers on two commitments in the Community Energy Strategy – published earlier this year.

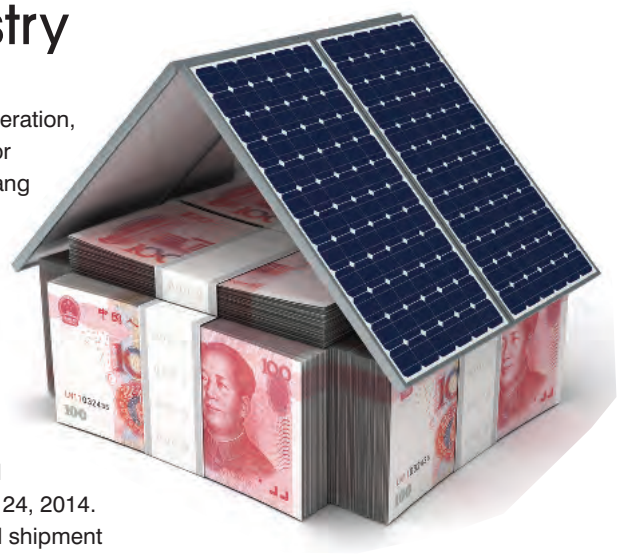
Robert Goss, MD Conergy UK (who participated on DECC's Solar Strategy taskforce), had a more reasoned response to the proposals than some industry watchers and said, "Let's wait on the results of the consultation, but DECC's proposals are more of a gradual recalibration than an earthquake for British solar. Rather than disappearing overnight, we'd just select projects in different ways.

Many large solar farms would continue to be built under the CfDs but the trend towards smaller sites, which are politically more attractive, offers encouragement for projects that have been neglected in recent months.

The wider trend towards on-site power generation and consumption, which is Europe-wide and technology-specific, will take place with or without government intervention.

There are hundreds of thousands of acres of roofs that currently go unused in Britain, on office buildings, factories, warehouses and hospitals, and where the opportunities are huge for solar to cut customers' energy bills, and to reduce demands on the grid."

Tone set for Chinese PV industry



ENERGYTREND hosted a PV forum in conjunction with SNEC in Shanghai and offered in-depth analyses on the Chinese covering important issues within PV and energy-storage industries. A key topic was distributed PV and how it will become an important future demand source for the Chinese market and how will affect global supply chain development.

The forum heard that global PV installation continues to increase in 2014. Aside from large demands from utility-scale power plants and residential systems; expanding distributed PV systems, ranging from several thousand to a couple million watts, have become an focus that is leading and motivating the foreign solar market.

"Global PV demand is 46.6GW in 2014, in which, Chinese market has the fastest growth. In just two years, China's demand increased from 1GW to more than 10GW to becoming the largest PV market in the world," said Jason Huang, research manager of EnergyTrend.

China is devoted to the development of distributed PV systems mainly to use solar power more efficiently. Solar plant power capacity in 18 pilot projects installed in 2013 amounted to 749MW and is expected to soar 243% to 1823MW in 2015. Although, China is still exploring promotion, construction, operation, and investment strategies for distributed PV systems, Huang noted distributed PV is still an important future demand source for the Chinese market.

The recent demand spike is due to the postponement of the US-China anti-dumping and countervailing ruling to July 24, 2014. In addition, China increased shipment demands, while Japan's shipments remained high, the Europe's economy also recovered. Based on the uptrend of manufacturers' monthly revenues, wafer prices should be stable in 2Q14.

"High-efficiency wafer price will remain at above US$ 1.0/piece in 2Q14, while mono-si wafer price, with relatively stable supply and demand, will fall between US$1.2-1.25/piece," said Arthur Hsu, research manager of EnergyTrend.

Looking to the future, new capacities of polysilicon and module will enter mass production stage in 2H14. In addition, various relevant policies will become clearer including the US-China anti-dumping and countervailing results, which might trigger polysilicon oversupply. As countries continue to promote energy policies related to sustainable development, energy-storage market demand has increased.

Japan began issuing residential energy-storage system subsidies in 2011. It was the first sign of energy-storage systems entering the residential market, rather than for emergency industrial power. Later in 2014, Japan introduced another plan to raise energy-storage system subsidies by 60%. On the other hand, Germany's electricity retail price is now higher than FiT leading to rising demand for autonomous energy-storage systems. The subsidy for energy-storage systems represented 30% of overall subsidies in 2013. A battery with solar power capacity of 30kW the battery subsidy would approximately amount to EUR 600 /kW.

Yingli Solar announces trial of metal wrap through module

YINGLI SOLAR has announced that it has begun trial production of monocrystalline silicon modules with N-type Metal-Wrap-Through ("N-MWT") technology, by adopting equipment provided by Formula E s.r.l. (Formula E), a supplier of photovoltaic technology and automated manufacturing lines.

As part of the companies' strategic collaboration agreement, Formula E designed and produced manufacturing equipment for back contact applications in the production of N-MWT modules. The equipment has been installed in one of Yingli Green Energy's module workshops, and production trials are currently on-going. The N-MWT technology can reduce power loss in the module encapsulation process and improve cell efficiency by reducing the amount of metal applied to each solar cell, which exposes more of the solar cell's surface area to sunlight than with traditional monocrystalline technologies.

"The Formula E team worked tirelessly to put in place a pilot production line that enables the automated manufacturing of different module architectures, delivering unprecedented reliability, accuracy and precision in the manufacturing ofMWT modules. Our collaboration with Yingli Solar is definitely strategic for our growth. We believe a new age for PV industry is now open and promises very appealing results for end users," commented Davide Spotti, the president of Formula E.

"We believe that cost reduction and technology improvement are critical to achieving our mission," said Cindy Hu, Vice President & Technical Director of Yingli Green Energy. "These innovations inMWT technology are the result of our team's strong partnership with Formula E. We look forward to further optimizing our manufacturing processes through joint efforts with PV equipment manufacturers, including Formula E."

European market to stabalise at 10GW after slowing demand

SOLAR PHOTOVOLTAIC (PV) demand from Europe is forecast to reach 10 gigawatts (GW) during 2014, representing an annual decline of 7 percent compared to 2013, according to the NPD Solarbuzz European PV Markets Quarterly report. This will be the third consecutive year that European solar PV demand has declined, after reaching a peak of 19.2GW in 2011. During this period, Europe's contribution to global PV demand has fallen rapidly from 70 percent in 2011 to just 22 percent in 2014.

Germany, Italy, and Greece accounted for 71 percent of European demand in 2012, but these countries now provide just 37 percent of the European market. "The decline in PV demand from Europe in 2014 is due mainly to the effects of major funding reductions in Germany, Italy, Greece, and Romania" said Susanne von Aichberger, analyst at NPD Solarbuzz. "In fact, for Europe to reach 10 gigawatts of demand in 2014, the United Kingdom would need to meet expectations of doubling in size."

During the first quarter (Q1) of 2014, European PV demand grew 10 percent compared to the fourth quarter (Q4) of 2013, but declined by 8 percent compared to Q1 2013. "Historically, the first quarter has represented a weak period in Europe, but planned reductions in the U.K.'s incentive rates in April 2014 boosted final Q1 figures," Aichberger said.

The U.K. accounted for 43 percent of European demand in Q1 2014, its highest quarterly share yet; however, in the past few weeks, the U.K. market has been struck by new policy uncertainty that is likely to have an immediate effect on demand from the U.K and Europe. "2014 PV demand is expected to grow in France, the Netherlands, Austria, Portugal, and Switzerland, and Turkey is forecast to become a significant PV market this year," noted von Aichberger. "Belgium, Denmark, Romania and Ukraine, however, are forecast to experience annual declines."

During 2014, Europe's most mature PV markets (Germany, Italy, and France) will transition away from feed-in-tariff (FIT) incentives, which were widely adopted within Europe to stimulate initial PV market adoption. The new driver for PV growth in Europe is coming directly from the energy markets in each country, where PV is now competing with other forms of traditional and renewable energies. This increased competition is creating new PV opportunities, but requires overcoming regulatory and funding challenges.

"Within Europe's established PV countries, policy makers in Italy have taken the most radical steps to transition away from FITs. The Conto Energia funding scheme was discontinued in July 2013, with the final projects completed in May 2014," added von Aichberger, "In the future, demand will be driven by installations based on net-metering, power purchase agreements (PPAs), direct marketing, and tax benefits."

Japan's growth pushes sharp back to top

SHARP SOLAR returned to the top of the solar photovoltaic (PV) module shipment rankings during the first quarter (Q1) 2014, after a five year absence, according to findings in the latest NPD Solarbuzz Module Tracker Quarterly report. Sharp was the solar PV industry market leader for 45 years between 1963 and 2008, before manufacturing capacity was scaled up in China. Between 2009 and 2014, First Solar and Chinese-based solar PV suppliers dominated the top rankings within the industry.

"The first quarter this year was the first time a non-Chinese module supplier has taken the leading position in the solar PV industry, since the fourth quarter of 2009," according to Ray Lian, senior analyst at NPD Solarbuzz added. "Sharp Solar benefited from strong end-market demand in Japan, and the ability to increase shipment volumes through a flexible strategy of using outsourced supply from China and Taiwan."

During its previous reign as the industry's leading PV module supplier, Sharp pursued a vertically integrated strategy, manufacturing its own solar cells and modules; however, during the past few years, Sharp has shifted its emphasis to selling modules manufactured by outsourced partners.

"Sharp's success during in the first quarter of this year confirms the value of brand-recognition within the PV industry," Lian said. "It also shows the viability of the so-called 'fab-lite' model, in which either internal manufacturing capacity or outsourced supply can be managed effectively to address short-term opportunities. The fab-lite model is now used by several of the leading vertically-integrated companies in the PV industry."

EPIA outlines Europe success at Intersolar

THE EUROPEAN PHOTOVOLTAIC INDUSTRY ASSOCIATION (EPIA) released a new report entitled "Global Market Outlook for Photovoltaics 2014-2018".

Compared to the two previous years, where global installed capacity hovered slightly above 30GW annually, the PV market progressed remarkably in 2013, reaching a new record-level.

Nevertheless, for the first time since 2003, Europe, with a very high and stable level of nearly 11GW connected to the grid in 2013, lost its leadership to Asia. PV markets have become global!

EPIA's major findings for 2013 include that at least 38.4GW of PV systems were installed globally in 2013, up from 30GW in 2012. Almost 11GW of PV capacity were installed in Europe in 2013, compared to 17.7GW in 2012. China (11.8GW) was the top market in 2013, followed by Japan (6.9GW) and the USA (4.8GW). Germany was the top European market with 3.3GW. Several other European markets exceeded the oneGW mark: the UK (1.5GW), Italy (1.4GW), Romania (1.1GW) and Greece (1.04GW). PV now covers 3% of the electricity demand and 6% of the peak electricity demand in Europe

Several European markets that performed well in the past went down in 2013: Belgium (215MW), France (613MW) and Denmark (200MW). Outside Europe, several markets continued to grow at a reasonable pace, including India (1,115MW), Korea (442MW), Thailand (317MW) and Canada (444MW)

EPIA forecasts indicate that the globalisation trend of PV markets observed in 2013 will continue and further accentuate in the coming years.

"The forecast for Europe in the next years should, however, be put into perspective and be considered as a stabilisation towards a solid level, around 10GW a year," stated Oliver Schäfer, EPIA President, during the launch of the report at the Intersolar Europe Opening Session. "Europe's situation at the end of last year shows that PV, as any other energy business, remains policy-driven.

A series of retrospective measures were implemented in the last years in various European countries, leading to the sharp market decrease observed in 2013. Sustainable, predictable and dynamic framework conditions and policies are needed in Europe and globally to provide enough visibility to investors."

For the third year in a row, PV in 2013 was amongst the two most installed sources of electricity in the EU. "PV is becoming a major part of the electricity system all over the globe, changing the way our world is powered.

Policymakers and energy stakeholders should now understand that electricity grids and markets need to be adapted to fit these new realities and facilitate a cost-efficient energy transition," concluded Mr. Schäfer.

Global solar heads for record quarter results

GLOBAL PHOTOVOLTAIC (PV) installations will reach 15GW in the final quarter of 2014, beating the previous record of 12.7GW in Q4'13 according to latest analysis from IHS. The second half of 2014 will see a surge in global PV demand driven by incentive policy changes in several key markets as well as the ramping of installations triggered by record low system prices.

Despite high demand in the UK and Japan in Q1, globally, installations have been slower than some anticipated, with a 17% decline versus the final quarter of 2013. This seasonal slowdown was reflected in decline in shipments of most PV manufacturers, compounded by the fact that most of the UK and Japan's Q1 installations were served by components shipped at the end of 2013 to beat the March 31 deadline. Japan and UK accounted for 42 % of global installations in Q1.

Yet despite this slow start to 2014, IHS has reiterated its forecast of 46GW of installations this year, due to a surge in demand that it predicts for the second half of 2014, based on a quarterly review of PV installations in more than 100 countries conducted by the IHS PV Demand Market Tracker.

The analysis predicts installations of just under 15GW in the final quarter of this year – a new record for the industry and a remarkable achievement. Large-scale projects will be the main driver of this, with nearly 9GW ofMW-scale systems occurring.

China has set very aggressive targets for solar deployment in 2014 and also recently increased its long-term ambitions targeting 70GW of installations by the end of 2017. Despite this, its recent push to move the country away from huge utility-scale systems, to distributed PV has caused concern and uncertainty.

Industry players have rightly become concerned about China's ability to install 8GW of distributed PV in a single year,

given the lack of channel infrastructure, financing conditions and issues over roof ownership rights. IHS previously predicted this 8GW was unachievable and instead expect around 4-5GW to be installed. We do however expect new policy to be imminently released by the NDRC, as early as July to help speed development of this market segment and most importantly ease bottlenecks in financing.

Assuming new policy will be announced in Q3, IHS predicts China's PV installations to amount to 13.1GW in 2014, with more than 70% of this happening in the last six months of the year.

Whilst China will undoubtedly remain the world's largest PV market in 2014, a more surprising change in the top markets is that the UK will leapfrog Germany. This is due to policy changes in both countries.

The cuts to Germany's feed-in tariff, coupled with the minimum import price of Chinese PV modules has weakened demand considerably and less than 2.5GW will be installed there this year, we predict. On the other hand, the UK's recent announcement that it would review entitlement of large-scale solar's access to the ROC scheme two years earlier than expected will create a rush to complete several gigawatts of ground-mount projects before April 2015. Although much of this will be completed in Q1'15, developers will likely push ahead and aim to complete projects earlier in 2014.

USA in milestone as non-hydro renewable out produces hydro

ACCORDING to the latest statistics and for the first time, during the first quarter of 2014, electricity generated by non-hydro renewables (i.e., biomass, geothermal, solar, wind) exceeded that provided by conventional hydropower. This is according to data from the U.S. Energy Information Administration's (EIA) "Electric Power Monthly,").

Non-hydro renewables provided 53.16% of the net U.S. electrical generation from renewable energy sources for the period January 1 - March 31, 2014 while hydropower provided the balance of 46.84%. This reflects an increase of 11.3% in electrical generation by non-hydro renewables compared to the first quarter to 2013 as well as a decline of 4.5% in hydropower's output. Electrical generation from solar PV and solar thermal grew by 103.8% while wind expanded by12.6%; biomass also increased - by 2.2%, but geothermal dipped by 3.3%.

Electrical generation from all renewable energy sources combined, including hydropower, was 3.29% higher during the first quarter of 2014 compared to the first three months of 2013 and accounted for 13.09% of net U.S. electrical generation. Hydropower accounted for 6.13% of net U.S. electrical generation for the period, followed by wind (4.82%), biomass (1.46%), geothermal (0.39%), and solar (0.29%).

"For more than a decade, renewable energy sources - led by wind and solar - have been rapidly expanding their share of the nation's electrical generation," said Ken Bossong, Executive Director of the SUN DAY Campaign. "Recent data affirm that the trend is continuing unabated."

SMA And Danfoss sign agreement to form converter alliance

SMA SOLAR AND DANFOSS have signed a contract to enter into a close strategic partnership. With this agreement, the goal is to sustainably strengthen their cost positions through economies of scale and through joint development initiatives. According to the plans announced in February, Danfoss will acquire 20% of SMA's outstanding shares and sell its entire solar inverter business to SMA. The necessary approval by the antitrust authorities has already been granted.

"Danfoss is successful in the field of automated drives. This market has been characterized by fierce competition for many years. Danfoss has focused its strategy on continuous cost reduction by using global procurement opportunities and technological innovations.

We will benefit from this experience and from economies of scale, thereby strengthening our leading position in the global photovoltaic market. We will accelerate innovation cycles through collaborative efforts in development and systematically reduce our product costs," explained SMA Chief Executive Officer Pierre-Pascal Urbon.

In addition, by taking over Danfoss's PV inverter business SMA will be able to serve the high-growth market segment of medium-sized PV systems in Europe, the U.S. and Asia even better.

"This strategic partnership is economically attractive to both companies. Together with SMA, we will form one of the world's largest inverter alliances. In the coming years, Danfoss will certainly benefit from the pooled purchasing power and the high growth rates of the solar industry.

The procurement synergies are expected to save both companies double-digit millions of euros annually starting in 2015. Furthermore, with our 20% stake in SMA we want to continue our involvement in the solar sector and participate in the mid- and long-term positive growth potential in that sector," said Niels B. Christiansen, President and CEO of Danfoss. Urbon

and Christiansen emphasize that they will implement the cooperation just as swiftly as the prior negotiations. This will be evident at the world's largest solar trade show, Intersolar Europe, on June 4-6, 2014, in Munich. SMA will present the MLX inverter (now Sunny Tripower 60000 TL), developed by Danfoss for medium-sized PV systems, at their booth.

The system optimally enhances the SMA product portfolio. In addition, SMA and Danfoss employees will answer questions on products and services together at the companies' exhibition booths. SMA will take on responsibility for full service for all installed Danfoss inverters.

As part of the cooperation, Danfoss acquires 6.94 million of SMA Solar Technology AG shares at a price of €43.57 per share from the SMA founders, their trusts and families. The cash consideration corresponds to a premium of 21% based on the volume-weighted average share price over the last 60 days before the cutoff date of 27 May, 2014. The transaction volume amounts to €302.38 million. After the transaction's completion the freely tradable free float of SMA shares will be at 25.05%.

The SMA founders, their trusts and families will hold 54.95% of SMA shares after the transaction is completed. Danfoss will not buy or sell any further SMA shares for a lock-up period of at least two years.

SunEdison launches module with PERC technology

THE SUNEDISON Silvantis R-series increases solar module efficiency via Passivated Emitter and Rear Cell (PERC) technology, for higher power output and maximum durability.

"PERC technology delivers more than 10 extra watts of power per module," said Dave Ranhoff, President of Solar Materials at SunEdison. "The R-series modules capture the maximum amount of energy in a given area and deliver better solar system economics."

The new modules also go well beyond the industry standard for potential induced degradation (PID) resistance.

The SunEdison Silvantis R-series is warranted for operation with high efficiency transformerless inverters and has been thoroughly tested beyond standard PID certification conditions.

Ranhoff stated: "The majority of the solar modules we manufacture are used in SunEdison-owned systems—the success of these projects depends upon the performance of the solar module. The new R-series modules are built to deliver outstanding performance and durability through the 25-year or more life of a solar system."

Trina Solar supplies 1MW to Africa's largest rooftop

TRINA SOLAR has played a role in the creation of Africa's largest industrial grid-tied solar plant. The roof-mounted system was assigned by Belgotex Floorcoverings at their PietermaritzburgkWaZulu Natal-based manufacturing facility, and the project was developed by Sustainable Power Solutions.

Trina Solar was selected as sole supplier of over 4000 245W PV modules, for the complete installation of the 1 megawatt, 100 000 m² rooftop project. Belgotex Floorcoverings undertook the project as part of their Africa strategy to offset their carbon emissions by 5%. The daily solar energy now generated to power the facility is the equivalent to the power used by an estimated 700 average households. For this project, Sustainable Power Solutions needed to partner with a tier-1 PV supplier with a strong global supply network as well as an established local footprint.

"As one of the largest manufacturers of solar modules in the world, Trina Solar was well placed to deliver the required panels on time. This, combined with the excellent efficiency, performance, and

quality standards of our panels - as well as offering a wide range of solutions and services - meant that were the ideal partner for the project," says Ben Hill, Head of Europe and Africa for Trina Solar. As in any newly established industry, it is companies such as Belgotex that lead the way for others.

"The fact that Belgotex chose to use PV technology, a relatively new concept in South African renewable energies, was a bold step," Hill continues. "This project was instrumental in demonstrating PV's potential to other local companies seeking power solutions that not only reduce costs, but also minimize electricity consumption and an organization's carbon footprint. This was illustrated by the fact that Belgotex's PV installation project has successfully resulted in the reduction of 1,386 tons from the company's carbon emissions each year, as a result of their move away from coal produced electricity."

Hill advises corporations to choose their partners wisely when undertaking significant energy projects. "On any large scale project such as this one which will operate for 20 years, where major commercial companies and finance institutions are involved, it is a vital requirement that you work with tier-one, financially stable partners who can, without any doubt, see a project through from initiation to completion.

This is also significant on an on-going basis where aspects such as future projects, support and warranties need to be taken into consideration. It is crucial that you are confident that you will receive the same level of service throughout any project as well as further down the line," Hill concludes.

Two large solar energy plants opened in South Africa

SOLARRESERVE has announced that two 75-megawatt solar photovoltaic (PV) projects have completed construction and are fully operational and successfully helping to power the Eskom South African electric grid with renewable energy. The Lesedi and Letsatsi Projects, totaling 150MW-DC of installed capacity, are capable of powering more than 130,000 South African homes with clean energy and have provided significant economic benefits to the region. Combined, the two projects generated 2.3 million man-hours during construction.

As mandated under the South African Renewable Energy Independent Power Producer Procurement Program (REIPPPP), the projects set aside a percentage of total project revenues for enterprise and socioeconomic development, which will be invested for the benefit of the local communities.

Among the largest project finance transactions ever completed in South Africa and largest renewable energy projects in continental Africa, the Lesedi Project and Letsatsi Project, each respectively located in the Northern Cape and the Free State, were selected by the South Africa Department of Energy (DOE) in the first round of bids under the REIPPPP. The projects have each executed 20-year power purchase agreements with Eskom, the South African power utility company ranked as one of the top 20 utilities in the world by power generation.

"The social and economic benefits that these projects are imparting in South Africa demonstrate the positive results of close cooperation between the U.S. and South African governments along with private companies in each nation," said SolarReserve's CEO Kevin Smith. "We look forward to continuing this momentum through collaboration on further projects, including concentrated solar thermal power (CSP) plants, featuring SolarReserve's industry-leading CSP technology with integrated energy storage."

SENS and PV CYCLE to partner on WEEE compliance

PV CYCLE has announced that an agreement has been signed under which the Swiss take-back system SENS eRecycling will be responsible for the return, taking back and recycling of photovoltaic modules.

The Swiss Federal Office for the Environment (FOEN) has added photovoltaic modules as a new device category to the Ordinance on the Return, Taking Back and Disposal of Electrical and Electronic Equipment (ORDEE). This ordinance is currently being revised.

While the current ordinance – much like the European Union's WEEE Directive – represents a voluntary agreement for companies or private individuals who bring electrical or electronic appliances onto the Swiss market, the revised version includes a planned advance recycling fee (ARF) to cover the costs of processing appliances that have reached the end of their operating life.

The SENS Foundation, operating under the SENS eRecycling brand, is the largest take-back system for electrical and electronic appliances, lamps and lighting equipment in Switzerland, and already takes back discarded photovoltaic modules. Although SENS is responsible for the collection and recycling, PV CYCLE also contributes its expertise in photovoltaic module waste management. The industry association SWISSOLAR and PV CYCLE shall together be represented in the ARF (Advanced recycling fee) Commission of SENS ensuring that the interests of the PV industry are represented.

With SENS, PV CYCLE enters into its second national partnership after having agreed with the Czech WEEE-scheme RETELA to collaborate on PV waste management in the Czech Republic in April 2013. PV CYCLE is represented with own offices in Germany, Italy, Spain, Belgium, France and the United Kingdom today and offers PV-focused waste management and compliance services to the European PV industry.

Rebuilding confidence

Not so long ago Suntech was the leading photovoltaic (PV) manufacturer and the company founder was feted as leading a new breed of Chinese solar entrepreneurs. Then the company became the first high profile casualty of an over cooked industry. Restructure sees the company back in business and ready to return to strength. David Ridsdale caught up with the CEO to discuss the new growth ahead.

ERIC LUO is a suave looking man who has a relaxed genial nature that makes it very easy to talk to him. That is lucky as Luo is the CEO of Wuxi Suntech and his job is to convince the industry that, what was once the largest solar brand in the world, is ready to regains its position having dealt with a financial scandal and subsequent collapse of the Suntech. On the strength of his performance in media interviews where he is a knowledgeable and candid speaker, Luo is performing rather well.

The board and shareholders seem happy with Luo as well, giving approval to 3 billion yuan deal which saw Hong Kong based Shunfeng Photovoltaic International acquire Wuxi Suntech. A deal designed to return the Suntech brand to the top of the pile and the company is expecting to be the third largest manufacturer this year behind Yingli and Trina.

The financial collapse and enforced bankruptcy of Suntech Power Holdings is a complicated story involving parent and subsidiary companies, debt defaults and excessive expenditure. Wuxi Suntech was the production asset arm of the company and was auctioned to Shunfeng last year. Although the deal has only just closed the new company will maintain the Suntech brand. Suntech develops, manufactures, and delivers solar energy solutions. Founded in 2001, they have supplied more than 8GWs PV panels to more than a thousand customers in more than 80 countries. The Suntech story began with Shi Zhengrong who was a pioneer of the Chinese market and the first solar panel maker to list on the NYSE, back in 2005. Sadly the excitement of being number one led to expansion plans that could not be maintained and once the loan default was announced the company unravelled seeing the founders removed and enforced financial measures undertaken. There were many industry observers assumed it would be the end of a pioneering brand.

Maintaining momentum

Taking on the role of CEO at such a turbulent time in a company's history may be off putting for many but Luo seems to take it in his stride. He has been with the company since 2010 and was responsible for Suntech's worldwide sales and marketing activities. He has a 20 year history in global supply chain and business management and his experience is evident in his polished presentation. Luo admits that there have been difficult times but he never felt a time the company was at risk.

"We never stopped producing and shipping panels to the market," he points out. "There were times we had to have some production capacity idle while restructuring took place but never really dropped capacity."

The company already announced strong shipping expectations, expecting to move 2.5GW of panels this year. A 20% increase on the previous high in 2011. With the completion of the Shunfeng announcement operations will increase to between 3GW to 3.5GW. Through Shunfeng subsidiaries a number of key materials and balance of system companies are part of the Shunfeng value chain. This includes polysilicon supplier LDK, who have been feleing financial pressure.

“Shunfeng’s goal is to become the world’s largest integrated clean-energy supplier,” says Luo.

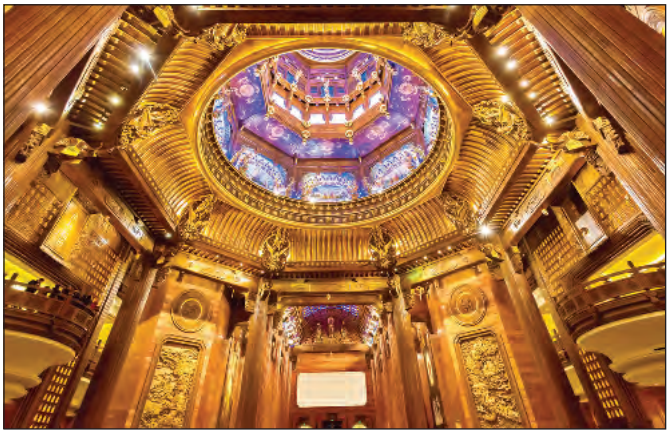
Luo’s awareness of industry eyes focused tightly on the company fortunes was evident in his pro-active response to the finalisation of the Shunfeng deal. He released a personal letter on the company website assuring customers of the two previous owners that all agreements would be honoured.

His tone of family and environmental stewardship is not uncommon in China but the announcement that the company will honour warranties for the more than 30 million panels globally installed and has a fund set up to cover all financial obligations points to a company understanding the long term battle it has to return customer and industry confidence.

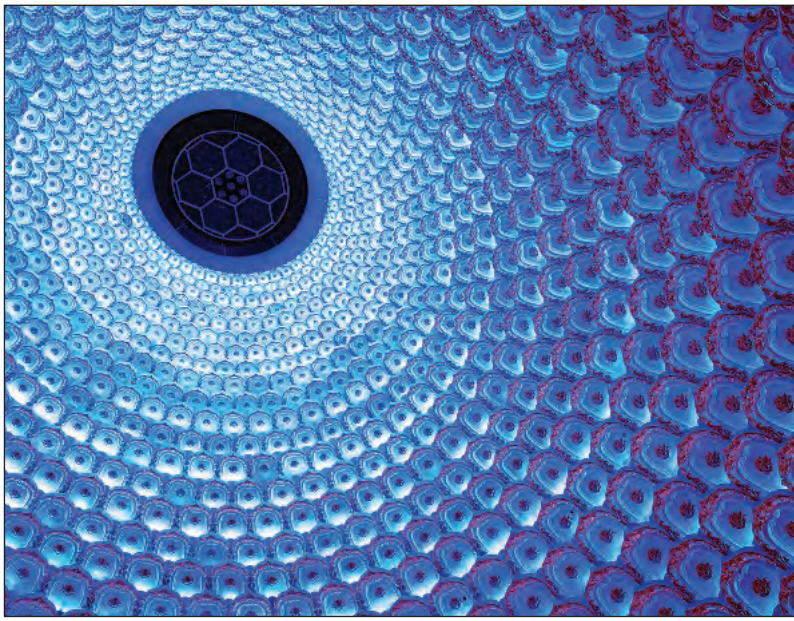
Brighter futures

Although happy to converse about the challenges the company faces, Luo consistently steers the conversation back to the future plans of the company. He stated that the restructuring process provided the opportunity to turn attention to research and development of products and production capacity. While not keen to describe it as a blessing, he did see it as an opportunity for the company to gain some advantage over rivals in a hard fought market place.

The company fine tuned their complete our operations and set about finding ways to reduce costs while optimizing manufacturing and automation processes. With the sale comes an injection of funds and the company moves to its next phase with a strong balance sheet and practices that Luo claims will provide an advantage that will become clearer.



The Wuxi region creativity provides inspiration



The Wuxi region is famous for its Buddhist temples and some designs look remarkably like the PV panels now produced in the region.

“ We are now in the process of increasing our staff and will be announcing strategic acquisitions and launches of new products,” said Luo in his recent industry reassurance. “Shunfeng International has acquired a variety of companies with Suntech at the helm. The companies acquired make up a synergized ecosystem, yet unseen in our industry.”

Wuxi Suntech have also announced a number of strategic agreements with its former parent company to ensure distribution and after sales support of the former company’s products in Europe and the USA. Suntech has agreed to license certain product certificates to Wuxi Suntech, although it expects the company to obtain its own product certificates in 2014. Wuxi Suntech will also support the restructuring of Suntech’s primary operating subsidiary in Europe, Suntech Power International Ltd.

With the financial tangles nearing the end of their frayed existence Wuxi Suntech’s new owner’s are moving ahead to raise capital to begin a production expansion for the company. Shunfeng is aiming to issue HKD 6 billion (US$774 million) worth of new shares for the construction of new solar power stations and increase production of PV holdings. Especially developing production facilities closer to end markets.

Luo believes that solar PV is not far from coal driven grid parity. Once that barrier is passed Luo expects the industry to accelerate in growth. Despite the challenges the company faces, there are plenty of positives that this fresh faced CEO with a healthy bank balance and the third largest capacity in the world, should not only be around for some time but may return Suntech to the top of the pile sooner than some may think.

Perovskite promises

NREL is one the many research centres studying perovskite and the potential of the material in photovoltaic manufacturing. Bill Scanlon from the NREL outlines some recent discoveries.

A NEW SOLAR MATERIAL that has the same crystal structure as a mineral first found in the Ural Mountains in 1839 is shooting up the efficiency charts faster than almost anything researchers have seen before—and it is generating optimism that a less expensive way of using sunlight to generate electricity may be in our planet's future.

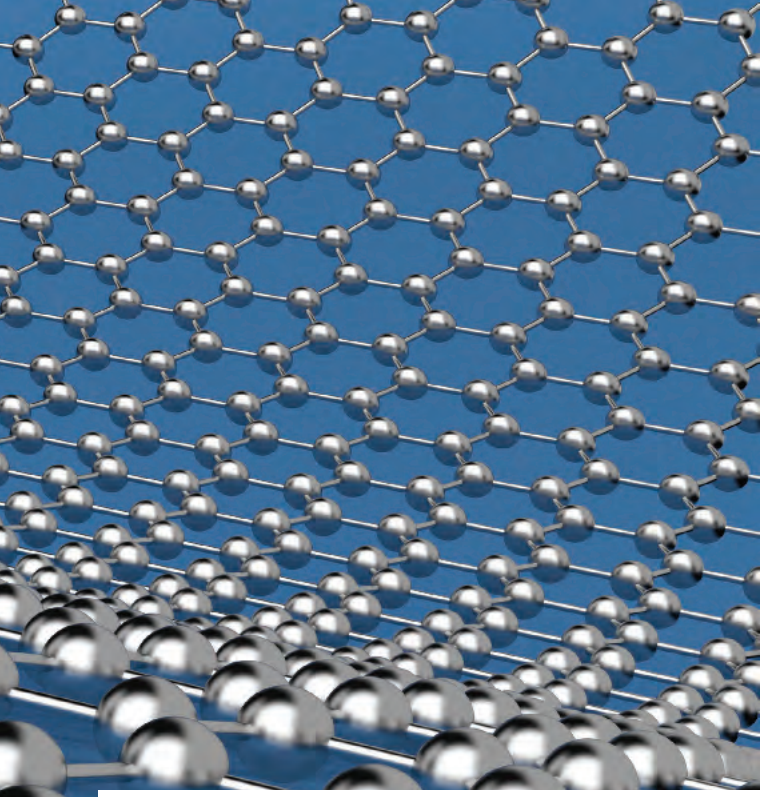
Researchers at the Energy Department's National Renewable Energy Laboratory (NREL) are analysing the new material, perovskite, using the lab's unique testing capabilities and broad spectrum of expertise to uncover the secrets and potential of the semiconducting cube-like mineral. A number of other institutes around the world are also on the trail of applications for the exciting new material.

NREL has already produced three scientific papers on perovskite, reporting on the science behind the very large length of the electron pairs (or charge diffusion length) in mesostructured perovskite solar cells. The two most-studied perovskite device structures are mesostructured (of medium complexity) and planar (two-dimensional). NREL Research Fellow David Ginley, who is a world-renowned materials scientist, said what makes perovskite device structures so remarkable is that when processed in a liquid solution, they have unusual abilities to diffuse photons a long distance through the cell. That makes it far less likely that the electrons will recombine with their hole pairs and be lost to useful electricity. And that indicates a potential for low-cost, high-efficiency devices.

NREL Senior Scientist Daniel Friedman notes that the light-absorbing perovskite cells have "a diffusion length 10 times longer than their absorption length," not only an unusual phenomenon, but a very useful one, too.

Flexible manipulation

The new cells are made from a relative of the perovskite mineral found in the Ural Mountains. Small but vital changes to the material allow it to absorb sunlight very efficiently. The material



is also easy to fabricate using liquids that could be printed on substrates like ink in a printing press, or made from simple evaporation. These properties suggest an easy, affordable route to solar cells.

By playing with the elemental composition, it is also possible to tune the perovskite material to access different parts of the sun's spectrum. That flexibility can be crucial, because it means that the material can be changed by deliberately introducing impurities, and in such a way that it can be used in multijunction solar cells that have ultra-high efficiencies.

Multijunction solar cells are an NREL invention from 1991, but because of high material costs, standard multijunctions are used mostly in outer space applications such as satellites and the Mars rovers. Cheaper multijunction cells based on perovskites could radically change this.

In four years, perovskite's conversion efficiency—the yield at which the photons that hit the material are turned into electrons that can be used to generate electricity—has grown from 3.8% in 2009 to just north of 16%, with unconfirmed reports of even higher efficiencies arriving regularly. That's better than a four-fold increase.

By contrast, efficiencies of single-crystal solar cells grew by less than 50% during their first five years of development, and most other types of solar cells showed similar modest improvements during their first few years.

NREL materials scientists are encouraged by the possibility of optimizing the materials. Replacing lead with tin in the cells could improve the efficiency of multijunction cells made from perovskite. Besides switching to a more environmentally friendly material, the change from lead to tin would also allow the finished solar cell to better withstand high humidity.

Right: The band gap of perovskites can be adjusted by changing their compositions to access different parts of the sun's spectrum. Credit: Dennis Schroeder

Application capabilities

"We can help the field, especially in areas where they need help in reliability and larger development," including understanding transport, or moving electrons from the solar cell to a circuit, Ginley said. "Those are all the things we do well."

"Perovskite shows promise to be a whole lot easier to make" compared to most other solar cells, said NREL Senior Scientist Joey Luther, who works with nanomaterials. "It doesn't require high-temperature processing. You can just dip glass into two chemicals and get the material to form on it."

The field is growing fast, but that's because there is so much to do, Luther said. "Every technique that everyone has used for every solar cell in the past, they want to try it on perovskite solar cells to see what they can learn. Anytime you jump into a new material, you need to get a feel for how it works—you just have to play around for a while,"

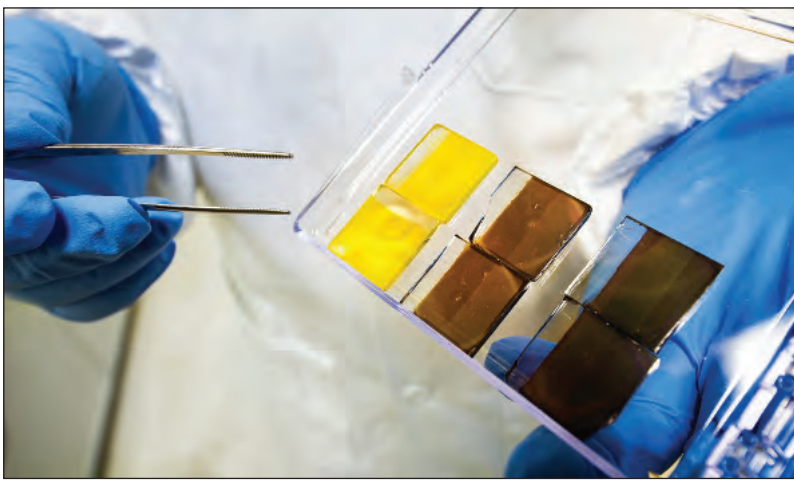
"Look at the layers, see what modifications you can make with new materials, see what you can do to tune it."

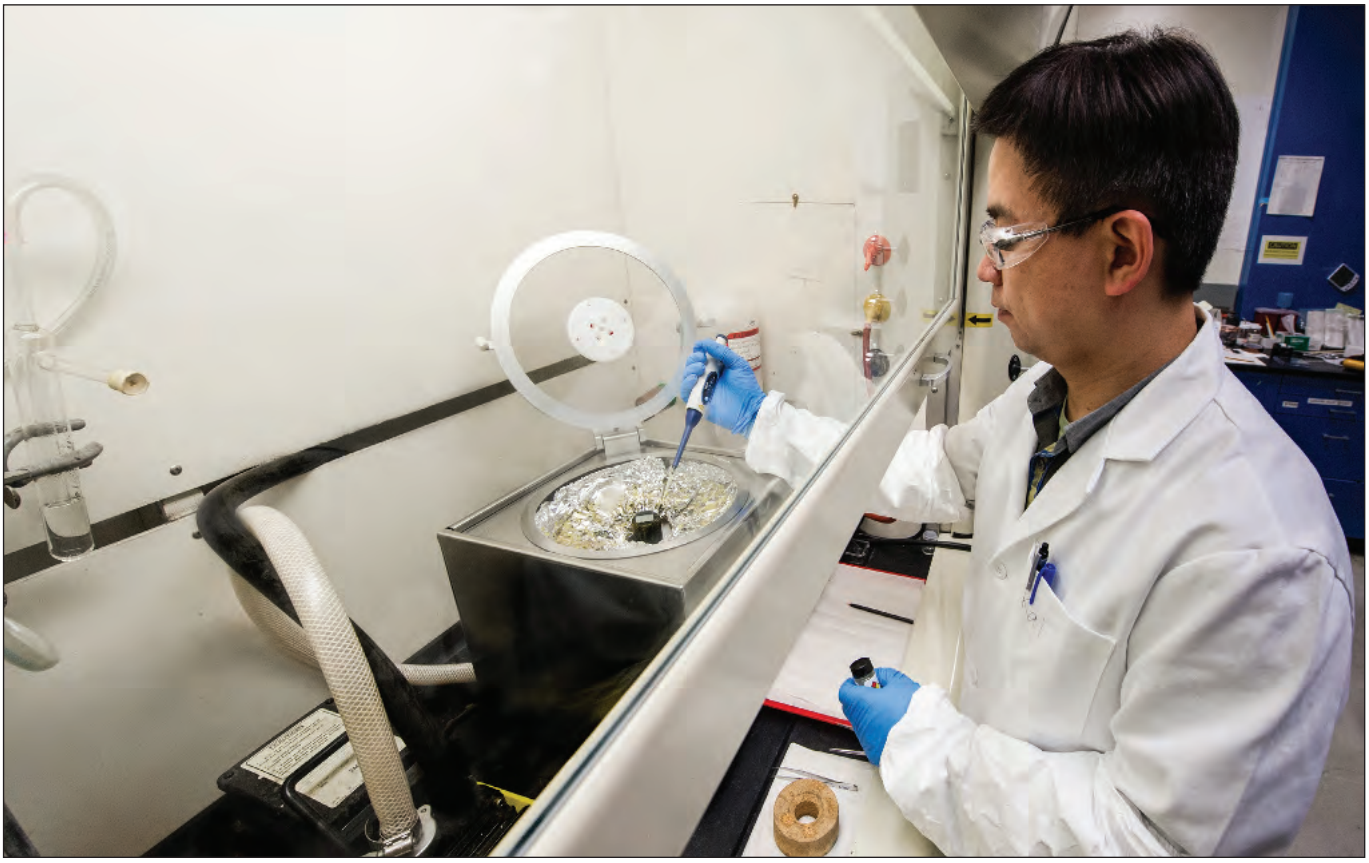
Maximizing Efficiency, Minimizing Costs

Luther predicts that researchers will approach perovskite from two different directions. One will be to make the best semiconductor possible without regard to cost, and the other will be to try to make it as cheap as possible, trying spray-on techniques, for example.

"Those fields are going to merge eventually," he said, as researchers discover the optimal trade-offs.

"What is interesting about perovskite is that all the research groups—in Korea, England, Switzerland, the United States—they're all getting very high efficiencies," Luther said. "It's not as if just one person knows the secret."

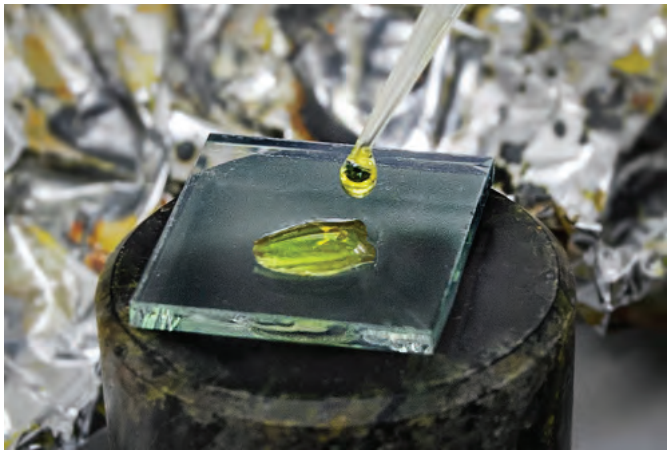




NREL Senior Scientist Kai Zhu prepares a perovskite solar cell in his lab, using a precursor solution that converts from a liquid base to an absorber in a device. Perovskite has shot up the conversion efficiency charts faster than any other solar cell material. Credit: Dennis Schroeder

The theoretical maximum efficiency of a perovskite-based solar cell is about 31%, meaning that of all the solar energy contained in the sunlight that hits the cell, 31% is converted to useful electrical energy. Multijunction cells based on perovskites could attain higher efficiencies still.

"The goal shouldn't be to stop at 20% efficiency," Luther said. "The goal should be to try to get to 28% or higher. In the lab, the best cells need to be almost perfect at small scale. Then the commercial people can stop at whatever efficiency is economical for them to deploy."



NREL Senior Scientist Kai Zhu applies a perovskite precursor solution to make a perovskite film. Credit: Dennis Schroeder

NREL has experts in several fields needed for the exploration and improvement of this new promising material: experts in so-called III-V cells from the third and fifth columns of the periodic table; in quantum dots, materials, and transport; in computational materials design; and in doping materials with new materials to change their band gaps, and thus their usefulness in harvesting electrons.

In fact, NREL's latest world record has echoes of properties inherent in perovskite. NREL recently set a world record of 34% conversion efficiency for a gallium indium phosphide cell atop a gallium arsenide cell under lenses that multiply the sun's power. Last June, NREL set the world record of 31.1% for the same cell under one sun. In both cases, NREL reached unprecedented efficiencies by improving the ability of electrons to diffuse out of their traps. It's that long-diffusion, short-absorption phenomenon that has scientists so excited about perovskite.

Remarkable Progress in Just Five Years

NREL Senior Scientist Kai Zhu is co-organizer of a scientific conference on dye-sensitized solar cells, which are low-cost thin-film cells. So far, he says, the majority of talks, posters, and papers proposed for the conference are on the subject of perovskite—so exciting is the field even though perovskite isn't technically a dye cell.

In 2009, Japanese scientist Tsutomu Miyasaka reported perovskite's potential as a light absorber and possible material

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for a solar cell, noting a 3.8% conversion efficiency, but that was such a low rate that it didn't spark much interest, said Zhu.

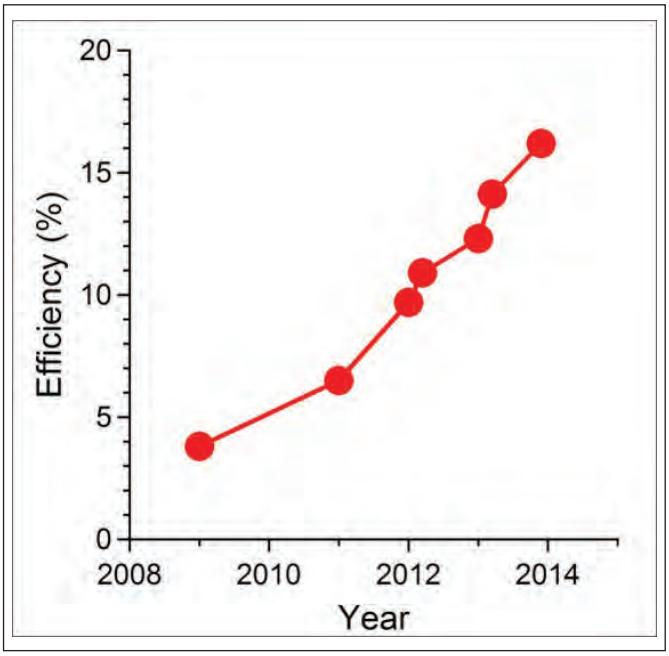
But in 2011, a Korean scientist, Nam-Gyu Park reported achieving 6.5% efficiency with perovskite. A year later, Michael Grätzel, a top solar scientist from Switzerland, teamed with Park on a paper, sparking more widespread interest. Their paper in the journal Nature Scientific Reports reported a conversion efficiency of about 10% with perovskite. "By then, I knew this was something I wanted to pursue," Zhu said. At the beginning of 2013, the efficiency level for perovskite had climbed to 12.3%.

"And then about a year ago, when they added chlorine to the materials, the electron and hole diffusion lengths just went through the roof," Ginley said. "The most remarkable thing is that you add a little bit of chlorine and you see how the diffusion lengths change—by a factor of 10. That really brought attention to them."

Ideally, a solar cell has a diffusion length long enough for the electron to reach the contacts both above and below it, and thus escape the possibility that it will be trapped in its layer and recombine into an electron-hole pair.

When Zhu's proposal to examine perovskite was approved, the efficiency level had climbed to 14.1%. Now, the highest certified rate is 16.2% by Sang Il Seok of Korea. "Seeing how rapidly this field is progressing, I feel very lucky that I started on this more than a year ago," Zhu said.

Meanwhile, Zhu is in the midst of an experiment in which he prepares a precursor solution that converts from a liquid base to an absorber in a device. "This material is so easy to work with," Zhu said. "Working on solution processing, we can make a device in one or two days, from beginning to finish."



Progress in efficiency for solar cells made from perovskite absorbers. Efficiency values were taken from publications and NREL's latest chart on record cell efficiencies.

"But this new material can probably be processed at a much lower cost" than rival materials, he said. It doesn't have to deal with the problem of the substrate not matching with the material above it, or with the delicate deposition process necessary with many alternative solar materials. Several companies are already interested in forming cooperative research and development agreements so they can work with NREL on perovskite. "

At NREL, we have this depth and breadth of understanding of materials, devices, transport, and, really, all aspects of solar cells that should help us make an important contribution to this new material," Zhu said.

Delving into perovskite's secrets

MATERIALS researchers at NREL have produced three papers on perovskite, the mineral that is showing great promise in solar cells.

A paper in The Journal of Physical Chemistry Letters reports that as the titanium dioxide layer of a perovskite-like cell thickens, there is a sharp shortening of the diffusion length—and thus more difficulty in freeing up the electrons for use. The report concludes that it is important to develop compatible redox electrolytes as alternatives to titanium oxide in order for perovskite to be useful for photoelectrochemical applications.

A report in the journal Chemical Communications shows that ammonia gas can induce a rapid change in color in perovskite film, suggesting the potential use of perovskite halides as ammonia sensors. Furthermore, the authors said the study will help researchers fully use the unique properties of the new system for solar cell applications.

A study in The Journal of Physical Chemistry Letters shows that mesostructured perovskite solar cells have transport and recombination properties similar to those of dye-sensitized solar cells. The study also found that the transporting of electrons in the cells happens mostly within the titanium dioxide network. And it found that the efficiency of the cells increases as the titanium dioxide layer thickens—but only to a point. Thickening is a net benefit from 240 nanometers to about 800 nanometers, primarily because it enhances light-harvesting abilities. But any thicker than that, and the efficiencies fall. The NREL researchers also found that the electron diffusion length—directly related to the ability of the electrons to escape the cell and form useful electricity—is very long, greater than 1 micron, for more than four orders of magnitude of light intensity.

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

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

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

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

Materials key to future batteries

With the growth of renewable technologies and a higher demand for batteries as energy storage devices, there is a growing concern that some batteries create a safety hazard unless properly utilised. Researchers in Mexico have been probing different polymeric materials to discover ways to optimise battery performance whilst improving safety issues.

CREATING ENVIRONMENT FRIENDLY energy storage systems, non-explosive and with charge/discharge long-term cycles, motivated a group of scientists from the Autonomous Metropolitan University, Campus Iztapalapa (UAM -I) in Mexico, to research which polymeric materials have the properties to maintain the highest level of energy in a lithium - ion battery.

According to Judith Martinez Cardoso, co-head of the project at the Department of Physics, this research was supported by the Ministry of Science, Technology and Innovation of the Federal District. "Our commitment is to design batteries that can replace those currently used in the Public Transport System Metro, of nickel- cadmium, which are highly polluting and when breaking eliminate fluid that can cause serious toxicity problems."

She also notes, that this development would also achieve the creation of optimized polymer electrolyte lithium-ion rechargeable batteries for electric or hybrid vehicles, computers, cell phones and camcorders, including portable systems.

This material (polymer electrolyte) is similar to plastic and, in solid state, has the ability to contain the lithium inside a battery, because of its low weight enables greater amount of driving electric charge with a lower weight.

"A battery is a current generator because it transforms chemical energy into electrical, in this case provided by the processing of materials containing lithium, in the two electrodes that are part of the generator and in the polymer," Ignacio Martínez González explains, a project partner within the Department of Chemistry at UAM -I.

Safety concerns

Lithium-ion rechargeable batteries have been readily available since late last century, but they have several disadvantages. According to the researchers, batteries tend to deteriorate if stored unloaded, support a limited number of charges, are expensive and can overheat to the point of exploding.

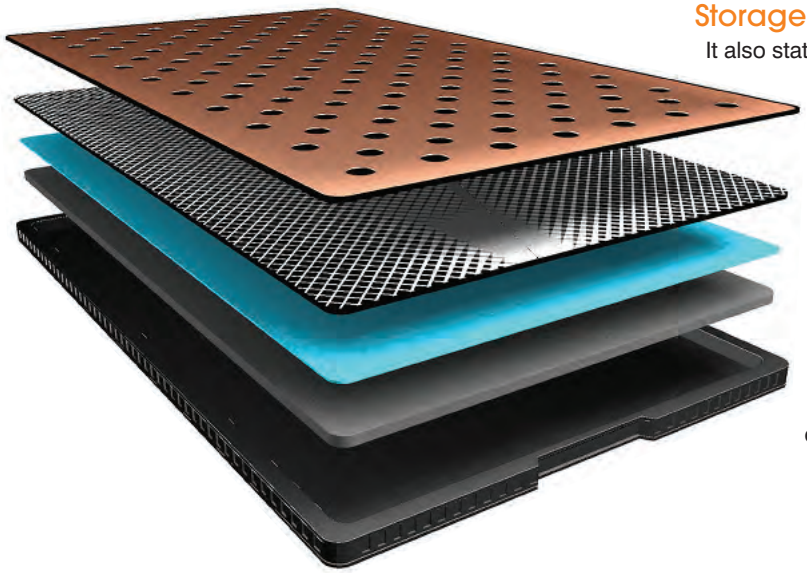
"Because it requires an electrolyte (which dissociates a lithium salt) to lead the charge, the problem was that manufacturers have used chemicals that can degrade and generate this explosion," said Martinez González.

For these reasons, according to researchers, the lithium-ion batteries have been modified to prevent bursting. Furthermore, different countries are working on technologies that have a higher yield and making them safer for users. In fact, says Martinez

Above: Solar powered trams will benefit from the new technology
Below: The layered structure of the new battery

Cardoso, it was the problem that presented with some Boeing aircrafts which used the lithium-ion battery, which contained organic liquids that became flammable when a critical temperature was reach.

“Hence, our work is aimed to use non-toxic and non-explosive materials, such as polymers. Although we still lack a prototype, we are developing three very important elements, such as the chemicals that will carry the two electrodes and the polymer system that will contain the electrolyte. The idea is to have greater capacity to store energy and a durable cycle of loading and unloading without losing efficiency, “ said Martínez González.



Storage Objectives

It also states that the objective is to design a safe technology, at a low cost and efficient enough to meet the needs of energy storage and increase the capacity of the batteries. “The polymer electrolyte we work with has great potential to be used, so we are building cells to test this material as a whole together with the lithium electrode.”

So far, the research team has used synthetic type materials; however, they have a widespread interest in using biological polymers to make the batteries biodegradable and avoid creating any environmental damage.

RENSEF

2nd Renewable Energy Systems and Energy Efficiency Exhibition

30th Oct. • 2nd Nov. 2014 Antalya TURKEY

Tourism and agriculture investors are meeting with renewable energy systems and energy efficiency industries at the south of Turkey, in Antalya. Increasing electricity costs of tourism and agriculture facilites is driving investors through alternative searches. Especially, producing electricity out of sun is on the agenda. Antalya's claim to be the capital of electricity production out of sun in Europe is mentioned regularly. Seeking to convert the biowaste and biogas from millions of tons of organic plant waste of greenhouse industry and food wastes of tourism facilites into energy is on the agenda.

In this context; Antalya, the capital of tourism and agriculture invites energy industry to meet with potential investors in an efficient and joyful exhibition.

There Is Energy In This Exhibition!

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This exhibition is organized with the consent of TOBB (The Union of Chambers and Commodity Exchanges of Turkey) in accordance with law no. 5174

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Renewable energy will be the lifeline for future generations. It is a legacy that will be valued and will enhance the quality of life.

I welcome you all to be part of The Indian Renewable Energy Summit 2014."

Shri Narendra Modi
Hon'ble Chief Minister, Gujarat

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Hitting small businesses hardest

The EC has released guidelines that are intended to marry energy needs with environmental concerns. Alexandre Roesch, Head of Regulatory Affairs for European Photovoltaic Industry Association (EPIA) discusses what is wrong with the new rules and who they affect.

THE EUROPEAN COMMISSION (EC) has presented its new State Aid Guidelines for environmental protection purposes and energy will be included for the first time in the scope of these guidelines.

You may think that this was the perfect occasion to clarify how Member States are supporting different forms of energy, including for conventional and mature technologies. Well, you will have to wait another couple of months. Indeed, the EC is expected to present a new study on direct and indirect public support to various energy producers over the last decades. Meanwhile, the debate about State Aid focused once again on the support to renewables, which were presented one-sidedly as troublemakers. The EC itself stated during the launch of the new State Aid regime that renewables have "caused serious market distortions" and that "it is time for renewables to join the market".

In a nutshell, these new rules depict a vision of the electricity system where renewables are mainly developed by large, established players. And, do not expect the system to change: If you're generating renewable electricity, you'd better be prepared to be squeezed into pre-existing, non-suitable frameworks. The imposition of standard balancing responsibilities to all generators is a good example of such underlying philosophy. Presented as a way to integrate renewables into the market, such measure is actually, under the current market conditions, discriminatory against variable renewables. Balancing markets and products are far from being technology-neutral. They have been designed so as to accommodate the dispatchable nature of large power plants and several regulatory and practical barriers still prevent variable generators from reducing their imbalances. Moreover, established players with large and diversified generation portfolio are better placed than new and innovative market entrants to reduce their imbalances.

By favouring technology-neutral competitive bidding processes as the main mechanism to allocate support, the EC is also discriminating against small scale electricity generators, as these cannot bear the risks and transaction costs associated with such tendering schemes. Even with a 1MW threshold, this measure remains discriminatory. Cooperatives and community projects, for instance, will now be forced to place their bids in a scheme that is much more suited to the largest established energy players. Since many Member States complained that this supposedly technology-neutral model would deliver neither technology cost-decline nor a suitable energy mix, but would force them to pick the most mature and currently cheapest renewable technology, the EC finally introduced a series of generous derogations.

The notion of "grid competitiveness", which is meant to become a reference point to phase out support to renewables after 2020, is another example of this willingness to squeeze renewables into the old system. While technologies like PV will indeed become competitive in terms of power generation costs, their market integration and viability mainly depends on an electricity market design which today remains biased in favour of centralised dispatchable power plants.

While these new rules are supposedly intended to integrate renewables in the market, they are in fact maintaining in place a system which ignores the progressive shift towards decentralised, small-scale renewables. The EC should focus on the fundamental adjustment of market rules to allow renewables a fair access, instead of forcing them into a market which is simply not fit for them. Until that has happened, claiming that renewables should join the market is putting the cart before the horse.

Background to concerns

The European Commission presented its new Environmental and Energy Aid Guidelines (EEAG) for the period 2014-2020. EPIA had sent out a warning that this revised State Aid regime discriminates against small-scale generation and could badly harm the Member States' ability to design efficient and adequate measures to support the uptake of different renewable energy technologies.

According to the EPIA, the European Commission, in its new EEAG, appears to envision an electricity system where renewables are mainly developed by large players, adopting a series of discriminatory measures against small-scale generation.

Detailed account

All new aid schemes will have to comply with several rules (evolving over time) with a view to integrating renewable electricity in the market. Prolonged or modified existing schemes will also have to comply with such rules, as well as schemes for which the validity of the Commission's compatibility decision has expired.

As of 01 January 2015:

- Market premiums or green certificates will be the main forms of aid allowed
- Standard balancing responsibilities will apply to beneficiaries of the aid, "unless no liquid intra-day markets exist"
- Generators will no longer receive support in periods of negative prices

During 2015 and 2016:

- For at least 5% of the planned new renewable electricity capacity, aid shall be granted through technology-neutral competitive bidding processes

As of 01 January 2017:

- Competitive bidding processes will apply to all new renewable electricity capacities, with a number of derogations foreseen if:
- Only one or a very limited number of projects/sites would be eligible to the aid; or
- The bidding process would lead to higher support levels; or
- The bidding process would result in low project realisation rates
- Technology-specific tendering schemes will remain possible where a process open to all generators would lead to a suboptimal result. In such cases, Member States will have to justify their choice based on the long-term potential of a given technology, the need to achieve a diversified technology mix, grid stability concerns or system integration costs

The Guidelines propose exemptions and aid can still be granted to installations below 1 MW capacity without a competitive bidding process.

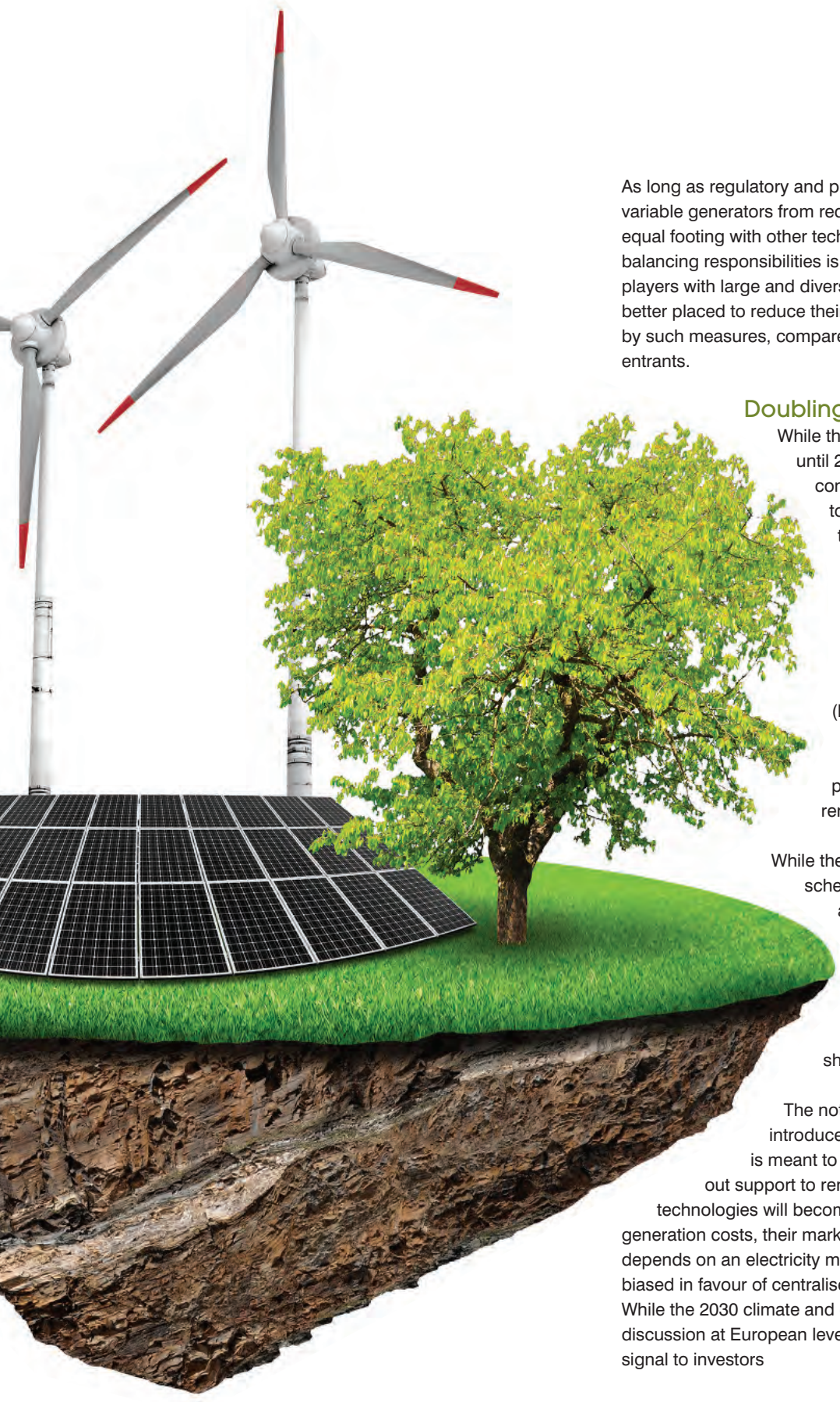
For installations below 500 kW, Member States remain free to decide on the type of support (no obligation to go for a market premium or a green certificate) while respecting a number of conditions regarding the level of aid per unit of energy.

Provisional analysis

The new rules proposed by the European Commission depict a vision of the electricity system where renewables are mainly developed by large players, as reflected by three central provisions of the new rules.

The imposition of a technology-neutral competitive bidding process as the main mechanism to allocate support: Small market players are unable to bear the risk and cover the costs of a tendering scheme. The 1 MW threshold under which a different support regime is possible will not be sufficient, as it will still force cooperatives and community projects to place their bids in a scheme much more suited to the largest energy players.

The imposition of market premiums or green certificates as the main types of support scheme: Direct marketing of electricity is not possible for small and medium-sized players, who do not have a direct access to the wholesale electricity market and therefore need to go through a third party or an intermediary. This requires proper communication infrastructures between small-scale generators and intermediaries, which do not exist at the moment.
The imposition of standard balancing responsibilities to all generators: Balancing markets and products are everything but technology-neutral. They have been designed so as to accommodate the dispatchable nature of large power plants.



As long as regulatory and practical barriers will prevent small variable generators from reducing their imbalances on an equal footing with other technologies, imposing them standard balancing responsibilities is discriminatory. Moreover, established players with large and diversified portfolio of generation are better placed to reduce their imbalances and thus favoured by such measures, compared to new and innovative market entrants.

Doubling up on guidance

While these Guidelines will be applicable until 2020, several provisions unduly constraint Member States' capabilities to reach their 2020 binding renewable targets.

The Guidelines allow for the exclusion of several renewable technologies based on network constraints and grid stability matters. The Renewable Energy Directive (Directive 2009/28/EC) however already describes when and how Member States should provide priority dispatch and access to renewable electricity.

While the Guidelines positively consider schemes that are open to other EEA and Energy Community countries, Member States need to fully control the means to reach their 2020 binding renewable energy targets. Therefore, the opening of national support mechanisms should remain voluntary.

The notion of "grid competitiveness", introduced by the Guidelines but not defined, is meant to be a reference point to phase out support to renewables after 2020. While some technologies will become competitive on the basis of power generation costs, their market integration and viability mainly depends on an electricity market design which today remains biased in favour of centralised dispatchable power plants. While the 2030 climate and energy framework is still under discussion at European level, the Guidelines send the wrong signal to investors

Australian study shows price drop with renewable uptake

Renewable energies industries have developed faster than traditional markets imagined. Industry driving government supports have slowed as uptake surpassed expectations. One argument against renewables is the added cost to consumer bills but a new report, as the country reviews federal support, shows that in long term prices will drop.

A STUDY RELEASED IN AUSTRALIA has shown that future power prices will be lower with Australia's Renewable Energy Target (RET) in place than they would be if it was removed, the Clean Energy Council has claimed.

Renewable energy faces constant change as government policies that drove recent industry market growth are under review in some form or another. Each of these changes are met with arguments for and against and the balance between maintaining support and balancing costs are often obscured by arguments aimed at supporting the interests of the arguer. Political changes will impact upon these decisions as new governments seek to make their mark to distinguish from the outgoing leaders. The regions may be different but the arguments tend to be similar.

Australia's RET was introduced in 2001 and has developed through a number of reviews and is now set to deliver at least 20 per cent of Australia's electricity from renewable sources of power such as solar, wind, bioenergy and hydro by the end of this decade.

The policy is currently under review as the legislation demands every two years. The process tends to create uncertainty amongst investors but this review is under higher scrutiny as it is the first under a new government. The new Australian government has sat in opposition for some time and is now keen to turn back a number of the predecessor's decisions creating turbulent times for the country. Many people within the renewable energy industry have expressed their concern that the latest review may result in the RET being cut back or

abolished altogether. The Clean Energy Council is a trade body representing Australia's clean energy sector. They are an industry association made up of more than 550 member companies operating in the fields of renewable energy and energy efficiency. The council has been strong in its advocacy role and sent a number of strong and public messages urging caution through the review process.

Part of this is the government's current record on environment and energy issues with a number of policy changes that announces a change of direction in how Australia develops sustainable and renewable technologies. The council strongly advocates that the RET should be maintained in its current form to provide the policy stability necessary to attract investment.

The RET has consisted of two main schemes in the Large-scale RET (LRET), which creates a financial incentive for larger renewable energy power stations and the Small-scale Renewable Energy Scheme (SRES), which encourages owners to install small-scale renewable energy systems such as rooftop solar, solar water heaters, heat pumps, and small-scale wind and hydro systems.

Clean Energy Council Chief Executive David Green said removing the RET means households would pay more than half a billion dollars a year extra for electricity in 2020, and up to $1.4 billion more each year beyond that.

The council had commissioned a study to look at what it would mean to the economy if the RET was changed or removed.

"This study shows that the RET is holding electricity prices lower over the long term by minimising the use of increasingly costly gas for electricity generation," said Green. "Recent price rises in Queensland and New South Wales reinforce estimates that gas will increase dramatically in price this decade, as Australia enters the international gas market."

"While the RET remains a critical policy to support Australian projects," continued Green. "The good news is that renewable energy is coming down in cost. The RET will help to protect consumers from the power price pain of rising gas prices, while delivering billions of dollars in investment and thousands of jobs for regional areas of the country".

Reviewing the possibilities

The report, commissioned by the Clean Energy Council, had energy market analysts, ROAM Consulting look at the impact of the RET under several different scenarios. What would happen with an increased target, business as usual, and a scenario in which the policy was removed.

The report revealed that each Australian household will pay over $50 more for electricity in 2020 if the RET is dispensed with. The total cost would be half a billion dollars extra for electricity in 2020 and up to $1.4 billion extra each year beyond then if the policy is removed.

The policy will generate approximately 18,400 new jobs by 2020 if retained in its current form. This is made up of 9700 jobs in large-scale technologies such as wind power and bioenergy and 8700 in household systems such as solar power and solar hot water.

In addition to the $20 billion of investment already generated, the RET will drive a further $14.5 billion of investment in large-scale renewable energy out to 2020, as well as many billions more in household renewable energy such as solar power. If the policy is removed, most of this simply won't happen.

Removing the RET means more of Australia's electricity will come from coal and increasingly expensive gas-fired power, forcing up both power prices and emissions. For the Federal Government to meet its target of reducing emissions by 5 per cent it would need to find an extra 34.7 million tonnes of emissions abatement from other sectors without the RET

Due to reduced demand for electricity in the country, the report estimates that renewable energy will deliver 22.6 per cent of the electricity consumed in Australia in 2020 as a result of the RET's current policy settings.

Much debate around the RET centres on forecasts of the percentage contribution of renewables to Australia's energy usage. When the original GWh targets were set in legislation in the 2009 review, the intention was that "the equivalent of at least 20 per cent of Australia's electricity supply is generated from renewable sources by 2020".

Since that time, forecasts of Australia's electricity demand in 2020 have decreased and rooftop PV uptake has been larger than anticipated. The combined effect of these factors is that achieving the current LRET target of 41,000 GWh in 2020 will likely deliver slightly more than 20% of Australia's electricity supply from renewables in that year.

ROAM estimates that renewables will deliver 22.6% of electricity consumed in Australia in 2020.

Wholesale price increases are reduced by the RET

Under the existing LRET and Small-scale Renewable Energy Scheme (SRES), wholesale electricity prices are expected to rise only moderately for the period to 2020, with growth in new renewables acting to reduce price rises that would otherwise occur.

The cost of the RET is largely offset by reductions in wholesale prices in the near-term. This is because of the merit order effect, whereby additional low Short Run Marginal Cost (SRMC) generation displaces more expensive generation thereby lowering the wholesale price of electricity in the market.

Solar and wind energy have very low SRMCs predominately because their fuel is free. These wholesale energy price savings are easily overlooked by consumers, as they do not appear as a "line item" on analyses of retail bills.

Repealing the RET would increase retail electricity bills

In the longer-term, in the absence of new renewable generation being built, wholesale electricity prices will increase from their current levels in response to demand growth and generator bidding strategies. The increase in wholesale electricity costs is greater than the costs of the RET in the medium- to long-term.

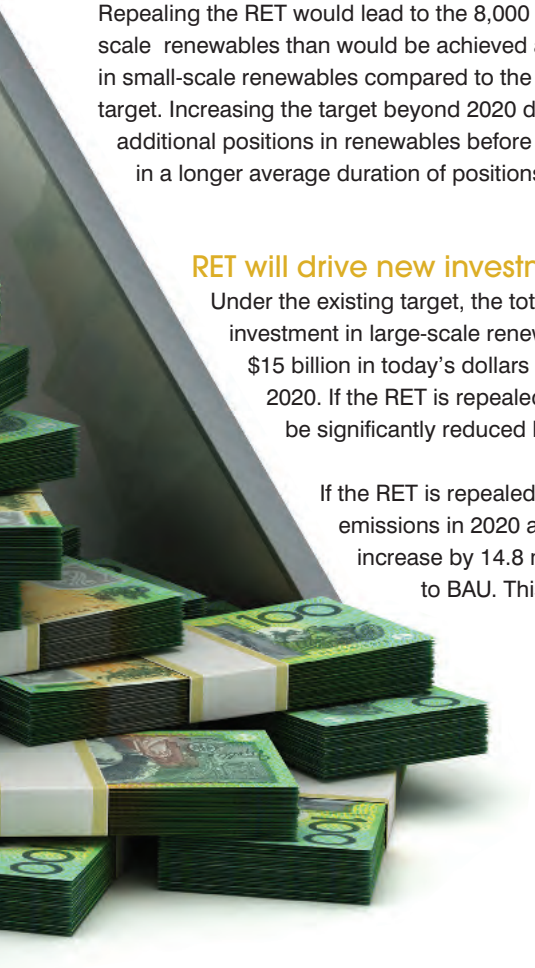
Average residential electricity bills would be $51 a year higher in

Whatever the outcome of the current RET review the renewable industry in Australia is a stronger voice than it once was and the upcoming review should be interesting to watch. The new government has committed to a transparent process that will accept community and industry input. It is an ideal time for the renewable industry to have their collective voices heard

2020, an average of $100 a year higher beyond 2020, and could be as much as $140 higher, if the RET is repealed compared to the current scenario.

It is worth noting that the size of the wholesale electricity price merit order effect modelled for Australia is comparable with international studies of similar electricity markets and comparisons can be construed from both electricity prices and the potential impact of a lack of long term clear policy when governments provide support.

Repealing the RET would lead to the 8,000 fewer jobs in large-scale renewables than would be achieved and 3,800 fewer jobs in small-scale renewables compared to the currently legislated target. Increasing the target beyond 2020 does not result in additional positions in renewables before 2020, but does result in a longer average duration of positions.



RET will drive new investment

Under the existing target, the total cumulative investment in large-scale renewables will be nearly $15 billion in today's dollars between now and 2020. If the RET is repealed, this investment will be significantly reduced by $11 billion.

If the RET is repealed, electricity sector emissions in 2020 are modelled to increase by 14.8 million tonnes relative to BAU. This is a 12.6 million tonne rise in emissions relative to 2000 levels. Cumulative emissions to 2019-20 will be 34.7 million tonnes higher if the RET is removed.

If the RET scenario is ended and the Federal Government is to achieve its commitment of reducing greenhouse gas emissions by five per cent of 2000 levels by 2020, the increase in electricity sector emission would have to be matched by reductions in emissions in other sectors.

Conclusion

Whatever the outcome of the current RET review the renewable industry in Australia has a stronger voice than it once had and the upcoming review should be interesting to watch. The government has committed to a transparent process that will accept community and industry input.

It is an ideal time for the renewable industry to have their collective voices heard. The need for renewable industries around the globe to speak in a singular and clearer voice on policy issues is shown clearly in the Australian example.

Renewable energy arrays are essentially small power plants and larger scale ones are taking enough market share to pose a real threat to the major energy companies.

A government used to dealing with a small powerful group of energy providers is having to deal with the reality of multiple energy providing companies. In Germany that impact continues and Australia is at a different point on that journey but there are lessons and similarities to be learnt from both.

Governments are reacting as renewables grow to become an agent for change in local industrial landscapes and renewable energy industries need to deal and respond to that change. As small players their impact is minimal but as a collective with public support they develop strength enough to positively impact on the future direction of energy development around the globe.

Leading the way for European energy

As the penetration of renewables in Germany gains pace, members of the advisory board for Renewable Energy World Europe discuss the lessons learnt so far around integration, intermittency, and grid stability in the German energy market.

GERMANY has been the poster child for the global solar industry for a number of years due to the early investment and adoption of solar energy that took place in the 1970s. Now the country is been observed as a benchmark for the changes the renewable programme has brought to the country's energy infrastructure and to teh companies involved.

The advisory board of the upcoming Renewable Energy World Europe 2014 have a number of years experience in the German market between them and such expertise seemed the perfect mix to hold QandA to discuss how Germany may approach the changing transition to power industries in Europe.

The participants cover an array of industries and were Dr. Jacob Klimstra, head of Jacob Klimstra Consultancy. Philippe Paelinck, Director of CO2 business development, Alstom. Pascal Stijns, Director water and power, Honeywell Process Solutions. Dr. Tamer Turna, CEO, Yildirim Energy Holding Inc.

How will the evolution of Germany's energy market influence other European markets and what lessons have been learned?

Philippe Paelinck: The energy market in Germany has proved a true test bed given the numerous policy changes it has witnessed recently. In the past two years, the country has taken the decision to exit nuclear generation, whilst moving to an ambitious penetration target of 70GW of renewable comprising wind and solar PV capacity. The consequences of these policies have seen structural imbalances in the transmission network from North to South, the mothballing of combined cycle gas turbine (CCGT) assets (some of which were new), a drop of 30 per cent in base-load electricity price, and consumer electricity bills that are more than 50 per cent higher than the average EU domestic kWh price. The main lesson learned from the experience in Germany is that the energy sector requires a long term strategy given that it is asset- and capital-intensive and requires a stable policy framework. It will be interesting to observe how Germany

will restore stability and confidence in its electricity market fundamentals while maintaining competitiveness, keeping consumers onside, and achieving its target of a 40% reduction in CO_2 emissions and 35% share of renewable electricity by 2020.

Pascal Stijns: Germany has older types of power generation, but has interconnectors to the rest of Europe, unlike the UK, and can import and export power as required, highlighting the need for collaboration and a price mechanism. Last year, for example, there was so much solar and wind power available that Germany was forced into reselling it at minus 200 EurosMWh. Although isolated it indicates areas that need to be addressed.

Tamer Turna: The evolution of the renewables market in Germany has been fuelled by the subvention scheme. The limitations in power transmission and the need to control balancing requirements from unpredictable day-ahead renewable power (especially wind power), adding cost. Moving forward, it will be the consumer that decides the direction of the market.

Jacob Klimstra: Germany is a prime example of a country that is disrupting its own energy markets as well as those around it, as a direct result of the renewable energy subsidies it has introduced. It is difficult to argue against the importance of stimulating renewable energy use, yet the impact of FiTs and other schemes on the wider energy market needs to be reconsidered.

Has the German experience shown that incentives are counterintuitive, and at what point should they be stopped?

Pascal Stijns: It depends on who you are talking to. Home owners that have solar panels on their roof and are getting a good price for the kilowatt will love it. Utilities have to cut back on power generation and are less positive. The initial idea was good, but as we have seen in Germany, any intervention by the Government can cause major disruption the market.

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Tamer Turna: Yes, the philosophy behind renewable power generation is sound, but I am not convinced that the targets have been set realistically. However, when it comes to energy, decision makers for incentives must create a technical and financial model which is both durable and doable. The current incentive scheme is now being questioned, so we need a better model that assesses the system boundaries at a larger scale and simultaneously foresees the root cause of issues at each decentralised point of generation and consumption.

Jacob Klimstra: The main issue is that back-up plants are currently not properly compensated financially for their service. The costs for back-up power are generally not taken into account when considering the costs of integrating renewable sources. Power plants should also be rewarded for providing a fast response to changes in required output caused by scenarios such as higher forecasting errors and rapid changes in output from renewables. It is essential that these financial considerations be incorporated when considering the costs of renewables.

Philippe Paelinck: Germany's experience has shown that incentives for renewables can be overgenerous and distort investment. In the future power market, renewables will need to contribute to security of supply just as fossil fuel operators will need to contribute to climate protection. Renewables should support the efficiency of the overall system by being traded together with stable forms of generation – and specifically in combination with efficient fossil fuel generation. Moreover, the market would need to factor in the cost of increased intermittency.

As the share of renewables rises, there is consensus that regulation of the grid will have to change, but how, given that utilities are increasingly unable to finance Europe's clean-energy system under current business models?

Jacob Klimstra: What the power sector needs right now is a robust reward mechanism to ensure a system capable of securing a stable and reliable supply of electricity in the long term. The best strategy for allowing a substantial share of intermittent renewable electricity sources in the system is to integrate electricity and heat requirements, since separating them will never result in an optimised system. Heat and chill can easily be stored, while the excess electricity from renewables can be used to generate heat in an efficient way.

Philippe Paelinck: The so-called capacity market is one of several potential solutions to this issue, but national initiatives would need to be closely coordinated at EU level to avoid another layer of complexity that could potentially further undermine the situation.

Alstom is participating in a number of pilot projects in order to help new business models emerge. These are designed to help develop new contractual frameworks for renewable integration, and to minimise the integration costs and delays resulting from network reinforcement, as well as incentives. The integration of distributed energy resources aggregation also offers a potential alternative to traditional generation.

The contractual framework for storage connection to the grid will need to be clarified, as will the management of Smart Metering data, and questions around ownership, security and privacy. The facilitation of self-consumption and peer-to-peer energy exchanges within distribution networks will bring new challenges.

Today, it is still too early to be able to say with certainty how all these issues will be solved. The technical and regulatory issues are similar in every country, but the answers will differ, because of the differences in energy mix and societal models.

Pascal Stijns: It all comes back to strong coordination at European level. The biggest question is how fast changes should be implemented, and political consensus on this will be critical, since you are interfering with market mechanisms and therefore impacting directly on private companies. Furthermore, the grid is just one element amongst several, in that it provides the mechanism for transporting a large amount of energy, but generation and storage are also major elements that need to be addressed. In any market mechanism, the companies that perform well are those that are innovative and creative in dealing with costs, whereas companies that are not doing this will eventually be phased out.

Crucially, the electricity market must be treated differently in respect of enforcing a pure market mechanism – like banks, we cannot allow utilities to go broke. So in the short term, it is fine to have targets for things like renewables and carbon emissions, but over the longer term, something has to change.
Tamer Turna: The consumer has to pay the real cost. And it's the job of the regulators to calculate and reflect the real cost in the form of consumer tariffs. Crucially, tariffs must be set at a level ensuring utilities can survive.

Using pumped hydro or batteries, to cover nightly use during the summer months is possible, but no cost effective means exists. Therefore, fuel-based back-up is needed and that means using local or central fuel-based generation. The same applies for extended periods of time with hardly any wind power output. As long as on average less than 20 per cent of electricity is originated from intermittent renewables, there is no serious threat to the stability of the grid. As soon as the contribution from renewables reaches 30 per cent, grid problems will arise.

Pascal Stijns: If you take Germany again as an example, where there is something like 20,000 megawatts of solar capacity installed, if that comes together with a high amount of wind on a bad day the grid will struggle to maintain stability and electricity has to be exported at negative prices (as it did last year). If this happens frequently there is a risk that utilities will collapse and the money men end up with the final say. There are regulations in place to prevent this scenario, but as renewables penetration increases, things will have to change to ensure greater flexibility in the grid and the energy market.

Philippe Paelinck: Although the threat posed to grid reliability by the rapid rise of renewables in Europe has not yet materialised, the on-going mothballing of CCGT plants, combined with

the electricity market must be treated differently in respect of enforcing a pure market mechanism – like banks, we cannot allow utilities to go broke. So in the short term, it is fine to have targets for things like renewables and carbon emissions, but over the longer term, something has to change

Threats to the reliability of the grid posed by increases in renewables have not materialised, but do you believe the risks remain significant, and how could they be mitigated?

Tamer Turna: Privatisation of the power system has resulted in the exploitation of the reserve capacities in the generation and transmission systems of Europe. In view of the technical challenge,, I believe there are two options. The first would be to let the liberal market decide – i.e. how much extra will consumers be prepared to pay? The most likely outcome would be lower growth of green energy on transmission grids, forcing the market towards decentralised solutions. The second option would be to establish a central fund to support investment in the transmission lines necessary for transporting renewable energy to areas of consumption. The adaptation of thermal generation technologies is easier to handle within the liberal energy market and would not need any special treatment in the form of subsidies.

Jacob Klimstra: The intermittent nature of renewable energy sources means large-scale back-up is required to guarantee an uninterrupted power supply. Take the large difference in output of solar panels between summer and winter as an example.

the coal plant retirements planned under the EU's Industrial Emissions Directive (IED), mean that we will soon have exhausted the hefty reserve margin of 40 per cent. And, with the weight of renewable energy in the system increasing, the overall stability of the grid will undoubtedly be undermined. We could enter the danger zone as early as 2016/17, or possibly sooner if the economy picks-up rapidly in the EU.

Fortunately, the installed thermal base, and especially coal power plants, has proven a lot more flexible than was anticipated initially. Continued efforts on energy efficiency should also keep demand in check. The financial crisis also provided a comfortable reserve margin by reducing demand. Nevertheless, EU energy security and unification are complementary goals – in that the latter will deliver the former. To achieve these goals the industry must now work together with regulators to ensure third parties have better access to the interconnectors that are being built, while unlocking the financing and implementing the new business models necessary to support these investments.

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Balance of system extends market reach

Solar is traditionally restricted by the ability of an installation to receive enough sunlight. A Californian installer had a problem roof in a problem area. They discovered the choice of the right sprocket from a BOS supplier enabled them to complete an install they would have turned down.

A barrel roof with HVAC equipment and skylights is not the ideal platform for a crystalline panel solar system, but a watertight attachment system from Silverback Solar allowed architects, engineers and contractors to work with such challenges.
As part of a major renovation seeking Net Zero energy LEED certification, DPR Construction of San Francisco wanted to install solar panels on its roof to generate electricity for use within its downtown office. The remodel also included natural lighting and a new energy efficient HVAC system.

"This project is 118kW, which is equal to about 26 residential solar systems," explained Sam Kim, sales engineer for Vista Solar, a California-based company that designs, engineers, finances, installs and maintains commercial solar systems. "Our energy production goal for this project is 158,000kWh in the first year. Normally this production ratio would be no problem, but this building is in an urban area in downtown San Francisco with buildings shading the roof on three sides. "

Challenging environments

Vista Solar encountered a number of unique challenges during the install. First, taller buildings on three sides of the DPR Construction offices required the arrays to be elevated to a level where the sun could hit them. Second, the roof has two large atriums, several skylights, HVAC units and 16 skylights.
"Not only are these objects taking up space on the roof for solar, but the fire guidelines that require pathways to and clearances around these objects further reduced the usable space we had on the roof," Kim said. "With a typical flat roof ballasted system, we could simply design modules to wrap around these objects, but that wasn't an option available to us because of the surrounding buildings and the barrel roof construction."
Finally, the truss engineering of the roof dictated very specific loading points to attach the solar system. They were at 20 foot spans, so the racking solution required had to be able to handle 20-foot spans, at elevation, with minimal part count, no field welding and have the versatility to accommodate site changes for newly installed solar tubes.

The layout and design of the solar panels depended on the ability of the Silverback Solar team to work around solar lights, skylights and HVAC equipment. It was all made easier by the versatility the company's adjustable sprocket

Flexible mountings

Engineering and unique innovation from Silverback Solar went a long way to helping complete this curved roof solar project.
"Not only was Silverback able to deliver the needed solutions, but the engineers at Silverback were able to work with our team to help create some custom attachments that allowed us to work around an HVAC unit and maximize the system capacity for the client," said Kim.

Silverback Solar's mounting system features a roof attachment system that creates a completely watertight structural mounting point. It also features a patented adjustable sprocket to allow adjustments with the curvature of the roof.

Silverback Solar's engineering department was able to utilize as much roof space as possible for solar panels by elevating them above HVAC equipment with the Silverback Solar racking system

"The Silverback product is both lightweight and durable, which makes the building of the racking easy and faster to install than other similar racking systems," says John Bruce, general foreman for Vista Solar. "The ability to adjust the bracing and supports makes the racking adaptable to varying terrains. There was no cutting of materials since the racking comes precut and bundled per array."

According to Bruce, the Silverback base mounts were installed at truss supported locations. After all the mounts were installed, the tops of the base mounts were wrapped with plastic bags to protect them from the overspray of the foam roofing material. The foam roof was then sprayed throughout the roof and about the base mounts. After the foam roof was completed, the bags were removed from the mounts. Crews then installed the top bracket and started building the structure.

A shot from the inside of the facility, showing the existing truss system to which the Silverback Solar racking system had to be attached. Inset: Installers work on the framing system to support solar panels

Over a barrel

Staging and assembly was a challenge on the barrel roof, but made easier by the Silverback Solar framing and attachment system. Late changes to the HVAC equipment and solar lighting layout kept Bruce's crew on its toes.

"The most challenging parts of this project was the roof itself, the constant uphill climb due to the dome roof, and not being able to stage materials except for minimal space that is close to a flat surface on the peak of the dome," Bruce said. "Working around skylights and HVAC was probably more challenging on the design and engineering side. Sam was able to keep up with the ongoing changes with the solar tube layout and HVAC locations that were affecting our installation. Silverback was able to work with Sam to provide the necessary engineering and design support throughout the installation."

"This was an extremely complicated design and engineering project," Kim said. "We had weekly meetings leading up to the install to ensure that all the moving parts were working with each other. With a stellar engineering and support team consisting of our in-house team and the folks at Silverback, we were able to deal with most of them pre-installation and quickly make the field adjustments required to get the job done."

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Mixing solar with nature

Stanford scientists have developed a model for solar farms that "co-locates" crops and solar panels and could result in a harvest of valuable biofuel plants along with solar energy.

On a co-located solar farm, runoff from water used to clean photovoltaic panels would nourish agave or other biofuel crops. The plants would in turn provide ground cover, helping prevent dust buildup that decreases solar panel efficiency. (Courtesy Sujith Ravi)

GROWING AGAVE and other carefully chosen plants amid photovoltaic panels could allow solar farms not only to collect sunlight for electricity but also to produce crops for biofuels, according to new computer models by Stanford scientists.

This co-location approach could prove especially useful in sunny, arid regions such as the southwestern United States where water is scarce, said Sujith Ravi, who is conducting postdoctoral research with professors David Lobell and Chris Field, both on faculty in environmental Earth system science and senior fellows at the Stanford Woods Institute for the Environment. “Co-located solar-biofuel systems could be a novel strategy for generating two forms of energy from uncultivable lands: electricity from solar infrastructure and easily transportable liquid fuel from biofuel cultivation,” said Ravi, the lead author of a new study published in a recent issue of the journal Environmental Science & Technology that details the idea.

Using nature’s supports

Photovoltaic (PV) solar farms run on sunlight, but water is required to remove dust and dirt from the panels to ensure they operate at maximum efficiency. Water is also used to dampen the ground to prevent the buildup and spread of dust. Crops planted beneath the solar panels would capture the runoff water used for cleaning the PV panels, thus helping to optimize the land. The plants’ roots would also help anchor the soil and their foliage would help reduce the ability of wind to kick up dust.

Computer simulations of a hypothetical co-location solar farm in Southern California’s San Bernardino County by Ravi and colleagues suggest that these two factors together could lead to a reduction in the overall amount of water that solar farms need to operate. “It could be a win-win situation,” Ravi said. “Water is already limited in many areas and could be a major constraint in the future. This approach could allow us to produce energy and agriculture with the same water.”

But which crops to use? Many solar farms operate in sunny but arid regions that are inhospitable to most food crops. But there is one valuable plant that thrives at high temperatures and in poor soil: agave. Native to North and South America, the prickly plant can be used to produce liquid ethanol, a biofuel that can be mixed with gasoline or used to power ethanol vehicles. “Unlike corn or other grains, most of the agave plant can be converted to ethanol,” Ravi said. The team plans to test the co-location approach around the world to determine the ideal plants to use and to gather realistic estimates for crop yield and economic incentives.

“Sujith’s work is a great example of how thinking beyond a single challenge like water or food or energy sometimes leads to creative solutions,” said Lobell, who is a coauthor on the new study. “Of course, creative solutions don’t always work in the real world, but this one at least seems worthy of much more exploration.”

This research was supported by the TomKat Center for Sustainable Energy at Stanford.

Jet fuel
from solar technology

EU funded project demonstrates the entire production path of “solar” kerosene using solar energy to power and provide raw material.

WITH THE FIRST EVER PRODUCTION of synthesized “solar” jet fuel, the EU-funded SOLAR-JET project has successfully demonstrated the entire production chain for renewable kerosene obtained directly from sunlight, water and carbon dioxide (CO_2), therein potentially revolutionizing the future of aviation. This process has also the potential to produce any other type of fuel for transport applications, such as diesel, gasoline or pure hydrogen in a more sustainable way.

Several notable research organizations from academia through to industry (ETH Zürich, Bauhaus Luftfahrt, Deutsches Zentrum für Luft- und Raumfahrt (DLR), ARTTIC and Shell Global Solutions) have explored a thermochemical pathway driven by concentrated solar energy. A new solar reactor technology has been pioneered to produce liquid hydrocarbon fuels suitable for more sustainable transportation.

“Increasing environmental and supply security issues are leading the aviation sector to seek alternative fuels which can be used interchangeably with today’s jet fuel, so-called drop-in solutions”, states Dr. Andreas Sizmann, the project coordinator at Bauhaus Luftfahrt. “With this first-ever proof-of-concept for ‘solar’ kerosene, the SOLAR-JET project has made a major step towards truly sustainable fuels with virtually unlimited feedstocks in the future.

The SOLAR-JET project demonstrated an innovative process technology using concentrated sunlight to convert carbon dioxide and water to a so-called synthesis gas (syngas). This is accomplished by means of a redox cycle with metal-oxide based materials at high temperatures. The syngas, a mixture

of hydrogen and carbon monoxide, is finally converted into kerosene by using commercial Fischer-Tropsch technology.

"The solar reactor technology features enhanced radiative heat transfer and fast reaction kinetics, which are crucial for maximizing the solar-to-fuel energy conversion efficiency" said Professor Aldo Steinfeld, leading the fundamental research and development of the solar reactor at ETH Zürich.

Although the solar-driven redox cycle for syngas production is still at an early stage of development, the processing of syngas to kerosene is already being deployed by companies, including Shell, on a global scale. This combined approach has the potential to provide a secure, sustainable and scalable supply of renewable aviation fuel and more generally for transport applications. Moreover, Fischer-Tropsch derived kerosene is already approved for commercial aviation.

"This is potentially a very interesting novel pathway to liquid hydrocarbon fuels using focussed solar power", said Professor Hans Geerlings at Shell. "Although the individual steps of the process have previously been demonstrated at various scales, no attempt had been made previously to integrate the end-to-end system. We look forward to working with the project partners to drive forward research and development in the next phase of the project on such an ambitious emerging technology."

SOLAR-JET (Solar chemical reactor demonstration and Optimization for Long-term Availability of Renewable JET fuel) was launched in June 2011 and is receiving financial support from the European Union within the 7th Framework Programme for a duration of four years. In a first step, the technical feasibility of producing solar kerosene was proven.

In the next phase of the project, the partners will optimise the solar reactor and assess the techno-economic potential of moving to industrial scale implementation. The outcomes of SOLAR-JET will put Europe to the forefront of research, innovation and production of sustainable fuels directly from concentrated solar energy.

Pushing organic solar to manufacturability

German based Karlsruhe Institute of Technology (KIT) is coordinating a European Commission funded project that aims to develop sustainable and low cost production for organic solar cells.

ENVIRONMENTALLY COMPATIBLE production methods for organic solar cells from novel materials is the focus of “MatHero’. The new project coordinated by Karlsruhe Institute of Technology (KIT) aims at making organic photovoltaics competitive to their inorganic counterparts by enhancing the efficiency of organic solar cells, reducing their production costs and increasing their life-time. “Green” processes for materials synthesis and coating play a key role. “MatHero” is funded by the European Commission in the amount of EUR 3.5 million.

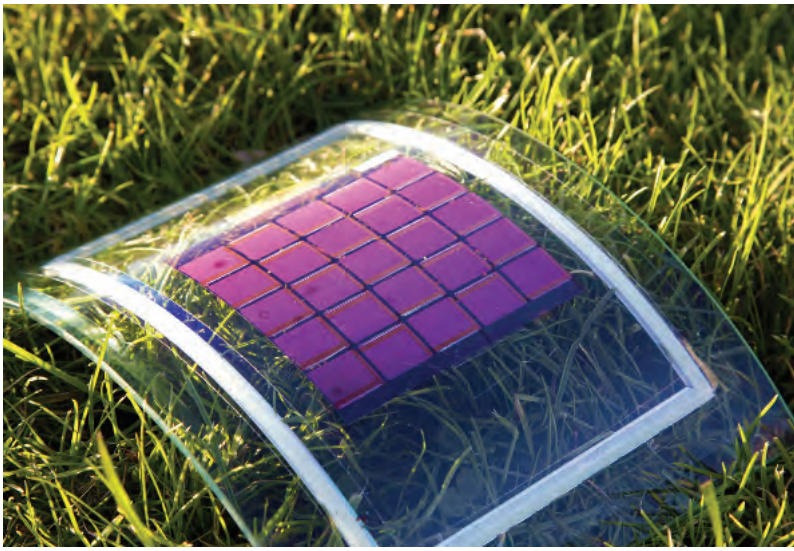
Organic solar cells will open up entirely new markets for photovoltaics. These “plastic solar cells” have several advantages: They are light-weight, mechanically flexible, can be produced in arbitrary colors, and hence allow a customized design for a variety of applications. Moreover, organic solar cells can be produced by printing processes with a low consumption of materials and energy, enabling the inexpensive production of high numbers of solar cells. In order to become competitive in established markets, various challenges still have to be mastered. The energy conversion efficiency has to be improved to more than ten percent. Costs of materials synthesis have to be reduced. The life-time of the materials and modules has to be enhanced to more than ten years.

To reach these objectives, the European project consortium of “MatHero” studies environmentally compatible processes for materials synthesis, coating and printing. All novel printable materials are formulated using non-chlorinated solvents. “The use of environmentally compatible

solvents is a major prerequisite for cost reduction, as complex safety measures on the industrial scale will no longer be required," Dr. Alexander Colsmann of KIT's Light Technology Institute (LTI) explains. Together with Christian Sprau, Colsmann coordinates the project.

"MatHero – New materials for highly efficient and reliable organic solar cells" covers the value chain of organic solar cell fabrication. From design and synthesis of the polymers used to assemble solar cells to the fabrication and characterization of modules to the assessment of device stability. The goal is an environmentally compatible printed organic solar module initially for off-grid. In the consortium, physicists, chemists, materials scientists, and engineers cooperate in an interdisciplinary project team in order to study fundamental scientific and product development aspects. The KIT scientists develop new solar cell architectures and analyze process up-scaling, focusing on enhancing solar cell efficiencies as well as on using environmentally compatible solvents.

"MatHero" is funded by the EC under the 7th framework programme with an amount of EUR 3.5 million. Besides KIT, the research institutions Fraunhofer Institute for Applied Polymer Research (IAP), Potsdam, the Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA) in France, and Acondicionamiento Tarrasense (LEITAT) in Spain participating in the project. The industry partners are Advent Technologies SA (Greece), and Arkema (France) and Eight19 Ltd (UK). The project started in 2014 and is scheduled for three years.



They are light, mechanically flexible and offer a variety of applications: "plastic solar cells" have several advantages (Photo: Alexander Colsmann, KIT)

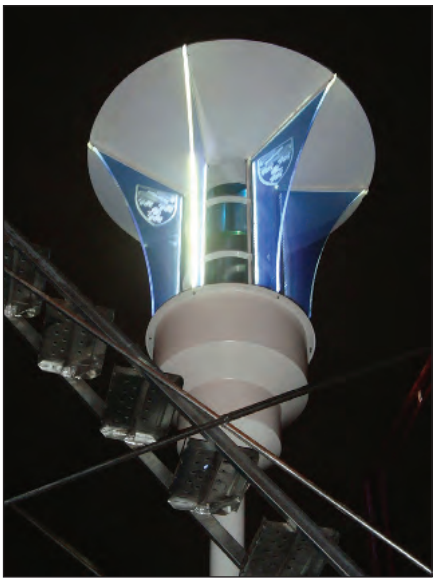
Malaysian researchers reveal new city centre hybrid streetlighting system

Lighting system implements multiple technologies.

AS AN OUTCOME from the continuous hybrid renewable energy research, an innovative outdoor lighting system powered by a shroud-augmented wind turbine and a solar panel was installed in the KL campus of University of Malaya (UM). This hybrid green energy system is a compact design that harmoniously integrates a vertical-axis-wind-turbine (VAWT) with the novel omni-direction-guide-vane (ODGV), solar panel and LED lighting system.

Consisting of several guide vanes, the ODGV is carefully designed and placed to surround the VAWT for wind power augmentation where the oncoming wind is guided through the ODGV. This will create a venturi effect that increases the wind speed before the wind-stream interacts with the turbine blades. Furthermore, the unique design of the ODGV that shrouds the wind turbine rotor provides a safer and more secure environment for maintenance workers and the public.

Ultimately, the ODGV overcomes the low wind speed challenge in the tropics by guiding and increasing the speed of the wind from all directions radially through



the guide-vanes before entering the VAWT at center portion. To harness power from the sun, a photovoltaic panel is mounted on the top surface of the ODGV for solar energy generation. The green energy generated from this wind-solar hybrid system is utilized to power the outdoor lighting system.

The team led by Dr. Chong Wen Tong was awarded a Pre-commercialized Prototype Fund to develop and install the product at suitable locations in the campus. The fund was provided by UM via UM Center of Innovation and Commercialization (UMCIC). The first unit was installed next to the outdoor gymnasium, opposite 1st Residential College. This unit will serve as the first full-scale trial and as a showcase unit of the product. Improvements on the design and features will be included in the next units.

For the commercialization of this product, a Memorandum of Understanding (MoU) has been signed between UM and a private company, Master Shanghai Turnparts Sdn. Bhd. (MSTSB).

MSTSB has provided great assistance in enhancing the product. The second unit of the product is currently in the final stages of fabrication and testing.

The product is protected by three intellectual properties and a trademark, all of which is owned by UM. It also has won several awards in local and international exhibitions. With a motto 'Lighting-up UM', the team aims to provide a sustainable solution for energy efficient and quality lighting powered by wind-solar hybrid renewable energy sources.

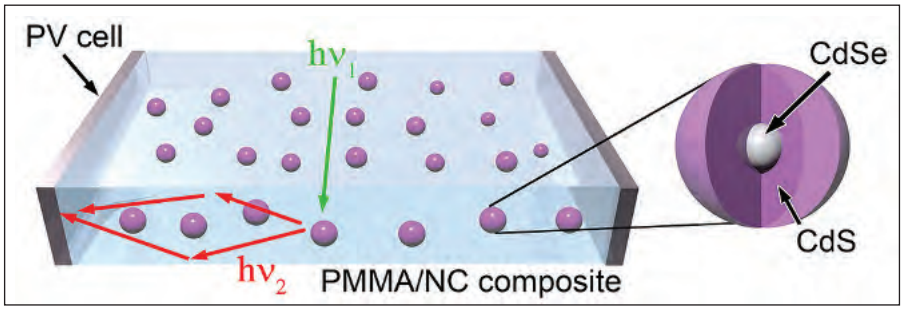
Future Solar brightened by quantum dot manufacturing possibility

Photovoltaic solar-panel windows composed of CdSe/CdS quantum dots could be the next technology used in housing.

A HOUSE WINDOW that doubles as a solar panel could be on the horizon, thanks to recent quantum-dot work by Los Alamos National Laboratory researchers with scientists from University of Milano-Bicocca (UNIMIB), Italy.

Their project demonstrates that superior light-emitting properties of quantum dots can be applied in solar energy by helping more efficiently harvest sunlight. "The key accomplishment is the demonstration of large-area luminescent solar concentrators that use a new generation of specially engineered quantum dots," says lead researcher Victor Klimov of the Centre for Advanced Solar Photophysics at Los Alamos.

Quantum dots are ultra-small bits of semiconductor matter that can be synthesised with nearly atomic precision. A luminescent solar concentrator (LSC) is a photon management device, representing a slab of transparent material that contains highly efficient emitters such as dye molecules or quantum dots. Sunlight absorbed in the slab is re-radiated at longer wavelengths and guided towards the slab edge equipped with a solar cell.



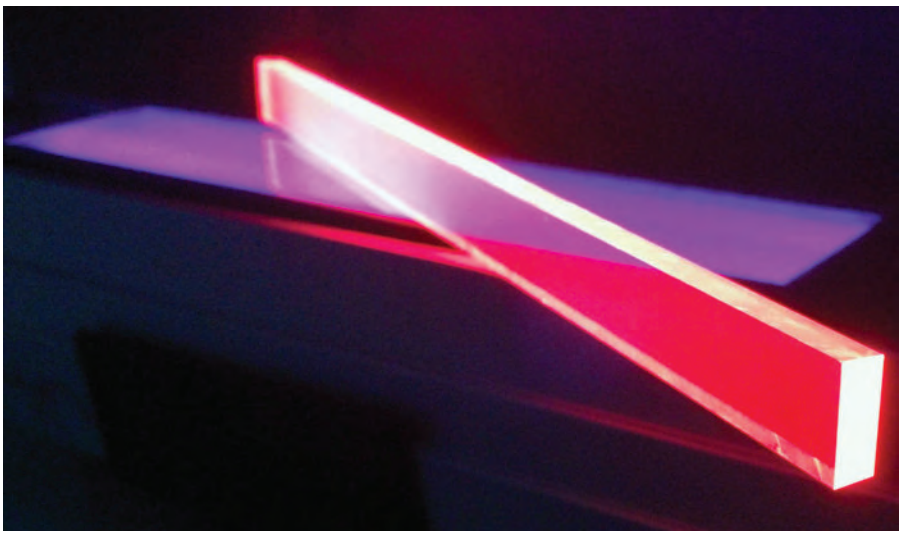
This schematic shows how the quantum dots are embedded in the plastic matrix and capture sunlight to improve solar panel efficiency.

Klimov explains, "The LSC serves as a light-harvesting antenna which concentrates solar radiation onto a much smaller solar cell, and this increases its power output."

"LSCs are especially attractive because in addition to gains in efficiency, they can enable new interesting concepts such as photovoltaic windows that can transform house facades into large-area energy generation units," adds Sergio Brovelli, a faculty member at UNIMIB.

Quantum dots are attractive materials for use in inexpensive, large-area LSCs. To overcome a nagging problem of light re-absorption, the researchers developed LSCs based on quantum dots with artificially induced large separation between emission and absorption bands (called a large Stokes shift). These "Stokes-shift" engineered quantum dots represent CdSe/CdS structures in which light absorption is dominated by an ultra-thick outer shell of CdS, while emission occurs from the inner core of a narrower-gap CdSe.

Los Alamos researchers created a series of thick-shell (so-called "giant") CdSe/CdS quantum dots, which were incorporated by their Italian partners into large slabs (sized in tens of centimetres) of polymethylmethacrylate (PMMA). While being large by quantum dot standards, the active particles are still tiny - only about hundred angstroms across. For comparison, a human hair is about 500,000 angstroms wide.



Journal Reference

The details of this work have been published in the article, "Large-area luminescent solar concentrators based on 'Stokes-shift-engineered' nanocrystals in a mass-polymerized PMMA matrix," by Francesco Meinardi et al in Nature Photonics.

Perovskite promising with tin

Researchers have found a way to improve the growing interest in perovskite materials for solar by replacing the lead with more friendly tin.

Northwestern University researchers are the first to develop a new solar cell with good efficiency that uses tin instead of lead perovskite as the harvester of light. The low-cost, environmentally friendly solar cell can be made easily using "bench" chemistry -- no fancy equipment or hazardous materials.

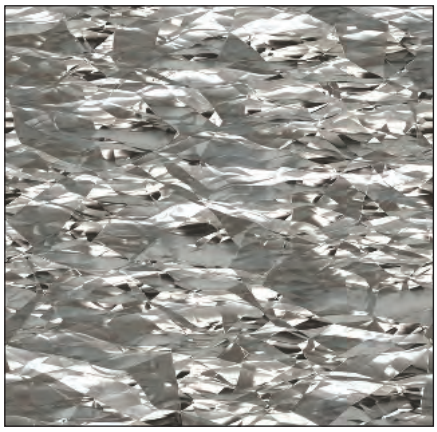
"This is a breakthrough in taking the lead out of a promising type of solar cell, called a perovskite," said Mercouri G. Kanatzidis, an inorganic chemist with expertise in dealing with tin. "Tin is a very viable material, and we have shown the material does work as an efficient solar cell."

Kanatzidis, who led the research, is the Charles E. and Emma H. Morrison Professor of Chemistry in the Weinberg College of Arts and Sciences.

The new solar cell uses a structure called a perovskite but with tin instead of lead as the light-absorbing material. Lead perovskite has achieved 15 % efficiency, and tin perovskite should be able to match, and possibly surpass that. Perovskite solar cells are being touted as the "next big thing in photovoltaics" and have reenergized the field. Kanatzidis developed, synthesized and analyzed the material. He then turned to Northwestern collaborator and nanoscientist Robert P. H. Chang to help him engineer a solar cell that worked well.

"Our tin-based perovskite layer acts as an efficient sunlight absorber that is sandwiched between two electric charge transport layers for conducting electricity to the outside world," said Chang, a professor of materials science and engineering at the McCormick School of Engineering and Applied Science.

Details will be published by Nature Photonics. Kanatzidis and Chang are the two senior authors of the paper.



Their solid-state tin solar cell has an efficiency of just below 6 percent, which is a very good starting point, Kanatzidis said. Two things make the material special: it can absorb most of the visible light spectrum, and the perovskite salt can be dissolved, and it will reform upon solvent removal without heating.

"Other scientists will see what we have done and improve on our methods," Kanatzidis said. "There is no reason this new material can't reach an efficiency better than 15 percent, which is what the lead perovskite solar cell offers. Tin and lead are in the same group in the periodic table, so we expect similar results."

Perovskite solar cells have only been around since 2008. In 2012, Kanatzidis and Chang reported the new tin perovskite solar cell with promises of higher efficiency and lower fabrication costs while being environmentally safe.

"Solar energy is free and is the only energy that is sustainable forever," Kanatzidis said. "If we know how to harvest this energy in an efficient way we can raise our standard of living and help preserve the environment."

The solid-state tin solar cell is a sandwich of five layers, with each layer contributing something important.

Being inorganic chemists, Kanatzidis and his postdoctoral fellows Feng Hao and Constantinos Stoumpos knew how to handle troublesome tin, specifically methylammonium tin iodide, which oxidizes when in contact with air. The first layer is electrically conducting glass, which allows sunlight to enter the cell. Titanium dioxide is the next layer, deposited onto the glass. Together the two act as the electric front contact. Next, the tin perovskite, the light absorbing layer, is deposited.

On top of that is the hole transport layer, which is essential to close the electrical circuit and obtain a functional cell. This required Kanatzidis and his colleagues to find the right chemicals so as not to destroy the tin underneath. They determined what the best chemicals were, a substituted pyridine molecule, by understanding the reactivity of the perovskite structure. This layer also is deposited in the glove box. The solar cell is sealed and can be taken out into the air.

A thin layer of gold caps off the solar-cell sandwich. This layer is the back contact electrode of the solar cell. The entire device, with all five layers, is about one to two microns thick. The researchers then tested the device under simulated full sunlight and recorded a power conversion efficiency of 5.73 percent.

Journal Reference:
Feng Hao, Constantinos C. Stoumpos, Duyen Hanh Cao, Robert P. H. Chang, Mercouri G. Kanatzidis.
Lead-free solid-state organic–inorganic halide perovskite solar cells.
Nature Photonics, 2014;
DOI: 10.1038/nphoton.2014.82

New level of power generation from tiny multi layer solar cells

Researchers at the University of Illinois at Urbana-Champaign use a printing process to assemble tiny cells into multilayer stacks for extraordinary levels of photovoltaic conversion efficiency.

AS AN ENERGY SOURCE, the sun has always been a dependable provider. Although it freely shines on everyone, the ability to capture and convert the sun's abundant energy is anything but free. However, new technologies aimed at achieving "full spectrum" operation in utility-scale photovoltaics may soon make solar energy a viable option.

"A few simple ideas in materials science and device assembly allow us to bypass many of the limitations of traditional photovoltaic technologies," explained John Rogers, whose research group is developing these concepts. As a result of these new efficiencies, external industry experts project solar energy electricity generation costs that can reach, without subsidies, levels that are lower than coal, natural gas, and nuclear.

A Swanlund Chair and professor of materials science and engineering, Rogers is a pioneer in semiconductor devices and manufacturing techniques. A printing approach, developed by Rogers and colleagues at Illinois, allows manipulation of ultrathin, small semiconductor elements that can be stacked on top of one another to yield an unusual type of solar cell capable of operating across the entire solar spectrum at exceptionally high efficiency.

"The strategy involves high-speed, printing-based manipulation of thin, microscale solar cells and new interface materials to bond them into multilayer stacks," Rogers said. "Quadruple-junction, four-terminal solar cells that we can build in this way have individually measured efficiencies of 43.9 percent."

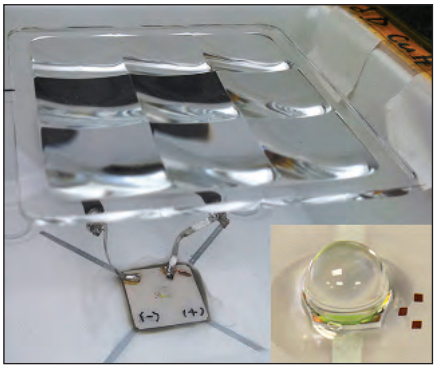
"This is a high-throughput, parallel assembly process that allows for simultaneous formation of arrays of stacked multi-junction cells in a fully automated step-and-repeat mode with high yields, greater than 95 percent, and accurate overlay registration. A newly developed interfacial material for these stacks enables ideal optical, electrical, and thermal properties, " stated Xing Sheng, a postdoctoral fellow with Rogers' research group and first author of the paper published this week in the journal Nature Materials.

The project involved a collaborative team of researchers at the University of Illinois and the photovoltaic companies Semprius and Solar Junction. According to the group's paper, the module's top cell consists of a three-junction (3J) microcell with its own anti-reflective coating to ensure efficient transmission of light to the uppermost layers.

The bottom cell uses a diffused-junction germanium (Ge) architecture. In a stacked 3J/Ge assembly, the top 3J cell captures light with wavelengths between 300nm and 1,300nm. Wavelengths from 1,300nm to 1,700nm pass through to the bottom Ge cell with minimal interface reflections, due to the use of a thin layer of a unique type of chalcogenide glass.

"We integrated these microscale, multijunction cells into Semprius' dual-stage optics, consisting of a molded primary lens and a secondary, miniature ball lens, to tightly focus incident sunlight by more than one thousand times," Rogers said. "Advanced packaging techniques and electrical matching networks yield fully integrated modules with efficiencies of 36.5 percent evaluated under practical conditions."

"This is very nice work. The results are impressive, and the schemes appear to provide a route to ultra-high efficiency



photovoltaics, with strong potential for utility-scale power generation," stated Ali Javey, a professor of electrical engineering and computer sciences at the University of California, Berkeley. Javey, who is a program leader for electronic materials at the Lawrence Berkeley National Laboratory and a co-director of the Bay Area Photovoltaics Consortium, was not involved with this research.

This work has been published in the paper, "Printing-based assembly of quadruple-junction four-terminal microscale solar cells and their use in high-efficiency modules," by Xing Sheng et al in Nature Materials (2014). doi:10.1038/nmat3946

In addition to Sheng, the paper's authors include Shuodao Wang (materials science), Anthony R. Banks (physics), Christopher J. Corcoran (chemistry), Ralph Nuzzo and John Rogers (materials science and chemistry) at Illinois; Christopher A. Bower, Salvatore Bonafede, John W. Wilson, Brent Fisher, Matthew Meitl, and Scott Burroughs (Semprius, Durham, NC); Homan Yuen (Solar Junction, San Jose, CA); and Ling Shen (Department of Physics, China University of Mining and Technology).

Researchers develop cheaper manufacturing process for TCO films

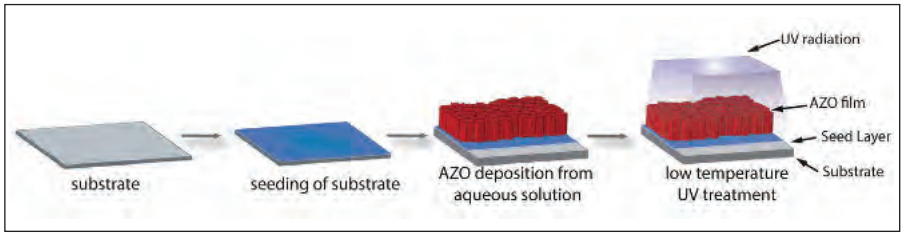
Industry moves closer to environmentally friendly production method for transparent conductive films.

TRANSPARENT CONDUCTIVE FILMS are now an integral part of our everyday lives. Whether in smartphones, tablets, laptops, flat screens or (on a larger scale) in solar cells. Yet they are expensive and complex to manufacture. Now, researchers at Empa have succeeded in developing a method of producing such TCO films, as they are known, that is not only cheaper, but also simpler and more environmentally friendly.

It is a requirement of the touchscreens for all our everyday gadgets that they are transparent and at the same time electrically conductive. Solar cells are also unable to operate without such a film, which allows sunlight to pass through it, but can also conduct the current generated. Conventional “transparent conductive oxide” (TCO) films consist of a mixture of indium and tin oxide. Indium in very much in demand in the electronics industry, but is rare, and therefore expensive.

A cheaper option (at least in terms of the materials used) employs zinc oxide mixed with aluminium, which is usually applied to the substrate in a high vacuum by means of plasma sputtering. However, the manufacturing process is complex, making it similarly expensive. In addition, it is energy-intensive and therefore not ideal from an ecological perspective. Empa researchers at the Laboratory for Thin Films and Photovoltaics have now developed a water-based method of applying a TCO film made of aluminium and zinc salts onto a substrate – without a vacuum.

Another advantage of the new method is that during the last stage of production, in which the TCO film is “cured”, the substrate does not have to be heated to 400 to 600 degrees as was previously the case, but only to 90 degrees. “This means that our method is not only cheaper and more environmentally friendly, but also requires less energy and it is even possible to use more heat-sensitive substrates, such as flexible plastics”, explains Harald Hagendorfer from the research team.



The biggest difference, however, lies in the principle behind the manufacturing process. Whereas with the sputtering method, the TCO film is deposited onto the substrate in a high vacuum using a high-energy plasma, with the Empa method, this occurs through a type of molecular self-organisation. Thus, the TCO film grows “by itself” - with no subsequent high-temperature thermal treatment. A short irradiation process with a UV lamp is sufficient to produce excellent conductivity.

Yet here too, a problem had to be overcome: aluminium zinc oxide (AZO) prefers to grow tapering upwards - like stalagmites in a limestone cave. For optimum conductivity, however, there must be no gaps between the “pillars”. The simple solution devised by the Empa team was to use a “molecular lid” during the crystal growing process. Thus, the material can only grow to a limited height and instead grows widthways, resulting in a compact film which is transparent and has optimum conductivity.

The Empa team, led by Ayodhya Tiwari, is now working to further improve the AZO films. In terms of electrical conductivity and transparency, they can already compete with indium-containing TCO films, but some optimisation is still required with regard to their use in solar cells. Tiwari and his colleagues want to reduce the TCO film thickness from one to two microns to just a few hundred nanometres. This would allow the AZO films to be used in flexible solar cells, further reducing the amount of material used. Tiwari’s team is also currently working with another Empa research group on the indium-free production of organic solar cells, which would make the process cheaper and more sustainable. There certainly seems to be a considerable amount of interest in the new method. Industrial project partners are already on board, opening up the possibility that Empa TCO films may soon be manufactured on a large scale.

Journal Reference:
H. Hagendorfer, K. Lienau, S. Nishiwaki, C.M. Fella, L. Kranz, A.R. Uhl, D. Jaeger, L. Luo, C. Gretener, S. Buecheler, Y.E. Romanyuk, A.N. Tiwari. Highly Transparent and Conductive ZnO: Al Thin Films from a Low Temperature Aqueous Solution Approach. Advanced Materials, 2014 DOI: 10.1002-adma.201303186

The transparent conductive film under an electron microscope: the crystals are grown widthways, close together using a “molecular lid” - giving the film optimum conductivity.

Six metre long flexible solar module on display

An organic solar cell, six metres long has gone on display.

A SOLAR MODULE, six meters long and 50 cm wide, consisting of flexible organic solar cells is the result of the European research project "FabriGen," a joint effort between six partners from four different countries. This novel power producing foil will be on display at an upcoming conference.

The module is manufactured exclusively with a roll-to-roll process. The organic solar cells do not contain the customary indium-tin-oxide and therefore have the potential to be particularly economical.

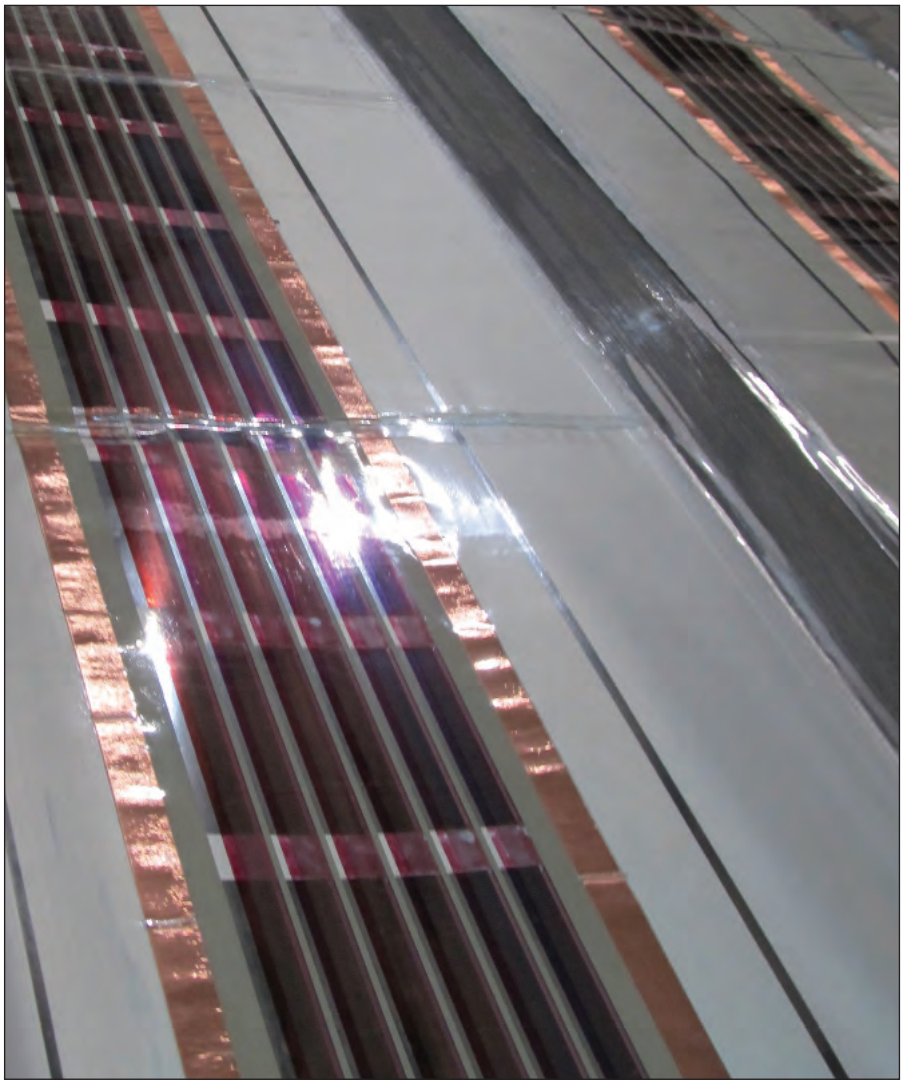
The project idea targeted applications in the field of membrane architecture, which incorporates tensile membrane structures as roofs, for example, in the architectural design.

"FabriGen, fabric structures for solar power generation" is an EU-sponsored project. Its project partners from Germany, Great Britain, the Czech Republic and Bulgaria had the mutual goal of developing fabric structures which are integrated with organic solar cells.

The project was initiated by Robert Carpenter, Managing Director of Inside2Outside (I2O), a medium-sized company in Great Britain. For his special fabric structures with organic solar cells, he has a variety of different uses in mind, especially in the field of architecture.

Applications include shading systems for pedestrian zones and bus stops as well as shed and carport roofs. The focus lies in cost-effectively covering large areas with flexible polymer constructions which cost markedly less than glass.

By making use of complex structures through membrane design, the area in question can be made as large as possible, thus maximizing the solar gain. At the same time, transport and installation costs are kept low due to the light weight of the structure.



"We are pleased to have produced this successful prototype with our partners within the short time span of six months," says Dr. Birger Zimmermann, Team Leader of Production Technology for Organic Solar Cells at Fraunhofer ISE.

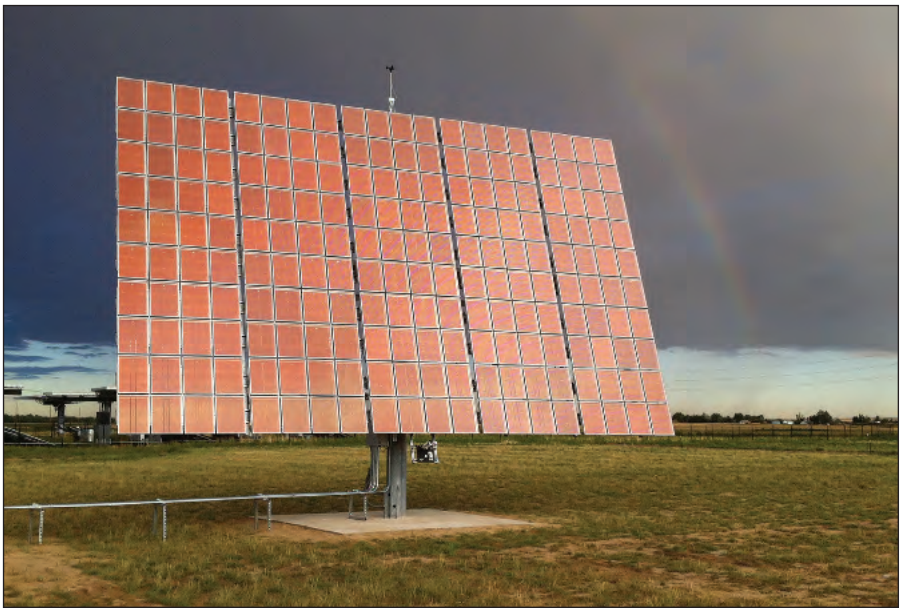
"Manufacturing the textile structure equipped with organic photovoltaic modules was a real joint effort," remembers the project coordinator Robert Carpenter, I2O. "From vacuum processing the metal electrode at CPI, followed by coating the organic semiconductor at Fraunhofer ISE through to printing the silver contacts and the lamination at Coatema and lastly the high frequency welding of the solar foil on the fabric membrane at I2O, a range of expertise was involved." The solar cell structure and the module design were developed at Fraunhofer ISE. The Freiburg researchers were involved in the encapsulation development with CPI in Great Britain.

All project partners contributed their input to integrating the photovoltaics into a fabric membrane, above all, CPI and the project coordinator Inside2Outside Ltd.

Coatema Coating Machinery GmbH was responsible for the process development of the large area lamination.

First four junction four terminal stacked solar cell

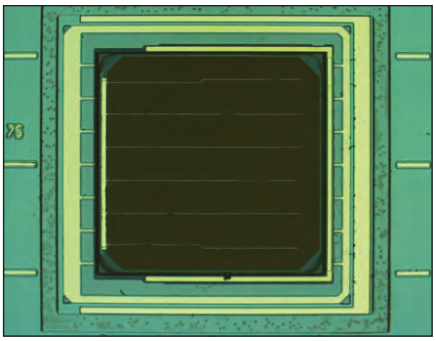
Semprius demonstrates four-junction, four-terminal stacked solar cell reaching an efficiency level of 43.9 percent.



The top cell in the stacked 3-junction/germanium assembly captures wavelengths between 300nm and 1,300nm; wavelengths from 1,300nm to 1,700nm pass through to the bottom cell.

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

The new stacked solar cell is comprised of a three-junction microcell that is stacked on top of a single-junction germanium microcell using Semprius' high-speed micro transfer printing process, which enables the simultaneous formation of thousands of stacked microcells with very high yields.



Dual-stage optics, consisting of a molded 2 X 2 cm primary lens and a secondary, 2 mm ball lens (inset) focus incident sunlight by more than one thousand times. –

By using four junctions, the stacked cell is able to capture light across a broader portion of the solar spectrum and therefore achieve efficiencies much higher than conventional silicon and thin-film single-junction solar cells. Initial trials yielded solar cells with measured efficiencies up to 43.9 percent. This process is capable of achieving solar cell efficiencies greater than 50 percent in the near future.

A key achievement of this project was the development of a new interfacial material that is placed between the top and bottom cell to minimize optical losses within the stack and thereby optimize overall conversion efficiency. In addition, the new stacked cell has four terminals, rather than the standard two. This reduces the spectral dependence of the solar cell and increases the solar cell's energy yield under normal operation in the field.

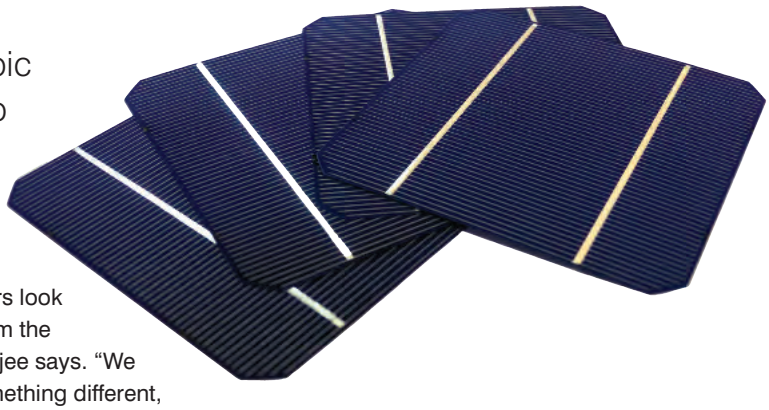
Semprius is a graduate of the U.S. Department of Energy's SunShot Incubator Program. "This achievement is notable because it establishes a straight-forward path to significant future increases in conversion efficiency," said Dan Friedman, manager of the National Renewable Energy Laboratory (NREL) III-V Multijunction Photovoltaics Group. "Increasing efficiency is critical to reducing the cost of solar energy because it helps drive down not only module costs, but also many other costs, including the cost of land, labor and wiring."

Semprius has been at the forefront of high-efficiency, HCPV solar module development for the past seven years. In 2012, Semprius announced the first mass-produced photovoltaic module that exceeded 33 percent efficiency. In September 2013, Semprius increased this record to 35.5 percent, as confirmed by the Fraunhofer Institute for Solar Energy Systems ISE in Germany.

"We would like to thank our collaborators at the University of Illinois and Solar Junction for their help in this project," said Scott Burroughs, vice president of Technology at Semprius. "Because the process we used is fully compatible with our current production processes, we believe this demonstration can be easily transferred to manufacturing."
Over the past two years, Semprius has deployed systems with strategic customers in six U.S. states and eight countries around the world.

Copper nanowires show promise for solar cells

Observation of copper growth at microscopic levels has enabled a team of researchers to imagine future solar cells from copper nanowires.



BY LOOKING at a piece of material in cross section, Washington University in St. Louis engineer Parag Banerjee, PhD, and his team discovered how copper sprouts grass-like nanowires that could one day be made into solar cells.

Banerjee, assistant professor of materials science and an expert in working with nanomaterials, Fei Wu, graduate research assistant, and Yoon Myung, PhD, a postdoctoral research associate, also took a step toward making solar cells and more cost-effective.

Banerjee and his team worked with copper foil, a simple material similar to household aluminum foil. When most metals are heated, they form a thick metal oxide film.

However, a few metals, such as copper, iron and zinc, grow grass-like structures known as nanowires, which are long, cylindrical structures a few hundred nanometers wide by many microns tall. They set out to determine how the nanowires grow.

"Other researchers look at these wires from the top down," Banerjee says. "We wanted to do something different, so we broke our sample and looked at it from the side view to see if we got different information, and we did."

Results of the research were recently published in CrystEngComm.

Washington University's International Center for Advanced Renewable Energy & Sustainability (I-CARES) and the McDonnell Academy Global Energy and Environment Partnership (MAGEEP) provided funding for the research.

The team used Raman spectroscopy, a technique that uses light from a laser beam to interact with molecular vibrations or other movements.

They found an underlying thick film made up of two different copper oxides (CuO and Cu^2O) that had narrow, vertical columns of grains running through them.

In between these columns, they found grain boundaries that acted as arteries through which the copper from the underlying layer was being pushed through when heat was applied, creating the nanowires.

"We're now playing with this ionic transport mechanism, turning it on and off and seeing if we can get some different forms of wires," says Banerjee, who runs the Laboratory for Emerging and Applied Nanomaterials (L.E.A.N.).

Like solar cells, the nanowires are single crystal in structure, or a continuous piece of material with no grain boundaries, Banerjee says.

The find may also benefit other engineers who want to use single crystal oxides in scientific research.

Manufacturing single crystal Cu^2O for research is very expensive, Banerjee says, costing up to about $1,500 for one crystal.

"But if you can live with this form that's a long wire instead of a small crystal, you can really use it to study basic scientific phenomena," Banerjee says.

Banerjee's team also is looking for other uses for the nanowires, including acting as a semiconductor between two materials, as a photocatalyst, a photovoltaic or an electrode for splitting water.

Funding for this research was provided by Washington University's International Center for Advanced Renewable Energy & Sustainability (I-CARES) and the McDonnell Academy Global Energy and Environment Partnership (MAGEEP).

Journal Reference:
Fei Wu, Yoon Myung, Parag Banerjee. Unravelling transient phases during thermal oxidation of copper for dense CuO nanowire growth. CrystEngComm, 2014; 16 (16): 3264
DOI: 10.1039/c4ce00275j

Perovskite power lights up solar energy market

New research from scientists at the University of Bath will help in the development of 'perovskite solar cells' that have the potential to radically revolutionise the solar market.

SINCE BEING UNVEILED last year, researchers around the globe have been excited by the prospect of perovskite solar cells. These cells are cheap and easy to produce, highly efficient at converting the sun's rays to electricity and therefore, combined, have strong commercial potential.

Recently published research from the Materials Design Group within the University's Department of Chemistry now explains how and why these cells work so well which will help in the future development of solar technologies. Professor Aron Walsh, who leads the Group, explains: "Hybrid perovskites are an exciting development for solar energy research. The field is rapidly progressing, but the devices have been developing faster than our fundamental understanding of how they work."

Perovskites combine organic and inorganic chemistry to mimic a crystal structure found in a natural mineral, 'perovskite', discovered in Russia in 1839. Using the UK's largest supercomputer, the researchers at Bath have been able to model the chemical and physical properties of these materials.

The first publication, led by Federico Brivio as part of Bath's DESTINY Initial Training Network, in Physical Review B details how the quantum mechanical interaction between electrons and their rapid motion in these materials allows them to absorb sunlight so strongly.

The second paper, led by Dr Jarvist Frost as part of an EPSRC energy materials consortium, in Nano Letters, reveals the mechanisms by which the materials can convert sunlight to electricity.

This is distinct from previous generations of solar cells due to the role of organic molecules not present in natural perovskite minerals.

Commentators suggest that if we could capture approximately 1 per cent of the sunlight falling on the UK and turn it into electricity, we would meet current energy demands. With recent studies suggesting that new solar cells using perovskites could create efficiencies pushing 20 per cent, such technologies could elevate solar power in the UK at a cost that could compete with fossil fuels.

Such high efficiencies would also make perovskites competitive with existing commercial silicon solar cells while at the same time being much cheaper to produce in high volumes. Suitable for incorporating into roofing materials and glass panels, new solar technologies could soon be a common feature in city architecture.

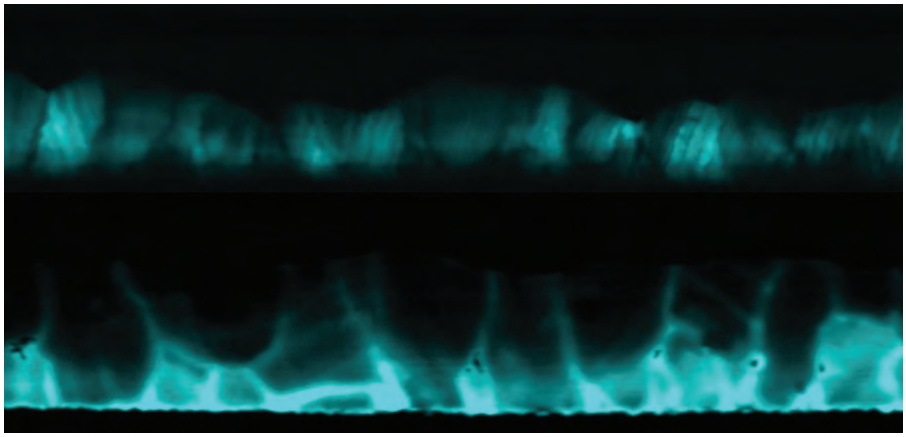
Professor Walsh added: "Our materials simulations are complementing experimental characterisation in our Department, by Dr Petra Cameron and Professor Laurie Peter, which is allowing us to bridge from the fundamental to applied science."

Journal Reference

American Physical Society
Relativistic quasiparticle self-consistent electronic structure of hybrid halide perovskite photovoltaic absorbers. Phys. Rev. B 89, 155204 – Published 21 April 2014. Authors Federico Brivio, Keith T. Butler, Aron Walsh, and Mark van Schilfgaarde.

Researchers explain CdTe thin-film solar cell mystery

A long standing mystery in thin film manufacturing with CdTe has finally been explained.



Cross-sectional electron beam-induced current maps show the difference in cadmium telluride solar cells before (pictured above) and after (below) cadmium chloride treatment. The increased brightness after treatment indicates higher current collection at the grain boundaries. Cross-sectional electron beam-induced current maps show the difference in cadmium telluride solar cells before (above) and after (below) cadmium chloride treatment. The increased brightness after treatment indicates higher current collection at the grain boundaries.

TREATING CADMIUM-TELLURIDE (CdTe) solar cell materials with cadmium-chloride improves their efficiency, but researchers have not fully understood why. Now, an atomic-scale examination of the thin-film solar cells led by the Department of Energy's Oak Ridge National Laboratory has answered this decades-long debate about the materials' photovoltaic efficiency increase after treatment.

A research team from ORNL, the University of Toledo and DOE's National Renewable Energy Laboratory used electron microscopy and computational simulations to explore the physical origins of the unexplained treatment process. The results are published in Physical Review Letters (PRL).

Thin-film CdTe solar cells are considered a rival to silicon-based PV systems because of their theoretically low cost per power output and ease of fabrication. Their comparatively low historical efficiency in converting sunlight into energy has limited widespread use. Research in the 1980s showed that treating CdTe thin films with cadmium-chloride raises the cell's efficiency, but scientists have been unable to determine the causes. ORNL's Chen Li, first author on the PRL study, explains that the answer lay in investigating the material at an atomic level.

"We knew that chlorine was responsible for this magical effect, but we needed to find out where it went in the material's structure," Li said. "Only by understanding the structure can we understand what's wrong in this solar cell -- why the efficiency is not high enough, and how can we push it further."

By comparing the solar cells before and after chlorine treatment, the researchers realized that atom-scale grain boundaries were implicated in the enhanced performance. Grain boundaries are tiny defects that that normally act as roadblocks to efficiency, because they inhibit carrier collection which greatly reduces the solar cell power.

Using state of the art electron microscopy techniques to study the thin films' structure and chemical composition after treatment, the researchers found that chlorine atoms replaced tellurium atoms within the grain boundaries. This atomic substitution creates local electric fields at the grain boundaries that boost the material's photovoltaic performance instead of damaging it.

The research team's finding, in addition to providing a long-awaited explanation, could be used to guide engineering of higher-efficiency CdTe solar cells. Controlling the grain boundary structure, says Li, is a new direction that could help raise the cell efficiencies closer to the theoretical maximum of 32 percent light-to-energy conversion. Currently, the record CdTe cell efficiency is only 20.4%.

"We think that if all the grain boundaries in a thin film material could be aligned in same direction, it could improve cell efficiency even further," Li said.

The research was supported by the Department of Energy's Office of Energy Efficiency and Renewable Energy through the SunShot Initiative and the Office of Basic Energy Sciences. The work was sponsored in part by the UK Engineering and Physical Sciences Research Council and through a user project supported by ORNL's Center for Nanophase Materials Sciences (CNMS). This research used resources of the National Energy Research Scientific Computing Center.

Journal Reference:
Chen Li, Yelong Wu, Jonathan Poplawsky, Timothy J. Pennycook, Naba Paudel, Wanjian Yin, Sarah J. Haigh, Mark P. Oxley, Andrew R. Lupini, Mowafak Al-Jassim, Stephen J. Pennycook, Yanfa Yan. Grain-Boundary-Enhanced Carrier Collection in CdTe Solar Cells. Physical Review Letters, 2014; 112 (15) DOI: 10.1103/PhysRevLett.112.156103

Scientists reveal flappable ultra-thin cells

Researchers in the US reveal nanostructures like a hall of mirrors. Nanostructures that trap photons inside ultrathin solar cells.

IN THE QUEST to make sun power more competitive, researchers are designing ultrathin solar cells that cut material costs while keeping efficiency by sculpting the surfaces with PV nanostructures that behave like a molecular hall of mirrors.

"We want to make sure light spends more quality time inside a solar cell," said Mark Brongersma, a professor of materials science and engineering at Stanford and co-author of a review article in Nature Materials.

Brongersma and two Stanford colleagues -- associate professor of materials science and engineering Yi Cui and professor of electrical engineering Shanhui Fan -- surveyed 109 recent scientific papers from teams around the world.

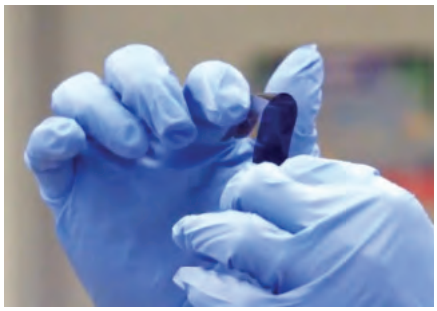
Their overview revolves around a basic theme: looking at the many different ways that researchers are trying to maximize the collisions between photons and electrons in the thinnest possible layers of photovoltaic materials. The goal is to reveal trends and best practices that will help drive developments in the field.

Solar energy is produced when photons of light collide with the electrons in a photovoltaic crystal. As loose electrons move through the crystal, they generate an electrical current.

Today's solar cells are already thin. They are made up of layers of photovoltaic materials, generally silicon, that average 150 to 300 micrometers, which is roughly the diameter of two to three human hairs.

As engineers continue to shave down those dimensions they have to develop new molecular traps and snares to ensure that photons don't simply whiz through their ultrathin solar cells before the electrical sparks can fly.

"A lot of the excitement now is about using the principles of photonics to manage



Thin silicon with thickness below 10 micrometer has excellent flexibility. It can be handled and processed.

light waves in the most efficient way," Fan said. "There are perhaps hundreds of groups in the world working on this."

The review article provides a high level view of how scientists are trying to design structures to facilitate interactions between the infinitesimal instigators of solar current, the photons and the electrons. Research face enormous challenges in trying to architect nanostructures attuned to catch light.

Creating different nanostructures to catch the pot of photons at the end of each color of the rainbow is part of what this research is about.

"We are seeing systems that use one one-hundredth as much photovoltaic material as today's solar cells while getting 60 percent to 70 percent of the electrical output," Brongersma said.

The most common photovoltaic material is a refined form of silicon similar to that found in computer chips. This material accounts for 10 percent to 20 percent of a solar cell's cost. Lowering those expenses 100-fold would therefore have a considerable effect on the overall cost-efficiency of solar energy production.

But Cui says lowering material costs is only part of the ultrathin solar story. Another benefit is flexibility. Because of the thickness of the light-catching silicon layer, today's solar cells must be kept rigid lest their crystal lattice be damaged and the flow of electrons disrupted.

"But at 10 micrometers of thickness silicon has a high degree of mechanical flexibility," said Cui, citing a dimension less than one-tenth the thickness of the PV layer inside today's solar cells.

Cui, who has made just such an experimental material, shows a movie of flapping this thin silicon like a piece of paper and cutting it with a scissors. Those thin silicon strips incorporate some of the photon-trapping nanostructures described in the Nature Materials article. Cui says the light-to-energy conversion efficiency of thin silicon is approaching that of the rigid silicon in today's solar cells.

Flapping silicon isn't just a science project. Such flexibility would pay a dividend when it comes to installation, which accounts for roughly one-third of the total cost of a rooftop solar array. "These thin silicon cells can be embedded into flexible plastic, making installation like rolling out a carpet," Cui said.

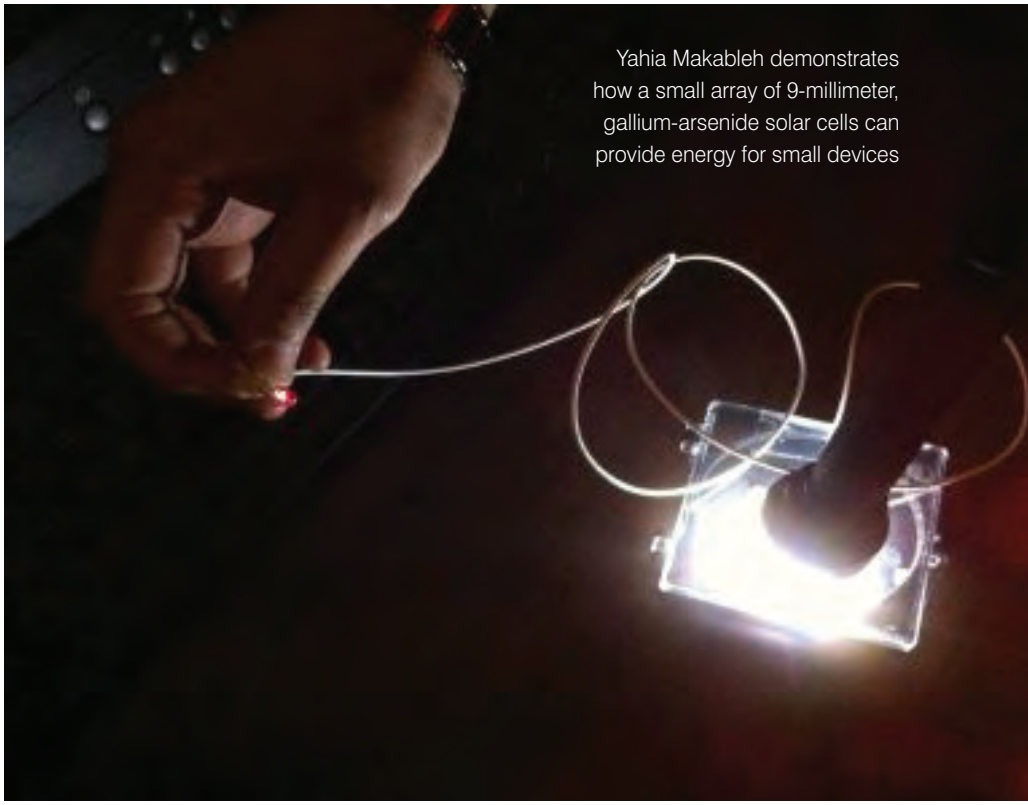
Yet even as researchers succeed in getting more from less, many hurdles remain according to Fan, who develops computer models to study how different nanostructures and materials will affect photon-electron interactions.

"There are an infinite number of structures, so it isn't possible to model them all," he said, alluding to what he called the "theoretical bottlenecks" that impede understanding of this ethereal realm where light and matter intersect.

"For instance, right now, we really don't have a way to know when we've gotten the most out of our photons," Fan said.

Researchers use zinc oxide coating to achieve higher efficiency

Scientists have achieved efficiency records by using zinc oxide to instigate surface modification on gallium arsenide that allows cell to absorb more light.



Yahia Makableh demonstrates how a small array of 9-millimeter, gallium-arsenide solar cells can provide energy for small devices

ENGINEERING RESEARCHERS at the University of Arkansas have achieved the highest efficiency ever in a 9 millimeter-squared solar cell made of gallium arsenide. After coating the cufflink-sized cells with a thin layer of zinc oxide, the research team reached a conversion efficiency of 14 percent.

A small array of these cells – as few as nine to 12 – generate enough energy for small light-emitting diodes and other devices. But surface modification can be scaled up, and the cells can be packaged in large arrays of panels to power large devices such as homes, satellites, or even spacecraft.

The research team, led by Omar Manasreh, professor of electrical engineering, published its findings in Applied Physics Letters and the April 2014 issue of Solar Energy Materials and Solar Cells.

An alternative to silicon, gallium arsenide is a semiconductor used to manufacture integrated circuits, light-emitting diodes and solar cells. The surface modification, achieved through a chemical synthesis of thin films, nanostructures and nanoparticles, suppressed the sun's reflection so the cell could absorb more light. But even without the surface coating, the researchers were able to achieve 9-percent efficiency by manipulating the host material.

"We want to increase the efficiency of small cells," said Yahia Makableh, doctoral student in electrical engineering. "With this specific material, the theoretical maximum is 33 percent efficiency, so we have some work to do. But we're making progress. The beauty of zinc oxide is that it's cheap, non-toxic and easy to synthesize."

Makableh said the surface modification could also be applied to other types of solar cells, including those made of indium-arsenide and gallium-arsenide quantum dots. Solar cells made of these materials may be able to achieve towards 63 percent conversion efficiency, which would make them ideal candidates in the search for future development in manufacturing solar cells.

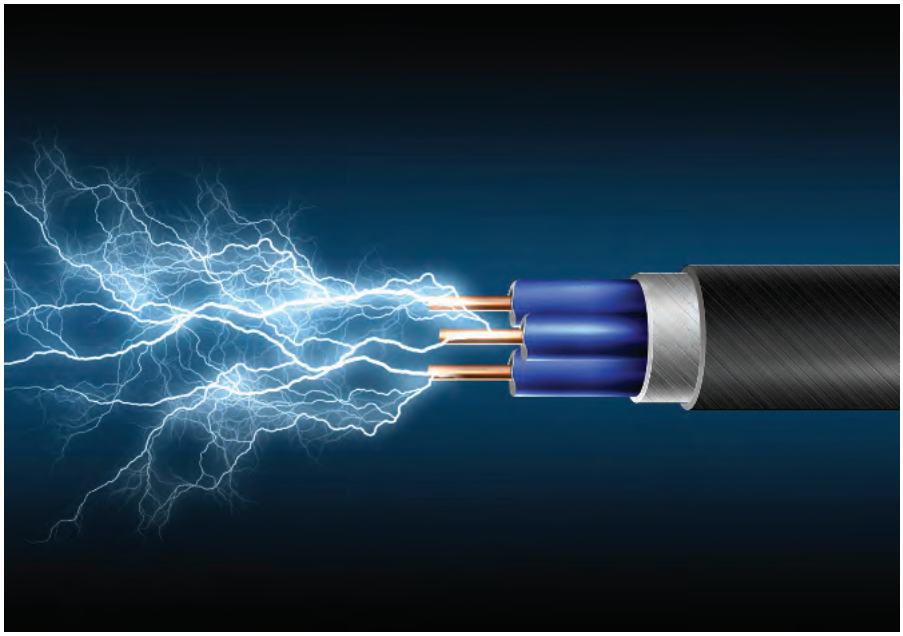
Makableh used equipment and instrumentation in the College of Engineering's Optoelectronics Research Lab, which is directed by Manasreh. Researchers in the lab grow and functionalize semiconductors, nanostructured anti-reflection coatings, self-cleaning surfaces and metallic nanoparticles to be used in solar cells. Their ultimate goal is to fabricate and test photovoltaic devices with greater solar-energy conversion efficiency.

Manasreh focuses on experimental and theoretical optoelectronic properties of semiconductors, superlattices, nanostructures and related devices. Since joining the University of Arkansas in 2003, he has received more than $8 million in public research funding from the National Aeronautics and Space Administration, the U.S. Air Force and the National Science Foundation.

Journal Reference:
Y.F. Makableh, R. Vasan, J.C. Sarker, A.I. Nusir, S. Seal, M.O. Manasreh. Enhancement of GaAs solar cell performance by using a ZnO sol–gel anti-reflection coating. Solar Energy Materials and Solar Cells, 2014; 123: 178 DOI: 10.1016/j.solmat.2014.01.007

Energy storage breakthrough uses cables as batteries

SOUNDS LIKE SCIENCE FICTION, but it may become a reality thanks to breakthrough technology developed at a University of Central Florida research lab. So far electrical cables are used only to transmit electricity. However, nanotechnology scientist and professor Jayan Thomas and his Ph.D. student Zenan Yu have developed a way to both transmit and store electricity in a single lightweight copper wire.



Their work is featured in Advanced Materials and science magazine Nature has published a discussion about this technology. “It’s an interesting idea,” Thomas said. “When we did it and started talking about it, everyone we talked to said, ‘Hmm, never thought of that. It’s unique.’”

Copper wire was the starting point but eventually, Thomas believes and as the technology improves, special fibres could be developed with nanostructures to conduct and store energy.

More immediate applications could be in the design and development of electrical vehicles, space-launching vehicles and portable electronic devices. The ability to store and conduct energy on the same wire could see heavy, space-consuming batteries become a thing of the past. It will also be possible to further miniaturize the electronic devices or take advantage of the space previously used for batteries to add functionality to a device. In the case of launch vehicles designed for space haulage, that could potentially lighten loads and reduce costs dramatically.

Thomas and his team began with a single copper wire. They then placed a sheath over the wire made up of nanowhiskers the team grew on the outer surface of the copper wire. These whiskers were then treated with a special alloy, which created an electrode. Two electrodes are needed for the energy storage. So they had to figure out a way to create the second electrode.

This was achieved by adding a thin plastic sheet around the whiskers and wrapping it using a metal sheath after generating nanowhiskers on (the second electrode and outer covering). The layers were then glued together with a special gel. Because of the insulation, the inner copper wire retains its ability to channel energy, but the layers around the wire independently store energy. In other words, Thomas and his team created a supercapacitor on the outside of the copper wire. Supercapcitors store energy, like that needed to start a vehicle or heavy-construction equipment.

Although more work needs to be done, Thomas said the technique should be transferable to other types of materials. That could lead to specially treated clothing fibres being able to hold enough power for large tasks. For example, if flexible solar cells and these fibres were used in tandem to make a jacket, it could be used independently to power electronic gadgets and other devices.

“It’s very exciting,” Thomas said. “We take it step by step. I love getting to the lab everyday, and seeing what we can come up with next. Sometimes things don’t work out, but even those failures teach us a lot of things.”

Yu is the co-author of the study. He works in Thomas’ Nano Energy-Photonics Group where they conduct research focused primarily on nanostructured supercapacitors and Lithiuim-ion batteries, nanoarchitectured light-trapping solar cells, photorefractive polymers for 3D display applications, and nonlinear optical materials.

Journal Reference:
Zenan Yu, Jayan Thomas. Energy Storing Electrical Cables: Integrating Energy Storage and Electrical Conduction. Advanced Materials, 2014;

Efficient and cost effective dye sensitized cells

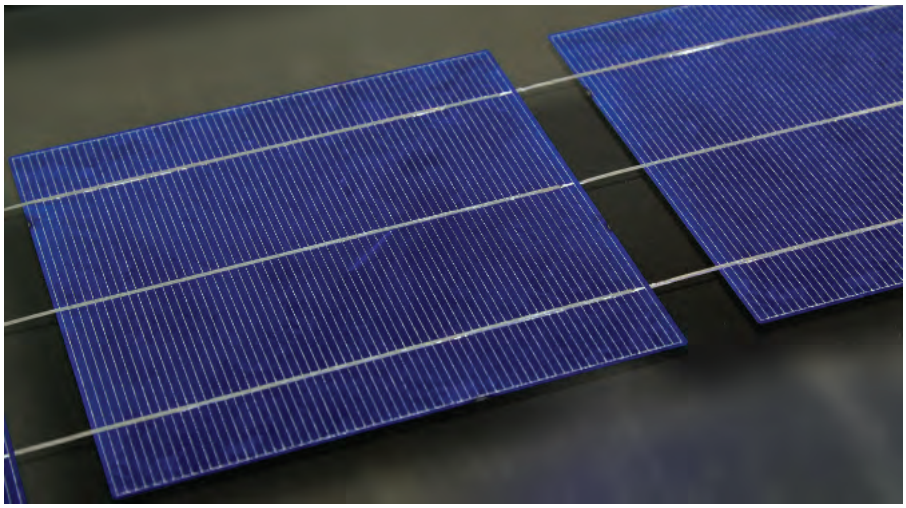
Working on dye-sensitized solar cells researchers from University Malaya (UM) and National Tsing Hua University (NTHU) have achieved an efficiency of 1.12 %, at a fraction of the cost compared to those used by platinum devices.

MALAYSIAN AND TAIWANESE researchers have made advances in dye sensitized solar cells with two groups of researchers announcing advances in the field of solar cells with a cheaper and efficient replacement for platinum and better synthesis of zinc oxide.

The study in Taiwan took on the challenge of making dye-sensitized solar cells more affordable by replacing the platinum counter-electrodes with bismuth telluride (Bi2Te3) nanosheet arrays. Using an electrolysis process, the group managed to manipulate the spacing between individual nanosheets and control the thermal and electrical conductivity to achieve the 1.12%, comparable to platinum but at a fraction of the cost. The research was led by Prof. Yu-Lun Chueh of the Nanoscience & Nanodevices Laboratory, NTHU, and Alireza Yaghoubi, UM HIR Young Scientist.

“In light of the recent report by the UN about the effects of fossil fuels on climate change we think it is necessary to look for a sustainable, yet practical source of energy” Yaghoubi stated.

Meanwhile at University Malaya, Dr. Wee Siong Chiu and colleagues were working on controlling the secondary nucleation and self-assembly in zinc oxide (ZnO), a material which is currently being scrutinized for its applications in dye-sensitized solar cells as well as



photocatalytic reactions to generate clean electricity by splitting water under sunlight. In this work, Dr. Chiu and Alireza Yaghoubi demonstrated a route for synthesis of various zinc oxide nanostructures using the lipophilic interactions between a novel precursor and a number of fatty acids.

They are hoping to use this method to increase the efficiency of photocatalysts. According to the researchers, if this approach is successful, generating electricity is as easy as pouring some bioinert nanomaterials into a lake and fusing the split oxygen and hydrogen atoms back into water in a photoelectrochemical cell. The paper will be on the front cover of CrysEngComm. The collaboration between UM and NTHU was set in motion after a visit by a delegate of scientists. Renewable energies have been importnat research topics but technologies are still in their infancy and are expensive or not sufficiently efficient.

“This is only the beginning of a long-lasting collaboration between us”, Prof. Chueh remarked.

Yaghoubi and Chueh are at the moment working as a part of an international collaboration with universities in France and USA to find a substitute for two-dimensional materials such as graphene which have been difficult to use in large-scale industrial applications.

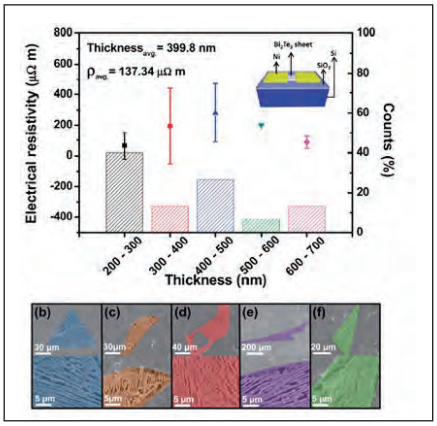
1. Hung-Wei Tsai, Tsang-Hsiu Wang, Tsung-Cheng Chan, Pei-Ju Chen, Chih-Chun Chung, Chien-Neng Liao, Alireza Yaghoubi, Eric Wei-Guang Diau, and Yu-Lun Chueh. “Fabrication of Large Scale Single Crystal Bismuth Telluride (Bi2Te3) Nanosheet Arrays by Single Step Electrolysis Process.” Nanoscale (2014). DOI: 10.1039/C4NR00184B

2. W.S. Chiu, A. Yaghoubi, M.Y. Chia, N.H. Khanis, S.A. Rahman, P.S. Khiew, and Y.L. Chueh. “Self-assembly and secondary nucleation in ZnO nanostructures derived from a lipophilic precursor.” CrystEngComm (2014). DOI: 10.1039/C4CE00442F

3. Dr. Chiu and Alireza Yaghoubi’s work is funded by the HIR Grant UM.C/625/1/HIR/079

Major breakthrough claimed for dye sensitive solar cells

Researchers have shown that air exposure causes incorporation of gas molecules into the spiro-MeOTAD layer and the findings could help extend solar efficiencies over time.

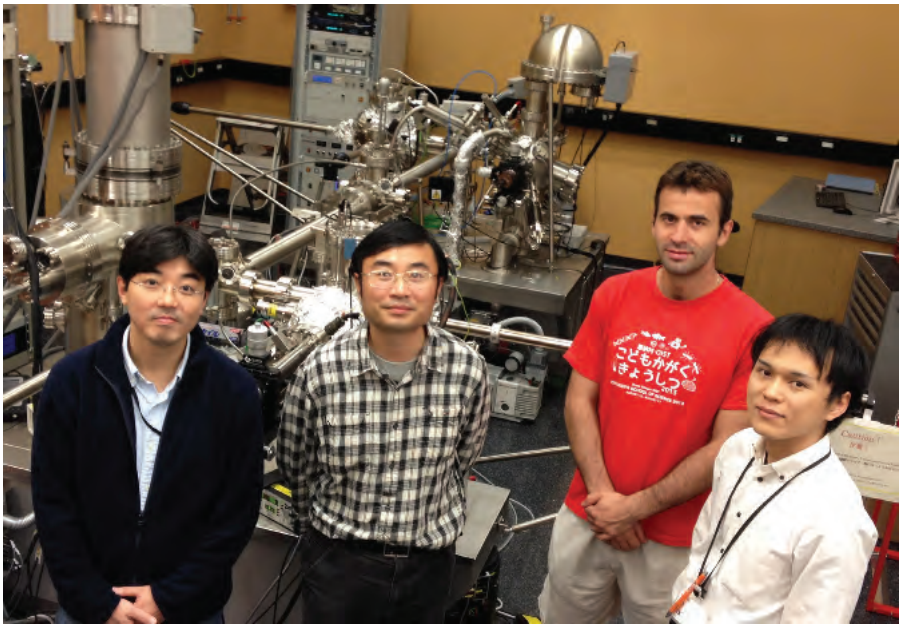


OIST's Energy Materials and Surface Sciences Unit has made a surprising discovery about the degradation of solar cells that could help pave the way to creating a longer lifetime for these cells. Key factors for creating cost-efficient solar cells to compete with conventional energy sources like fossil fuels include fabrication cost, efficiency and lifetime of the cells. Professor Yabing Qi and members of his unit have investigated the cause of degradation of a high efficiency solar cell. This discovery, published in The Journal of Physical Chemistry Letters, can help move various forms of solar cell technology forward now that researchers know what is causing degradation and shortening the lifespan.

Solid state dye-sensitized solar cells have shown their potential in achieving high efficiency with a low cost of fabrication. Degradation of these cells, which shortens lifespan, is not well understood.

To investigate the causes of degradation, Prof. Qi and colleagues focused on a material widely used in these solar cells, which is abbreviated spiro-MeOTAD. This material is used in the upper-most layer of the solar cell and comes into contact with the outside environment. Therefore, it is a likely candidate to be susceptible to degradation from many possible sources including air exposure, continuous light irradiation, elevated temperature and dust.

The most likely source of degradation was thought to be photo-oxidation, which is a chemical process caused by exposure to both air and light. Prof. Qi and colleagues tested whether this process was occurring. Surprisingly, they showed conclusively that there was no detectable photo-oxidation, or chemical degradation, of spiro-MeOTAD even after exposure for a few days. The researchers next looked at other possible degradation mechanisms due to exposure to air alone. Spiro-MeOTAD is an amorphous substance, which is the property that makes it useful in these solar cells. However, this property could also cause a problem in that molecules from the air may easily diffuse, or freely pass into, the spiro-MeOTAD. These air molecules would then become impurities in the solar cells, leading to degradation. After analysis, the researchers determined this was occurring; foreign air molecules were causing degradation of the spiro-MeOTAD layer, resulting in a drop in solar cell efficiency.



The next step is to find a material to encapsulate and protect the spiro-MeOTAD layer from air exposure and prevent diffusion and the subsequent degradation from occurring.

Prof. Qi sid, "If we can find a method of low cost encapsulation, it is possible, for the first time, to achieve low cost, high efficiency and long lifespans in the same cell." Since these solar cells are easy and cost-efficient to produce, adding this extra step can provide one more piece of the puzzle for an ideal solar cell. Prof. Qi added, "This technology is compatible with the coating technology of the flexible transparent electrodes that we are working on, meaning we can use this research for fabrication of large area, transparent, flexible solar cells."

This work was performed in collaboration with Professor Antoine Kahn and his research group at Princeton University. DSSC, Advanced Technologies R&D, Merck Ltd., Japan kindly provided spiro-MeOTAD for this study.

Smaller grids will prevent blackouts

Researchers in the USA have looked at the national electric grid set up across the country and concluded that right-sizing the grid could reduce blackout risk.

SOME 90 YEARS AGO, British polymath J.B.S. Haldane proposed that for every animal there is an optimal size, one that allows it to make best use of its environment and the physical laws that govern its activities, whether hiding, hunting, hoofing or hibernating. Three researchers are now asking whether there is a "right" size for another type of huge beast: the U.S. power grid.

David Newman, a physicist at the University of Alaska, believes that smaller grids would reduce the likelihood of severe outages, such as the 2003 Northeast blackout that cut power to 50 million people in the United States and Canada for up to two days. Newman and co-authors Benjamin Carreras, of BACV Solutions in Oak Ridge, Tenn., and Ian Dobson of Iowa State University make their case in the journal Chaos.

Their investigation began 20 years ago, when they were studying why stable fusion plasmas turned unstable so quickly. They modeled the problem by comparing the plasma to a sandpile.

"Sandpiles are stable until you get to a certain height. Then you add one more grain and the whole thing starts to avalanche. This is because the pile's grains are already close to the critical angle where they will start rolling down the pile. All it takes is one grain to trigger a cascade," he explained.

While discussing a blackout, Newman and Carreras realized that their sandpile model might help explain grid behavior. North America has three power grids, interconnected systems that transmit electricity from hundreds of power plants to millions of consumers. Each grid is huge, because the more power plants and power lines in a grid, the better it can even out local variations in the supply and demand or respond if some part of the grid goes down.
On the other hand, large grids are vulnerable to the rare but significant possibility of a grid-wide blackout like the one in 2003.

"The problem is that grids run close to the edge of their capacity because of economic pressures. Electric companies want to maximize profits, so they don't invest in more equipment than they need," Newman said.

On a hot days, when everyone's air conditioners are on, the grid runs near capacity. If a tree branch knocks down a power line, the grid is usually resilient enough to distribute extra power and make up the difference. But if the grid is already near its critical point and has no extra capacity, there is a small but significant chance that it can collapse like a sandpile. This is vulnerable to cascading events comes from the fact that the grid's complexity evolved over time.

In their new paper, the researchers ask whether the grid has an optimal size, one large enough to share power efficiently but small enough to prevent enormous blackouts. The team based its analysis on the Western United States grid, which has more than 16,000 nodes.

The model started by comparing one 1,000-bus grid with ten 100-bus networks. It then assessed how well the grids shared electricity in response to virtual outages. Though grid wide blackouts are highly unlikely, they can dominate costs. They are very expensive and take longer to get things back under control. They also require more crews and resources, so utilities can help one another as they do in smaller blackouts.

In smaller grids, the blackouts are smaller and easier to fix because utilities can call for help from surrounding regions. Overall, small grid blackouts have a lower cost to society. The researchers believe their insights into sizing might apply to other large networks.

Journal Reference

"Does size matter?" by B. A. Carreras, D. E. Newman, Ian Dobson appears in Chaos: An Interdisciplinary Journal of Nonlinear Science
(DOI: 10.1063/1.4868393).

Blending PV into the landscape

The fourth edition of the Special Session Photovoltaics | Forms | Landscapes will take place in Amsterdam in September as part of the EUPVSEC. The target audience present at this conference, about 4000 scientists, engineers, entrepreneurs, financing organisations and political decision makers, are not necessarily aware of the opportunities and specific features photovoltaics can offer. In the 4th edition of this event the organizers want to extend the possibilities with PV and have chosen the theme, 'Beauty and Power of Designed photovoltaics '.

Internationally renowned researchers, producers, architects and landscape designers present their concepts for making PV systems a new cultural experience which enhances the relationship between the citizens and the energy environment.

With the rising number of PV installations used on building roofs and as integrated systems in the urban environment or as large fields, acceptance by citizens becomes an increasing issue and in the case of larger installations, also an issue with authorities. Emphasis is given to designs which foster further cost reduction and which add value to the systems such as dual and hybrid functions of photovoltaic modules. Building integration such as modules as building material or as an integral part of the building construction. Visibility and "vivibility" of urban spaces with shading and weather protection two possibilities. Ideas where Upgrade of open spaces and landscape that can provide higher agricultural yield, reduction of soil degradation, water collection, industrial or transport infrastructures are to be featured.

The event is co-organised by the European Commission, Joint Research Centre (JRC), ENEA, the Italian National Agency for New Technologies, Energy and Sustainable Economic Development, WIP and ETA-Florence Renewable Energies.

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Solar International is published six times a year on a controlled circulation basis. Non-qualifying individuals can subscribe at: £110.00 (UK & Europe), $140 pa (USA). Cover price £5.50.
 Printed by: Pensord Press Ltd. ISSN (Print) 2040-8714 (Online) 2040-8722. © 2014.

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