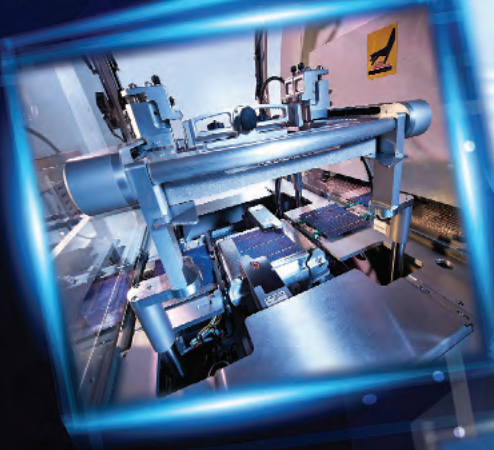


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A PV MANAGEMENT MAGAZINE

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Award winners  
revealed



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# editor's view

By david ridsdale, editor-in-chief

## A year of firsts

This year will be seen as a key year for the solar and PV industry as the global market goes from strength to strength, providing the impetus for prices to continue to drop as technological capacity improves.

This will be the year that some cities shut down traditional energy sources due to excess solar energy. This will be the year when solar became cheaper than nuclear. This will be the year that new PV installations outstrip wind installations. This will be the year when the regions battled over trade embargoes and market share. This will be the year when solar began to see its true potential realised.

Despite all these positives, solar based energy is still only a fraction of human energy requirements so there is so much room for growth. From a market perspective it is only the beginning of the PV and solar industries but initial fierce competition has meant the industry had to grow up faster than most. This has forced technology and fiscal improvements beyond expectations.

The solar and PV industry is moving to a new era where technology will drive the industry more than subsidies or policy decisions. The cost of solar and PV is heading towards sustainable levels relieving the industry of political struggles initiated by potential competition. The success of the industry has meant new eyes are watching and not everyone is happy with the growth. The industry will have to address the negative efforts by larger industries to slow the rapid growth and integration of solar energy.

Sadly more and more regions are under pressure to curtail renewable growth by incumbent energy suppliers desperate to hold onto dwindling margins and markets. Luckily the German experience demonstrates that over time the market will address



the behemoths desperate to prevent competition and to grab a hold of the sustainable future that is slowly being developed in global energy markets.

The solar industry is generally made up of small to medium enterprises that find themselves becoming energy generators and developers of power plants. As the growth continues and the larger utilities realise they cannot stop it, they will begin to use their large cheque books to buy and bully their way in. It will be the real test for the early commitments of some of the oldest solar companies who entered at a time of unlikely profits and held a philosophical approach to the energy business.

Governments will also need to be wary as too often the loudest voices, read wealthiest, get into the ear to advise a biased direction. If the industry is serious about maintaining its global energy aspirations now is the time to ensure that future direction does not slip into more expensive energy access.





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# UK Prime Minister under fire for energy announcements

FOLLOWING ANNOUNCEMENTS by UK Prime Minister David Cameron suggesting his government will roll back obligation quotas for utility companies as well as announcing a price deal struck with energy giant EDF for Hinkley point C Nuclear energy facility, there has been a strong response from industry, the Opposition government as well as a rebuke from the leader of the government's coalition partner.

Cameron pledged to roll back some of the green regulations that were pushing up consumer bills during Prime Minister Question time in a move that surprised his coalition partner, Deputy Prime Minister Nick Clegg who made it clear he was unaware of such a decision and that it would be Cameron's own goal. Some quarters of the media suggested Cameron was making a weak appeal to appease both consumers and utility giants as DECCs own figures showed the renewable costs to consumers bills was only 9 percent of the overall bill. Clegg even suggested that the bulk of the increases came from wholesale prices.

The Renewable Energy Association immediately called for the Prime Minister to clarify his comments with the fear that he could cause investor disquiet. The UK Building Associations condemned his comments as ill-advised but that is mostly due to the fact that Utility Obligation Requirements have been a huge boon for the building industry with over a quarter of a million houses retrofitted to meet the required improvements in energy savings. The economic benefit of the scheme has reached much further than the household bill as suggested.

REA Chief Executive Dr Nina Skorupska said, "Cameron must clarify which levies he is looking to roll back and how, or risk undermining investor confidence at a time when this country needs investment in new low carbon capacity. Renewables are the only low carbon options on the table to bridge the near term capacity crunch, which will bite before new nuclear or shale gas come on-stream.



Opposition leader Ed Milliband accused the Prime minister of being held hostage by big business and lacking the courage to take on the big six utility companies.

"Renewables policy makes up only 3% of average bills overall and only a third of the Government's 'green levies'," stated Dr. Skorupska. "Politicians and the media are simply wrong to say that green energy is to blame for pushing up bills. It is the ever-increasing cost of gas which has been the main cause of rising bills in recent months and years. With more energy-efficient homes and more home-grown renewables we become less exposed to these volatile gas markets."

The Government also came under attack for announcing details of the Hinkley Point C Nuclear energy facility that detractors say will take a decade to complete when recent studies suggest energy problems may begin in only two years. Renewable energy interests around the country reacted with concern that the same money invested in renewables could achieve the required returns in two years. Mark Turner, Operations Manager at Lighthouse Renewable Energy, a large UK solar power generator took the step to release an open letter to Mr. Cameron as well as sending it to all Cabinet and Shadow cabinet ministers. Part of the letter reads as follows.

"It is our belief that something needs to be done now to address our energy security needs. We must act to protect consumers from energy prices that have risen by over 25% since 2009. We urge you to move from debating about taxes on energy bills and take a serious look at how our future energy needs can be met sustainably.

We believe that solar power can provide energy security quickly, reduce electricity bills and protect the environment at the same time. It not only provides for the local electricity demand, but contributes to the stability of the rural economy and creates local jobs. The solar sector in the UK is gaining traction and the experience in Italy and Germany has shown that the solar industry has the capability to deliver the same energy production as Hinkley Point C in less than 2 years and at a comparable cost.

Solar power will not be the entire solution but if we supported its deployment then within a couple of years we could have 10% of the UK's energy mix completely free from the vagaries of the global fossil fuel markets. This would then combine with the 9% from Hinkley Point C when it eventually comes on stream."

A recent study showed that new solar is now cheaper than new nuclear energy and the pace of policy decisions does not always keep pace with technology cost improvements. Solar continues to reduce in price while improving in technology and the government needs to ensure that the most up to date knowledge is accessible in making decisions.

The overall reaction to the recent announcements suggests energy will remain a contentious topic in the region.

REA's Dr. Skorupska added, "In return for investing in renewables now, we create skilled green jobs in innovative new industries, bringing areas of previous industrial decline back to life. In the long-term we will also get lower, more stable energy prices and preserve a climate which is safe for our families in the future."



# China solar executives arrested over fraud

CHINA SOLAR ENERGY HOLDINGS has released an announcement pursuant to the Rules Governing The Stock Exchange of Hong Kong and Inside Information Provisions of the Securities and Futures Ordinance. The board of directors of the Company has been informed by the Stock Exchange that complaints have been filed with the Stock Exchange, which alleged that (i) the registration of the Changzhou Subsidiary has been revoked by the local administration for industry and commerce and all the assets of Dali Subsidiary, together with the Changzhou Subsidiary have been frozen for the reason that the registered capital of the Dali Subsidiary has not been paid up in accordance with the relevant PRC laws.

The company reports that Mr. Yeung Ngo, the chairman and executive director of the Company, Mr. Yang Yuchun, an executive director of the Company, and Mr. Hao Guojun, a non-executive director of the Company, have been detained by the PRC authority due to fraudulent acts in the PRC which involved the major assets of two subsidiaries of the Company.

Upon notification of the Allegations by the Stock Exchange, the Board has sought advice from its PRC legal advisers in order to ascertain the validity of the Allegations. Based on the investigation conducted by the PRC legal advisers of the Company, the Board would like to provide the following information to the shareholders of the Company in connection with the Allegations as follows:

## 1st allegation

The Changzhou Subsidiary is a wholly foreign-owned enterprise established in the PRC on 14 March 2007 and has an initial registered capital of US\$49,980,000 which shall be paid up on or before 13 March 2009. On 11 December 2007, the Changzhou Subsidiary increased its registered capital to US\$99,980,000 and the increase in registered capital in the amount of US\$50,000,000 shall be paid up on or before 23 June 2010.

As at the date of this announcement, the paid-up capital of the Changzhou Subsidiary is US\$19,358,000.



As advised by the PRC legal advisers of the Company, given that the registered capital of the Changzhou Subsidiary has not been paid up in accordance with the PRC laws, each of the annual review of the Changzhou Subsidiary for the years 2010, 2011 and 2012 has not been passed by the Changzhou Administration for Industry and Commerce and there is a legal risk that a penalty be imposed and/or the foreign investment enterprise approval certificate and the business license of the Changzhou Subsidiary be cancelled or revoked.

However, based on the investigation conducted by the PRC legal advisers of the Company and to the best knowledge, information and belief, after having made all reasonable enquiries by the Directors, the business registration of the Changzhou Subsidiary remains valid and has not been cancelled or revoked and the Changzhou Subsidiary has the corporate legal representative status as at the date of this announcement.

The Board further confirmed that the Changzhou Subsidiary is in the course of relocating its production plant and as such, the Changzhou Subsidiary is not in operation as at the date of this announcement. As advised by the PRC legal advisers, the relocation of production plant is not related to the business registration issue of the Changzhou Subsidiary.

## 2nd allegation

The Dali Subsidiary is a wholly foreign-owned enterprise established in the PRC on 24 January 2008 and has a

registered capital of US\$49,460,000 which shall be paid up within 1 year from 24 January 2008. As at the date of this announcement, the paid-up capital of the Dali Subsidiary as shown in the record of the Dali Administration for Industry and Commerce is nil.

Based on the investigation conducted by the legal advisers the assets and documents of the Dali Subsidiary have been temporarily seized by the Public Security Bureau of Dali as at the date of this announcement. The reason for freezing the Assets and seizure of the Documents is due to an investigation of a suspected case of making false report of registered capital which Mr. Yeung and Mr. Yang were involved in.

The Board further confirmed that the Dali Subsidiary has not yet formally commenced operation and it contributes no revenue to the Group up to the date of this announcement.

## 3rd allegation

The Board confirms that the Company is not able to contact the Relevant Directors since around August 2013. Based on the investigation by the legal advisers of the Company, each of the Relevant Directors has been arrested and detained by the Public Security Bureau of Dali since 26 August 2013 for their involvement in a suspected case of making false report in relation to the registered capital.

As the Relevant Directors remain uncontactable, the Company is not able to ascertain the nature and status of the Investigation by the Public Security Bureau of Dali as at the date of this announcement. Following the arrest of the Directors the Board has resolved to suspend the duties and functions of each of Mr. Yeung, Mr. Yang and Mr. Hao.

The Board now comprises 11 Directors, namely, Mr. Yeung Ngo, Mr. Yang Yuchun, Ms. Jin Yan, Mr. Sun Yanfeng, Mr. Guo Lijie, Mr. Hao Guojun, Mr. Li Jian, Mr. Yin Tat Man, Mr. Fan Chuan, Mr. Gu Yizhong and Mr. Zhang Jing. Among these 11 Directors, three Directors have been suspended from their duties.



# California sets energy storage targets

THE CALIFORNIA PUBLIC UTILITIES COMMISSION (CPUC) has set a target for California investor owned utilities to procure 1.325 GW of cost effective energy storage by 2020. The target, which is the largest of its kind worldwide, is set to increase California's installed energy storage capacity six fold from its current 35 MW (excluding large-scale pumped hydro storage). The decision is the result of a 2-year regulatory process that studied a multitude of innovative energy storage technologies and applications for meeting the state's growing grid needs. The CPUC has now arrived at a clear conclusion: energy storage is a vital part of the grid of the future, and should be deployed right away.

All 5 CPUC Commissioners approved the landmark decision unanimously earlier today. In her introductory comments, Commissioner Carla Peterman stated, "I believe energy storage has great potential to help us address grid reliability and renewables integration issues. This decision is an important and appropriate step, especially considering the leadership role California has and continues to play in advancing progressive energy policy."

The CPUC's action sets targets for California's investor owned utilities and direct access providers to procure a specified amount of energy storage every two years through 2020, with targets increasing with each solicitation. Some energy storage facilities are expected to come into service as early as 2015, meeting grid needs such as phasing out dirtier power plants, deferring expensive transmission and distribution upgrades, and helping to integrate renewables. This multi-stakeholder process and final decision was set in motion by AB 2514 (Skinner) which became law in 2010. Under AB 2514, the CPUC was required to open a proceeding to consider developing energy storage procurement targets for California utilities to integrate grid-scale storage into the state's electrical power system if determined to be viable and cost-effective.



Assemblywoman Nancy Skinner, the author of AB 2514, expressed excitement about the decision's impact. "California passed AB 2514 so that we would have the opportunity to harness excess electricity generation and use it when needed. The CPUC's decision to ensure storage capacity will increase the reliability of our grid and optimize solar, wind and other renewable resources."

Some of the Decision's highlights include:

- Specific, biennial energy storage procurement targets for Southern California Edison, San Diego Gas & Electric, and Pacific Gas and Electric beginning in 2014 with targets increasing.
- Utilities will be allowed to employ energy storage for a variety of functions throughout the electric power system.
- Utility ownership of storage projects should not exceed 50% of all storage across all three grid domains.
- While large scale pumped storage (>50MW) projects are excluded from the target, the Commission will hold a workshop to further explore the operational characteristics and uses for pumped storage projects.

"Some years from now we will look back in history and realize that Assembly woman Skinner and Commissioner Peterman's vision and leadership profoundly changed the way we operate the grid," said Janice Lin, Executive Director of the California Energy Storage Alliance. "We applaud Commissioner Peterman and the whole Commission for their skillful implementation of AB 2514. Today's momentous decision which will optimize our electric power system, lower costs for consumers, enhance reliability and decrease pollution."

## REC Solar head office moves to United States

FOLLOWING THE LISTING OF REC Solar the remaining operations of Renewable Energy Corporation ASA (REC) will be located in the US.

President & CEO of REC Ole Enger will step down on December 1, 2013 after heading up the company for 4.5 years.

"I want to thank Ole for his significant contribution to the development of REC. His deep industry knowledge and experienced leadership has been crucial in a very challenging phase for the solar industry," says Chairman of the Board, Mimi K. Berdal.



The REC Board of Directors has appointed Tore Torvund as President & CEO of REC/ Mr. Torvund is currently EVP REC Silicon and has been in that role since January 2009.

James May has been appointed CFO of REC. Mr. May is currently CFO of REC Silicon and he has been with REC Silicon since December 2008.

Furthermore Chief Financial Officer Kjell Christian Bjørnsen, Chief Legal Officer Florian Krumbacher and SVP Investor Relations & Business Development Mikkel Tørud will step down from their current positions.

SVP REC Solar Øyvind Hasaas has taken on the role of CEO in REC Solar ASA.





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# Centrosolar's court time accelerates changes

THE MANAGEMENT BOARD of CENTROSOLAR Group have taken the decision to accelerate their efforts to reorganise the operations. The relevant officers have applied to the Local Court of Hamburg, the court responsible in this instance, for the opening of protective shield proceedings which will enable them to retain control.

“Over the past few months we have been working very hard to clear the debt and reconstruct CENTROSOLAR's balance sheet through continuing operations. Our financiers, employees and business partners have supported us in this,” commented the CEO of CENTROSOLAR Group AG, Dr Alexander Kirsch.

However the basis for the restructuring of operations that was announced in parallel was an improvement in the market conditions specifically from CENTROSOLAR's perspective, following the shedding of overcapacity in the

market. The introduction of anti-dumping regulations by the EU in the course of this summer is likewise expected to provide a positive impetus.

“But the recovery is happening later than originally expected. That is why we have reached the conclusion that we need to accelerate and promote the reorganisation of individual group companies by making use of protective shield proceedings, along with the broader scope this approach offers,” added Dr Kirsch.

According to provisional calculations CENTROSOLAR achieved revenue of EUR 27.5 million in the third quarter of 2013. This figure was 40 percent down on the corresponding figure for the previous year – EUR 46.1 million – and above all fell short of the expectations on which the restructuring plan was based. For the first nine months CENTROSOLAR thus achieved a provisional revenue total

of EUR 85.0 million (previous year EUR 145.0 million). In line with the weaker revenue, the result too fell short of expectations.

Pending court approval of the protective shield proceedings, the management of the companies will remain in the hands of the people who are in office. Business operations will continue without restriction. There is no need whatsoever for protective shield proceedings for the subsidiaries, in particular Renusol GmbH, CENTROSOLAR America Inc. and CENTROPLAN GmbH, because they are operating profitably or close to profitability, are fully financed and have no material borrowings from third parties.

During the “protective shield” phase, which is limited to three months, the CENTROSOLAR companies covered by these arrangements are protected against execution and enforcement measures by creditors and remain fully able to act.

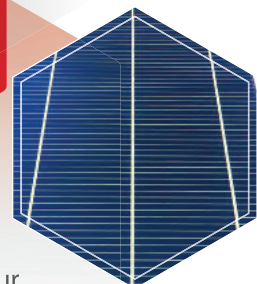
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# Inverter market forecast reassessed

GLOBAL MARKET revenue for solar photovoltaic (PV) inverters will drop by 9 percent in 2013, due to rapid price declines for commercial and utility-scale inverters and intense cost pressure in mature markets such as Germany and Italy, according to the latest data from IHS.

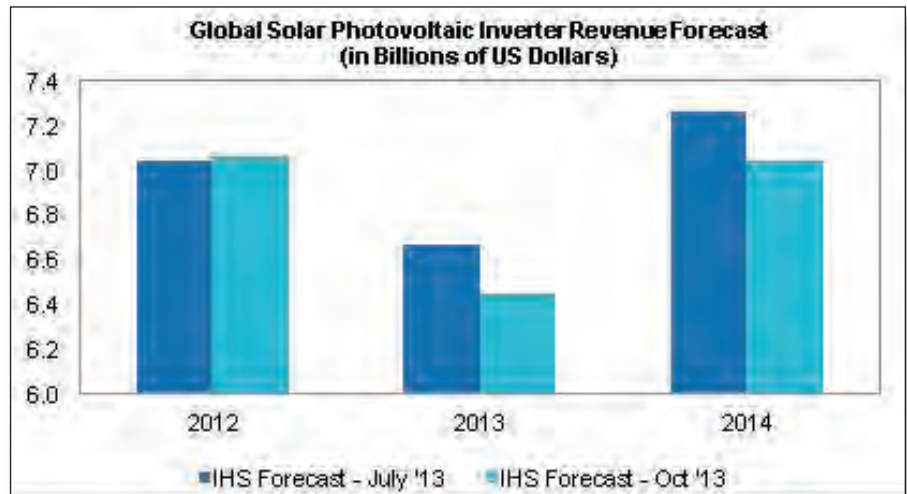
Although worldwide solar inverter unit shipments will rise by 7 percent in 2013, projections now show that market revenue this year will fall. Revenue is set to decline to \$6.4 billion, down from \$7.1 billion in 2012. The previous IHS forecast issued in July predicted a 5 percent decline in revenue in 2013, as presented in the figure on the right.

Average inverter prices now are set to decrease to \$0.18 per watt in 2013, down from \$0.22 per watt in 2012, according to the latest PV Inverter Market Tracker report from IHS. As total PV system prices continue to decrease, all parts of the supply chain, including inverter suppliers, are under pressure to reduce prices.

“During the past few years, solar module makers have endured much more price pressure than the inverter suppliers have,” said Cormac Gilligan, senior PV market analyst at IHS. “However, module prices now have reached an inflection point and have begun to rise. This is having major ramifications for inverter suppliers, with price pressure having shifted to their segment of the business.”

Inverter makers now must absorb some of the price pressure that module suppliers can no longer sustain. Further pressure is occurring because the inverter makers now are being forced to decrease prices in order to win business in a crowded market. Moreover, the solar market is entering a period when government subsidies have been reduced or eliminated in many countries, forcing inverter makers to cut costs to keep their products affordable.

One catalyst for the intense inverter price pressure is declining demand in some of the larger solar markets such as Germany and Italy, where subsidies have been



rapidly reduced or removed completely. Combined inverter shipments to these two markets will fall by more than half this year, dropping to 5.7 gigawatts (GW) in 2013, down from 11.5 GW in 2012. Inverter suppliers that previously relied heavily on these two markets now are being forced into a fiercely competitive market environment, compelling them to decrease prices.

“Total PV inverter revenue throughout Europe in 2013 will be down by 50 percent compared to 2011,” Gilligan noted. “However, the number of inverter suppliers in Europe is largely unchanged. This will result in fierce competition and will prompt inverter suppliers to aggressively enter new emerging markets, such as South Africa and Thailand, in order to find new growth opportunities.”

The price of low-power three-phase inverters decreased rapidly in the first half of 2013, due to a combination of intense competition from suppliers releasing new inverter products and commercial markets shrinking in size in some markets like Europe. A number of Chinese suppliers are also targeting this market, further adding to the competition that European suppliers are facing. In the United States, the world’s two largest suppliers, SMA and Power-One, have released inverters in this power range..

“IHS predicts that shipments of 20- to 35-kilowatt inverters in the United States will reach more than 200 megawatts (MW) in 2013, and new products from the two

largest inverter suppliers will certainly help to drive this growth,” Gilligan added. “Pricing in this segment in the United States is high compared to Europe, and it is likely that the presence of SMA and Power-One will contribute to American prices decreasing to European levels.”

Although utility-scale installations will rise to account for one-third of global demand in 2013 compared to 29 percent in 2012, global prices for large central inverters that serve this market are forecast to decrease by 16 percent to \$0.12 per watt, as shown in the attached figure.

Some of the largest utility-scale markets in 2013 will be Asian countries such as China, India and Thailand, which command prices as low as \$0.06 per watt. For inverter suppliers that do not have a local presence, these very competitive prices can mean that it won’t be economical to enter those markets, even though these nations represent significant growth opportunities.

Another factor that is causing prices for large central inverters to decrease rapidly is that an increasing number of projects are being awarded through bids and tenders, rather than via fixed feed-in-tariffs, particularly in emerging markets.

“Tender and bid mechanisms place a stronger emphasis on upfront inverter prices, which are being lowered in order to win large PV projects, particularly in today’s highly competitive market environment,” Gilligan noted.

# Euro energy infrastructure projects announced

A MODERN INFRASTRUCTURE with adequate interconnectors and reliable networks is crucial for an integrated energy market where consumers get the best value for their money. The European Commission has adopted a list of some 250 key energy infrastructure projects.

These “projects of common interest” (PCI) will benefit from accelerated licensing procedures and improved regulatory conditions and may have access to financial support from the Connecting Europe Facility, under which a €5.85 billion budget has been allocated to trans-European energy infrastructure for the period 2014-20. This will help them get implemented faster and make them more attractive to investors.

Energy Commissioner Günther Oettinger said, “We have to make sure that our limited funds are used wisely and that EU money goes where it can create most benefits to European consumers. With this list of energy infrastructure projects and their accompanying benefits, we also hope to attract more investors.”

The list includes up to 140 projects in the field of electricity transmission and storage, about 100 projects in the field of gas transmission, storage and LNG, and several oil and smart grids projects. The projects will benefit from a number of advantages:

- Accelerated planning and permit granting procedures (binding three-and-a-half-years’ time limit);
- A single national competent authority will act as a one-stop-shop for permit granting procedures;
- Less administrative costs for the project promoters and authorities due to a more streamlined environmental assessment procedure, whilst respecting the needs of Union law.
- Increased transparency and improved public participation;
- Increased visibility and attractiveness for investors thanks to an enhanced regulatory framework where costs are allocated to the countries that benefit most from a completed project;



- Possibility to receive financial support under the Connecting Europe Facility. This will play a role in leveraging the private and public funding, and possible financing can come in as early as 2014.

For a project to be included in the list, it had to have significant benefits for at least two Member States; contribute to market integration and further competition; enhance security of supply, and reduce CO2 emissions. The Commission will monitor closely the implementation of the permit granting measures and the construction of the projects. Finally, the list of PCIs will be updated every two years with the aim to integrate newly needed projects and remove obsolete ones.

The huge need for investment in energy infrastructure was one of the reasons for proposing the Regulation on the Guidelines for trans-European energy infrastructure (TEN-E Guidelines) in 2011. The TEN-E Guidelines provide a strategic framework for the long-term energy infrastructure vision of the European Union and introduce the concept of Projects of Common Interest. They identify nine strategic infrastructure priority corridors in the domains of electricity, gas and oil, and three EU-wide infrastructure priority areas for electricity highways, smart grids and carbon dioxide transportation networks.

The endorsement of the final list by the Commission is the result of a thorough identification and evaluation process.

## SunEdison terminates supply agreement with Gintech

SUNEDISON, INC. has announced that on September 30, 2013, its wholly owned subsidiary, SunEdison Singapore and Gintech Energy Corporation, have terminated a long-term solar wafer supply agreement.

Under the terms of the supply agreement, originally executed on October 25, 2006 and last amended on April 19, 2011, SunEdison was to supply Gintech with solar wafers for a 10-year period on a take or pay basis beginning in the second half of 2007. As part of the original supply agreement, Gintech advanced funds to SunEdison in the form of an interest-free loan or security deposit.

Issues with respect to Gintech’s price and volume purchase obligations have created challenges to reaching a mutually beneficial arrangement between the parties. After five formal contract amendments (in April 2011, September 2009, February 2009, November 2008 and October 2007), in order to resolve these ongoing challenges, the Company and Gintech have now agreed to terminate the supply agreement.

In exchange for SunEdison’s agreement to terminate the supply agreement, Gintech has agreed to irrevocably forfeit to SunEdison a portion of its security deposit.

“We are pleased to have reached a mutually agreeable conclusion to our 2006 solar wafer supply agreement with Gintech,” commented Ahmad Chatila, SunEdison’s Chief Executive Officer. “Gintech has been and continues to be an important strategic partner. We look forward to resuming a mutually beneficial commercial relationship with them,” Chatila concluded.





# Apollo has landed

DEK Solar win PV Tool Award 2013 rewarding the company's continuous innovation philosophy.

DURING A CEREMONY which saw the greatest solar industry developments of the year recognised, DEK Solar reaffirmed its place as a leading solar printing technology provider with its Apollo metallization platform, which won the Solar Industry Award's PV Tool category.

This award means each of DEK Solar's metallization platforms; PV 1200, Eclipse and Apollo have now been awarded the prestigious Solar Industry Award, recognizing DEK's emphasis on continuous innovation.

The 5<sup>th</sup> annual Solar Industry Awards took place on 1 October 2013 in Paris during the 2013 EUPVSEC conference and recognise innovative people, products and services that have had an impact on today's highly competitive PV market. During a rigorous 12-week selection process, Apollo was shortlisted by a panel of judges and then received the greatest number of customer votes. Customers and the judging panel felt that Apollo demonstrated DEK's ability to anticipate market advancements and to provide excellent tools to improve yields in PV manufacturing.



Dr Xiao Chen, DEK Solar, Chief Technology Officer and Darren Brown, DEK Solar, Alternative Energy Business Manager

The award was accepted on behalf of DEK Solar by Dr. Xiao Chen, Chief Technology Officer, and Mr. Darren Brown, Alternative Energy Business Manager. Commenting on the win, Dr. Xiao Chen said: "It's no secret that the past two years in the solar industry have been challenging.

Making solar technology affordable, efficient and accessible are some of the industry's primary obstacles and precisely what our Apollo platform was designed to address. We sincerely thank our customers and partners for recognising this fact and casting their votes overwhelmingly in favor of Apollo."

Apollo is DEK Solar's third-generation metallization line. This industry-leading platform offers  $\pm 10$  micron accuracy @ 2 Cpk capability, a breakage rate of less than 0.15% and can process 1,450 wafers per hour (wph).

Launched in May 2012, Apollo is known for its precision, accuracy and high performance, all whilst maintaining a small factory footprint in a single configuration line. Capable of supporting the full spectrum of PV customers, from entry-level start-ups to multi-national cell manufacturers, Apollo was designed to meet current and future demands for products that deliver improved throughput, precise



alignment, and robust wafer handling to prevent breakage. The driving force for all solar cell development is to attain high cell efficiency while ensuring the most cost-effective manufacturing process. Cell efficiency improvements are achieved in large part through techniques such as ultra fine-line printing, Selective Emitter, Print-on-Print and Metal Wrap Through (MWT) – all of which require superb wafer alignment functionality.

Apollo's alignment capability, in combination with its high throughput and low breakage rates, effectively deliver on the high-efficiency, high-yield, low cost of ownership requirements of modern solar cell manufacturers. What's more, the platform's state-of-the-art print engine design provides the highest level of



Left: Apollo offers  $\pm 10$  micron accuracy @ 2 Cpk capability and advanced automated features to deliver repeatability, accuracy and high performance - in a low footprint, single line configuration



print quality by using unique closed loop control technology and precise paste delivery systems. Print results are also monitored through a Statistical Process Control (SPC) software suite for optimal performance.

The recognition of Apollo with the PV Tool Solar Industry Award is proof of DEK's ability to transfer the experience it has gained from a long history in the screen and stencil printing business to innovative solar cell printing platforms and processes. DEK was originally founded in 1968 in the United Kingdom, and is responsible for ground-breaking products for industrial electronics screen and stencil printing. Today, it is a company with a global reach and a reputation as the leading provider for screen and stencil printing equipment, support products and processes for a variety of applications, including solar cell metallization.

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THE REVOLUTION discussed was not so much a call to arms but a call for awareness of major challenges facing the global market as it moves through a rapid phase of consolidation and growth. The challenges referred to were not the usual technological or financial issue but related to incumbent providers of energy who were beginning to feel the pinch from a renewable sector that has grown faster than could have imagined.

The official press conference of the 28th EUPVSEC demonstrated the change within the maturing industry. No longer is the discussion about which technologies will move the industry towards or when grid parity will be reached, the larger topic at the press event was the growing discontent towards the energy utility companies who were reacting negatively to the continued pace of growth of PV and renewable energy options.

The panel were vocal in the changes they saw emanating out of the growth of PV and the impact in Europe. Some felt that major utilities were a declining force that was resorting to dirty tricks to slow down the progress of solar PV energy integration. The example given was how energy giant EDF was lobbying the French government to reduce support for solar and renewables whilst at the same time were lobbying the UK government and demanding long term set prices for new nuclear projects.

The lack of mainstream media from host country France was also a source of ire to the panel with claims that the relevant

journalists had been whisked away on a chartered plane for a lavish freebie thrown to look at marine energy in the north of France. It was incomprehensible for the group to imagine a lack of awareness of such a major energy conference in France on the same day. Of course the situation is never so simple as was noted by the list of conference sponsors on the back of the press material given to us. The top sponsor was of course EDF.

### The next steps

New PV is now cheaper than new nuclear especially in terms of initial costs as well as the long term clean up costs. Despite all the wrangling around the world about subsidy levels for PV oil and gas based energy industries continue to receive more in the way of governmental support. A fact rarely mentioned in mainstream coverage of renewable energies and certainly not a point laboured by energy utility companies.

Germany remains the jewel in the solar crown with utilities share dwindling to a minority. It has been a citizens revolution in Germany and the example there shows the rest of the industry that the next major hurdle for the global markets is the democratisation of energy. The response from the utility companies can be explained from a business point of view but increasing prices from publically owned utilities will not be tolerated by communities slipping into energy poverty. Claude Turmes, EUFORES president and Member of the European Parliament for the European Greens pointed out that

# Viva la revolution

The EUPVSEC has been and gone and the move to Paris seemed appropriate given the cries of revolution that could be heard throughout the opening day. David Ridsdale looks at how the conference continues to deliver the broadest overview of solar and PV technologies available.



Europe has laws to double renewable energy by 2020 providing a path of progress. Most utility companies have been slow to react to the opportunities in solar and PV assuming profitability was still in the future. Europe still leads the global market in research and development as well as process innovation and inverter technology. Turmes sees promise in European potential to remain a major player. He felt Germany had been courageous 30 years ago and led the way to the current revolution. Other regions only became interested thanks to European success.

Despite the positive overview the panel acknowledged that the value chain remains depressed but cited recent analysis suggesting the industry was turning the corner. Now was the time for industry to tackle the growing external challenges before the strength of vibrant small enterprises are overwhelmed by larger interests more interested in shareholders.

Giovanni De Santi, Director Institute for Energy and Transport JRC agreed that Europe was slowing down but felt its market was still the largest which provided the impetus for growth. He cautioned a need to be critical of the European industry stating it had been focused too strongly on local opportunities and policy rather than technology growth. De Santi felt there was a need for a new European approach that is global in nature.

It was pointed out that Europe has a poor history of collaboration in technology and transferring research into manufacturing. The semiconductor industry was used as an example but there was an optimistic response with the panel believing strongly that a European collaborative approach was feasible. Big business would be too slow to adapt to the rapidly changing energy opportunities. Once electric cars became the norm then that would be the end of the game for large energy companies.

### Informative experience

The five day conference was ample evidence of Europe's place as research and development leaders in the global industry with European offerings dominating the hundreds of presentations and over 1200 research posters on display at the conference. The breadth of topics and research that is being conducted around the global sets the industry up very well as future directions are about the technology rather than policy. The industry has achieved parity targets faster than even the



Above left: Professor Martin Green

Above right: Giovanni De Santi

most optimistic would not have believed only five years ago. The quality of presentations is confirmed by attendance. Every session I attended was jam packed, often with standing room only. Every angle of the industry is covered and breaks saw people scurrying to connect with possible partners.

The conference saw around 1,600 presentations in the main events with 150 additional contributions in parallel events. There was key notes from Andreas Bett from Fraunhofer ISE, rightly pleased with a new efficiency record of 44.7% with III-V multi-junction concentrator cells. Conference favourite Professor Martin Green from University of NSW was a popular presenter as was Lars Samuelson from Lund University. Nicholas Hylton of Imperial College in London discussed future material considerations.

This year's Becquerel Prize was awarded to Prof. Gabriel Sala for his research results, ongoing activities and contribution to international standardization processes. Prof. Sala thanked his peers and held a brief presentation on the history and status of PV concentrator cells, illustrating current constraints and solutions.

### Dual purposes

The continued success of the conference was in stark contrast to the ever-declining number of exhibitors on the trade show floor. Two years ago the event attracted over 1500 exhibitors but this year there was lucky to be 300 and many were associations or media groups. This should not be taken as sign that Europe cannot transfer research to manufacturing but it sent an unusual message to visitors from other regions. The earlier Intersolar event in Germany has the opposite problem with a strong exhibition that shows European strength but its conference sector is declining. It is something the organisers of both events need to consider.

EU PVSEC looks set to remain the premier technical conference for some time to come and is a key event to instigate any collaborative and positive European changes that the industry leaders are calling for.

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# An energetic future

The World Energy Congress was recently held in Korea and unsurprisingly renewable energy was a hot topic of conversation for the delegates but also the reality that industry and policy makers must work together with all energy stake holders to achieve a positive energy future.





MORE THAN 6,000 of the world's most prominent energy leaders gathered in Daegu, South Korea for the 22nd World Energy Congress. Held every three years, the energy event attracts government ministers, industry leaders, NGOs, technology pioneers and energy experts from more than 114 countries. Aimed at stimulating debate and finding solutions to the world's energy challenges, this year's Congress adopted the theme "Securing Tomorrow's Energy Today".

An extensive four-day conference programme featured 272 expert speakers from 72 countries, supported by 44 sponsors and 46 media partners. Speakers included 55 government ministers and senior representatives from organisations including Asian Development Bank, the World Bank, the United Nations and the International Energy Agency. Sessions cover a broad range of energy issues and topics facing the international community, from the impact of global shale gas, to the true potential of renewables and, most crucially, an examination of how policymakers, industry and key decision makers must work together to form a more sustainable platform for future energy development.

Daegu marks only the second time that the Congress has been hosted by an East Asian city. Tokyo was the venue in 1995. The last Congress was held in Montreal in 2010.

Mr Khalid A. Al-Falih President & CEO of Saudi Aramco was a keynote speaker on the opening day and commented, "Since the last WEC in Montreal, the energy industry has witnessed momentous changes, and today it is healthier, more dynamic and more confident than ever. Thanks to innovation and technological breakthroughs, we are in an era of abundance for oil and gas. Despite that, a historic challenge looms ahead for all of us to provide access to adequate supplies of energy, particularly for billions of people around the world trapped in energy poverty. WEC Daegu 2013 provides the opportunity for all stakeholders to convene under one roof to collaborate and to address the future challenges that are ahead of us."

### Collective approach required

On the first day of proceedings the World Energy Council (WEC) warned that several prevailing myths are severely hampering the efforts of governments, industry and civil society to create a sustainable energy future. The Council urged stakeholders to take urgent and incisive actions to develop and transform the global energy system. Failure to do so could put aspirations on energy security, energy equity and environmental sustainability at serious risk, the WEC cautioned.

Pierre Gadonneix, Chairman of the World Energy Council, said, "Since our last congress in Montreal 2010 major events have impacted on the global energy context; the

financial crisis has put pressure on competitiveness as a major criteria for the energy sector. The development of unconventional hydrocarbons has emerged as a significant player and incidences such as Fukushima have all caused many countries reevaluate their energy strategies. As a consequence the CO2 targets for 2050 will be missed unless significant changes and policy frameworks are adopted.

"Our congress provides the perfect platform for discussions between leaders in such a context. "It is vital that we form a coherent, long-term framework within which to plan and implement future investment. Leadership is needed if we are to address the triple challenge of the energy trilemma, affordability, accessibility and environmentally sustainable energy for all."

Complexity and uncertainty are increasing at an accelerating rate and energy leaders in both the public and private sectors need to make inspired decisions. Action is needed now. The WEC's analysis has exposed a number of myths which influence our understanding of important aspects of the global energy landscape. If not challenged, these misconceptions will lead us down a path of complacency and missed opportunities. Much has, and still is, being done to secure our energy future, but the WEC's studies reveal that current pathways fall short of delivering on the global aspirations of energy access, energy security, and environmental sustainability.

Energy leaders in both the public and private sectors agree on many of the actions necessary, but significantly are not aligned on the nature, value and importance of political and institutional risks and their critical impact on investment. If we are to derive the full economic and social benefits from energy resources, then we must take incisive and urgent action to modify our approach to energy solutions. The usual business approaches are not effective. The focus has moved from large universal solutions to an appreciation of regional and national contexts and sharply differentiated consumer expectations.

Faced with an ever-changing kaleidoscope of issues, we have to embrace this new reality and define enhanced norms of performance and agility.

Christoph Frei, Secretary General of the World Energy Council said, "As we publish the results of our studies at the World Energy Congress in Daegu, Korea it is clear that we are at a tipping point. There are many myths that impact the energy sector which we have been able to expose through our studies. Our congress is the ideal place to bring these findings and recommendations to seek to find solutions to promoting the sustainable supply of energy for the greatest benefit of all."



### Myth Busting

The congress moved to dispel a number of energy myths that they feel are disrupting positive energy changes.

#### Myth 1: Global energy demand will flatten out

The Reality: Energy demand will continue to increase and double by 2050, primarily driven by economic growth in non-OECD countries.

#### Myth 2: Peak Oil – there is an imminent shortage of fossil fuel resources

The Reality: There is no shortage in sight. The continued discovery of new resources and the emergence of new technologies that both enable the release of unconventional oil and gas and improve the recovery rates from existing fields have already multiplied the available fossil fuel reserves by a factor of four, and this trend will continue.

#### Myth 3: Demand growth will be fully met by the new clean energy sources

The Reality: WEC analysis in the World Energy Scenarios shows that despite significant growth in the relative contribution of renewables from 15% today to a figure between 20% and 30% in 2050, in absolute terms the volume of fossil fuels used to meet global energy demand will be 16,000 MTOE in the Jazz (the more consumer-driven scenario) and 10,000 MTOE in Symphony (the more voter-driven scenario), compared to 10,400 MTOE in 2010. This represents a 5% decrease in the absolute amount of fossil fuels in Symphony but a 55% increase in Jazz.

#### Myth 4: We can reduce global GHG emissions by 50% by 2050

The Reality: According to the WEC's World Energy Scenarios, even in the best case we will see a near doubling of global greenhouse gas (GHG) emissions by 2050, compared to where we should be in 2050 to meet the 450 parts per million CO<sub>2</sub> reference adopted by many. At worst GHG emissions could increase by over four-fold.

#### Myth 5: Current business models and markets are delivering

The Reality: WEC analysis shows that energy markets are becoming increasingly complex, driven by accelerated change in energy policy, technological innovation, and consumer expectations. Current market designs and business models are unable to cope with the increasing renewable shares, decentralised systems, or growing information architecture.

#### Myth 6: Current programmes will deliver universal access to energy within the next 10 to 15 years

The Reality: Universal access is far from becoming a reality. While acknowledging recent progress and current programmes to reduce energy poverty, the WEC's analysis shows that on current paths, between 730 million and 880 million people for Jazz and Symphony respectively will still be without access to electricity in 2030 and between 320 million and 530 million people in 2050 globally.

#### Myth 7: On a global scale capital is cheap and abundant

The Reality: Capital is extremely sensitive to perceived political and regulatory risks. Moreover, due to the growing pressures on public finances in most countries, public funds will not be available to substitute or augment the private financing of energy initiatives.

### Defining the future

The global energy environment has increased in complexity. The global aspirations on energy security, access and environmental sustainability are destined to fail unless incisive and urgent actions are taken to both develop and transform the energy system.

**1. We are looking in the wrong place:** The focus of current thinking about the energy system is biased and inadequate: If we want to get the greatest social and economic benefits out of our energy systems, the focus must shift from the supply mix to demand efficiency. We need more demand-side investments, innovation, incentives and stronger technical standards to reduce energy intensity.

Price controls, subsidies, trade barriers and absolute targets for individual technologies distort the market and can have unintended consequences, so policymakers must use them only sparingly.

**2. In order to attract the needed investment national policy and regulatory frameworks have to be balanced:**

We need robust, predictable and transparent frameworks that allow the market freedom to exercise informed choices in terms of innovation, technology and investment. The "Energy Trilemma" provides a solid framework for every country to assess its own political risk and work towards balanced, predictable and stable policy and institutional frameworks.

The WEC's analysis reveals that there is little agreement between investors and governments on nature, price, and value of risks. It is therefore critical to improve the understanding of the nature of risk and the way to price it. In the absence of such understanding, investment will not flow.



**3. We need significant investments in R&D:**

We urgently need to realise the potential of breakthrough technologies such as electricity storage and CC(U)S. WEC analysis shows that the 450 parts per million CO2 goal cannot be achieved without CC(U)S. It is essential, therefore, that there are clear and unambiguous policy and institutional frameworks to support investment in this technology to justify its inclusion in roadmaps and carbon emission reduction strategies.

**4. The energy map is changing and our institutions need to change to keep pace with developments:**

The centre of gravity in energy has moved outside OECD countries – and so are interactions between the countries and regions. In addition, consumer groupings and civil society expect to influence our energy future.

Existing multilateral and plurilateral energy institutions need to reflect these changes, be more inclusive and responsive, or risk becoming obsolete.

**5. To ensure universal access to energy, policy and institutional frameworks and funds are urgently needed to de-risk and support entrepreneurial approaches:**

WEC recognises the need for urgent additional action and supports the objectives of the UN Secretary General's Sustainable Energy for All initiative. WEC further supports the inclusion of universal energy access as a key and distinct element in the post 2015 Millennium Development Goals.

Supporting mechanisms and suitable funding are essential in order to achieve this goal.

**6. It's no longer just about mitigation:**

Risks from the energy-water nexus, extreme weather events, or cyber terrorism (to name but a few) expose our energy infrastructure to potential disasters. We need to urgently adapt, re-think, and redefine the resilience for energy infrastructure.

**Regional implications of inaction**

- In Sub-Saharan Africa 250 to 400 million people could still lack access to energy in 2050.
- Asia will have the highest need for investments in energy infrastructure until 2050, a staggering US\$10 to \$12.5 trillion, compared to US\$3 to \$4 trillion for Europe or North America.
- The Middle East will struggle with increasing demand and energy intensity.
- Europe will struggle with balancing increasing energy prices and GHG objectives.
- North America will struggle with ageing and incremental energy plus issues of transport capacity and infrastructure.
- In Latin America, large hydropower will continue to dominate the energy mix until 2050 and building necessary infrastructure will struggle to meet the expected demand.

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## Highly productive laser system for opening the rear sides of PERC cells

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# Safety in your hands



Photovoltaic modules convert sunlight into electricity into direct current (DC) and must convert that to alternating current (AC) for general usage. One of the major concerns with this is the potential for electrical arcing that can create potential problems for any PV installation. Chris Oberhauser, Applications Engineer at Texas Instruments discusses why PV needs arc detection and when a fuse isn't enough.

FUSES ARE A CRITICAL SAFETY ELEMENT in almost every electrical system. By limiting current from reaching dangerous levels, they reduce the risk of fire or other hazardous conditions. However, a fuse cannot handle all of the significant hazards alone. One such hazard that it cannot protect against is electrical arcing.

Electrical arcing occurs when an insulator ceases to function as an insulator and, instead, starts conducting current. Most commonly, the insulator breaking down is air. Compared to the equivalent volume of copper, an arc is a poor conductor of current. As a result, a large amount of energy dissipates, mostly as heat. Electrically, arcs can be modeled as a variable negative resistor. This is valid since an arc does not store electrical or magnetic energy like a capacitor or inductor. It is a negative resistor since there are more air molecules available to ionize and act as charge carriers to sustain the arc, if higher current is available.

With a focus on photovoltaic (PV) applications, this article provides detail into the different aspects of designing a dedicated

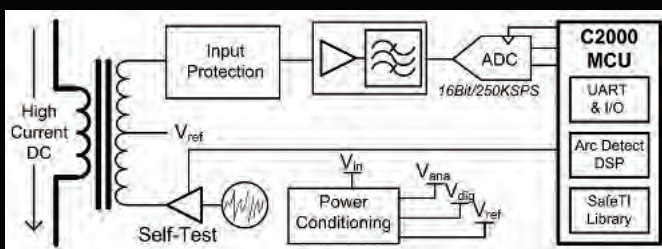


Figure 1: RD-195 system block diagram

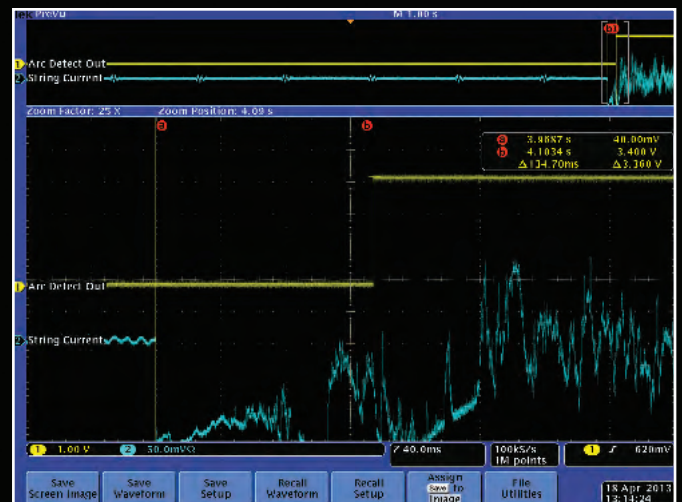


Figure 2: RD-195 detection interval

arc detect unit (ADU) to address the hazardous conditions created by arcs. The needs and challenges of such a system design are highlighted. This includes an assessment of arcing signatures, different system implementation techniques, self-testing and system handling of false-detect events. This article also summarizes the real-world performance of an extensible system design.

## Arcing hazards

Characteristics of PV systems introduce additional risks of arcing. These include high DC voltages in the range of 600–1000 V, degradation and insulation wear due to constant exposure to the

harsh environments, and minimal system maintenance over long periods of time. The DC power generated by PV systems is more hazardous as compared to AC power systems, because DC arcs do not periodically self-extinguish like AC arcs do. In PV systems, the current generated by the PV modules has a maximum level that does not cause the fuse to blow.

Due to the dangers from arcing, in 2011 the United States National Electrical Code included a section requiring the addition of arc prevention circuitry in new PV systems. Article 690.11 of the NEC2011 requires that inverters sold in the US be able to detect and interrupt series arcs in DC PV systems.

The solar industry adopted UL1699B, an extension onto the UL1699 Arc Fault Interruption specifications, as the applicable standard for detection and mitigation of arcing events. The standard applies to PV systems from 80–1000 V. Below 80 V the occurrence of an arc becomes less likely. Most of the damage caused by PV arcing is from fires that result from the energy dissipated by the arc. UL1699B sets 750 Joules (J) as the detection threshold, an amount of energy dissipation capable of igniting many common materials. With a 14 Ampere (A) arc generating 900 Watts of power, 750 J is discharged in approximately 800 ms. This time budget sets a strict schedule for detecting and responding to an arc.

### Arc detection system overview

To address this need, Texas Instruments designed a reference solution for an arc detection unit, the RD-195 (Figure 1). The goal was to make an effective, economical, and modular arc detection system for use in the real world. The development effort focused on real-world conditions as much as possible – different strings of PV modules and a variety of inverters were used to test the solution rather than a lab setup.

In Figure 2 the RD-195 was connected to a PV system, a string of 180 W modules, and an inverter. The string current was monitored using a current probe. A safe system was run for a week, after which an arcing event was generated. The start of the arcing event is visible as a sharp transition in the current trace followed by an increasingly chaotic signal. The RD-195 indicates detection 135 ms later. In a worst case situation, a system using an RD-195 still has more than 650 ms to respond to the arcing event. The large amount of margin allows the C2000 to monitor multiple DC lines concurrently.

After evaluating a large number of arcing conditions, a frequency range of 20–100 kHz was settled on as the detection range. This resulted from some straightforward considerations. First, the electrical signal generated by an arc is reduced at higher frequencies. At low frequencies, the electrical interference from line noise becomes more pronounced. In the 20–100 kHz region, the signal we are trying to detect is –60 dBm/Hz, which does not





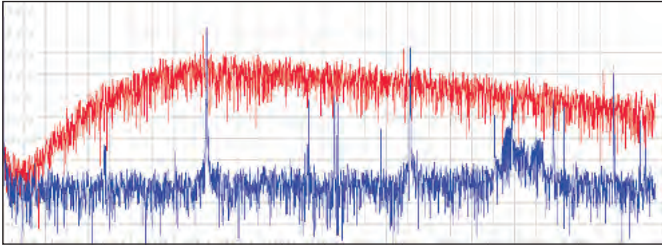


Figure 3: Comparison of arcing (red trace) and non-arcing (blue) signals from an inverter

present a significant challenge.

While the signal generated from an arcing event is quite easy to detect, the real world is not as friendly as a lab environment. Routing PV cables to minimize coupling from radio transmitters, solar flares, radar, and other potential interferers is usually not considered for system installations. In practice, however, the major source of interference turns out to be the inverter itself.

### Inverter interference

In Figure 3 the spectrum of an arcing event is compared to a normal operating system. This spectrum covers the range of 0–125 kHz, and the vertical axis is scaled to 10 dB/div. The roll-off in the lower frequencies is due to the transformer used to couple the signal to the digitizer in the system.

The switching interference from the inverter at 38 kHz is more than 10 dB above the peak amplitude of the arcing signal. A simplistic arc detection system that simply looks at the RMS level in the time domain would probably indicate an arc with this type of interference. Even an arc detection system that performs spectral analysis has to find a region of the spectrum with the largest separation between the arcing and non-arcing signals to minimize errors.

Still, with proper frequency range selection, it should not be too difficult to manage this interference. As long as a system does not rely on the range of 95–103 kHz, there should be no major difficulty. It turns out that this specific inverter generates a very low level of interference. The inverter response shown in Figure 4 contains a bit more interference – at 36 kHz it produces a signal with a peak about 45 dB more than the arcing signature trying to be detected.

This inverter presents a specific challenge to arc detection systems. With interference exceeding 45 dB over the arcing

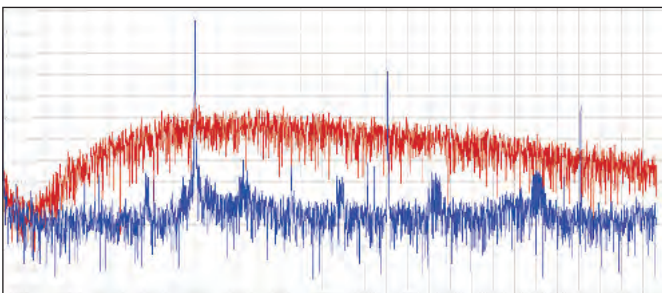


Figure 4: Higher interference inverter

signature, it is easy to overwhelm the arc signature for which the ADU is searching. During development of the RD-195, we evaluated inverters with interference levels 50 dB greater than the arcing signature. The RD-195 must reliably detect arcing even with such strong interference. This high level of potential interference requires a high-dynamic range for the system – with additional headroom needed on top of the 50 dB interference to ensure that the captured waveform response does not over-range or under-range in the presence of additional interference. It is important to note that the system must never encounter under-range/over-range conditions, as there is no useful information on monitored PV system when this condition occurs. Without that, a safe, non-arcing condition cannot be ensured.

It is necessary to maintain sufficient resolution at the low powers for effective detection. The system dynamic range calculation is:

- >3 dB of additional headroom to avoid clipping
- 50 dB of interference range
- 40 dB to non-arcing signal floor

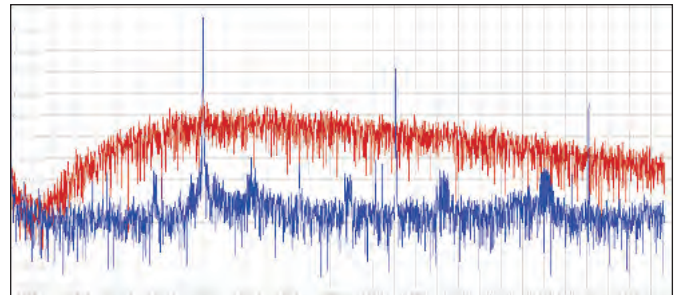


Figure 5: An inverter with a spread-spectrum switching interference

This exceeds 90 dB of dynamic range in the band between 20–100 kHz. Many components may meet this dynamic range requirement at 1 kHz, but have a performance roll off so that by 100 kHz, they are below 70 dB of dynamic range and not optimum for arc detection. In comparison, the analog-to-digital converter (ADC) used in the RD-195 is tailored to this application. It has over 100 dB of dynamic range and consumes little power in a small 10-lead MSSOP package.

Inverter switching interference can manifest in other ways. The inverter characteristic shown in Figure 5 has a spread-spectrum type of switching, which results in a more difficult detection challenge. Other inverters can present even more challenging interference characteristics. The inverter in Figure 6 has only a small region of the spectrum where effective detection is possible. Inverter interference has even more complexity. It can vary significantly across different panel configurations as the inverter attempts to extract the maximum power from the array, which can change due to shading or temperature. The inverter start-up and shut down sequences also can be quite different from the normal operation modes.

### Protection

It is clear that an effective real-world solution need to be able to detect an arc in the presence of high levels of interference, as

well as have a minimal chance of false detection. The cost of nuisance trips can be quite high. From the UL1699B detection requirements, an arc detect system must be able to quickly, but reliably, detect the presence of an arc without misinterpreting other interference to be an arcing event.

Due to the complexity of these detection requirements, a microcontroller (MCU) capable of digital signal processing is typically used. But the use of an MCU adds complexity to a critical application such as arc detection. A subtle bug in the programming could result in the MCU locking up or missing an arcing event. Even rigorous coding practices can't protect against a fault in an MCU or random events, such as random bit flipping due to radiation. With a system out in the field for more than 20 years, such rare events are not so unlikely. UL1699B requires all MCU-based arc detection systems to follow a modified version of UL1998, which addresses software implementation for fail-safe and fault tolerant systems.

The firmware in the RD-195 utilizes SafeTI, a modular safety library developed for TI's C2000 MCU family. This library includes functionality to ensure that the MCU instructions are not corrupted, the MCU is properly performing operations, MCU sub-systems (peripherals) are operating correctly, and if a fault is detected, the system enters a safe mode. This comprehensive library is useful for applications beyond that of arc detection. This library has been UL certified as recognized components based on UL1998:2008 Class 1 standard. As an additional level of protection, Arc Detection DSP routines are compartmentalized for ease of inclusion into a customized application. The Arc Detection Library includes self-testing to catch any errors in processing. This library is also UL certified as a recognized off-the-shelf (OTS) software component.

Development of the arc detection DSP used in the RD-195 took some time. Several different signal processing methods were evaluated during development. After extensive evaluation, time domain techniques, which attempted to extract the arc signal from any periodic interferer signals, were deemed ineffective or too complex. A learning algorithm was not adopted since an arcing event could occur while learning, which would compromise effective detection. Techniques which monitored several frequencies for absolute level had potential issues with cross-talk from non-arcing strings. Other methods were determined to require too much processing to fit within our system constraints. Consequently, a new method was developed for this application using heuristics controlled by a set of adjustable parameters to dynamically scan for interfering

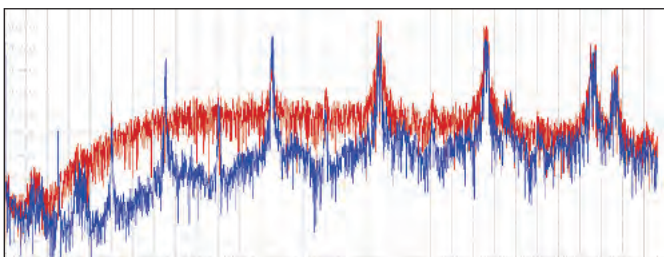


Figure 6: Some inverter interference is extremely difficult to differentiate from an arcing event

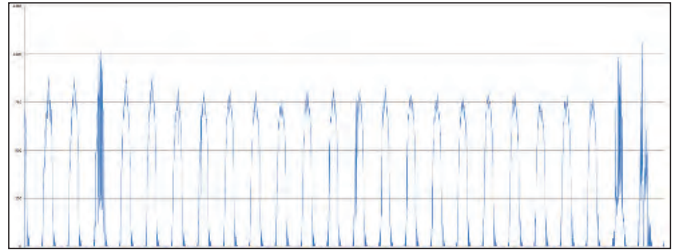


Figure 7: Monitored string power over time

signals and mathematically filter an interfering signal. A set of parameters were determined to provide effective detection for the majority of inverters on the market. The collection of all inverters on the market presented conflicting constraints on the detection parameters. For some inverters, 50 kHz was the optimum detection band, while for others the interference was at its worst extreme at 50 kHz. As a result, for some of the uncommon inverters (such as the one whose response is shown in Figure 6) the solution needed to use a different set of detection parameters.

During development, a technique used for optimizing DSP detection parameters was to automatically collect raw ADC data when a false detection occurred. In this way, the detection parameters could be adjusted to avoid false detection from these types of events. The RD-195 was routinely evaluated on a variety of PV systems for extended periods to ensure that the final parameters used are robust against false detection events. Some of these evaluations ran for more than a month, with occasional changes to system and periodic checks of the arc detection characteristics. During these extended tests the status of the tested RD-195 was monitored and the string current and voltage was recorded. Figure 7 illustrates the power during one extended test.

It is easy to overlook the need for a self-test circuit, but it provides a comprehensive verification of the entire signal path. Without the self-test circuit, a fault in the transformer, the input protection, filtering, or the ADC might not be detectable. As a result, effective detection would not be present. The self-test circuit in the RD-195 generates a noise pattern which emulates an arcing event. This noise is coupled into the transformer via a dedicated secondary. It goes through the signal path and is processed by the Arc Detect Library. The only fault this self-test implementation will miss is if the primary path of the transformer is open – this fault would be quickly apparent as no power is being produced.

## Summary

Detection of an arc is not easy to implement as there are many critical aspects to focus on – from interference to dynamic range to self-testing. A fuse does a great job for the protection it provides, but it can't provide arc detection. TI has worked to provide an extensible solution which can fit nearly any PV system needs. To assist developers, TI offers the RD-195 evaluation board with a C2000 MCU running UL1699B recognized firmware.



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# Storing energy for the future

Energy storage is a key driver of the evolution of solar and PV technologies. The state of California in the US has set pro-active storage targets to instigate the industry. Alex Ghenis, Senior Analyst at California Energy Storage Alliance asks if energy storage is cost effective and why the market needs a signal.

CALIFORNIA'S ELECTRICITY SYSTEM has reached a transforming regulatory milestone. Commissioner Carla Peterman of the California Public Utilities Commission (CPUC) authored a proposed decision ordering a 1.325 GW utility energy storage procurement target for California's electric grid by 2020, if viable and cost-effective. The CPUC is expected to decide on a final number for the target in the coming months. But many have seen the "cost-effectiveness" part of the equation with curiosity: "if cost-effectiveness is a requirement," they ask, "why are procurement targets necessary?" It's a sensible question - and the CPUC's conclusions show that specific targets are key to getting much-needed storage solutions onto the grid.

Energy storage does exactly what the name suggests: it takes energy and stores it for use at a later time. This can be accomplished many ways: chemically (e.g. batteries), gravitationally (e.g. pumped hydro), mechanically (e.g. flywheels)

and thermally (e.g. molten salt). On the electric grid, where supply must always equal demand, this enables more efficient utilization of existing system assets - whether it's by avoiding expensive transmission and distribution upgrades or substituting for the least efficient and most polluting "peaker" power plants. Energy storage is also a very diverse asset class, so it has many benefits that can address a variety of needs and locations across the grid.

As compared to many status quo grid solutions, energy storage demonstrates superior performance and system benefits. For example, while a state-of-the-art gas turbine can take 10 minutes to "ramp" to full power, many energy storage technologies can do so in under one second. In a system where supply must precisely equal demand, this flexibility and accuracy is extremely valuable. Whether it is substituting for less-efficient "peaker" plants, smoothing renewables' output, integrating micro-grids,



increasing efficiency of conventional generation, or alleviating local transmission/distribution congestion, energy storage enables greater system efficiency across the entire grid in a way that no other energy resource does.

Industry and government leaders are now recognizing the true value of these many benefits. New system models are showing that energy storage is cost-effective when its full range of services and benefits are fairly accounted for. The reason for this is that energy storage can deliver multiple services from one resource (e.g. reducing peak demand and providing frequency regulation). It is also recognized as a necessary part of the grid of the future: with more intermittent renewables, increasingly scarce and expensive fossil fuels, and system goals including emissions reductions and greater efficiency, energy storage is needed system-wide.

### Why are Targets Necessary?

AB 2514, California's law directing the CPUC to consider establishing procurement targets, directs the CPUC to "open a proceeding to determine appropriate targets, if any, for each load-serving entity to procure viable and cost-effective energy storage systems" for 2020. A comparable framework is required for publicly owned utilities. The cost-effectiveness requirement is appropriate because it ensures no incremental cost for ratepayers - but establishing targets is still crucial. Here are a few reasons why targets are necessary.

First and foremost, utility procurement targets will motivate utilities to embrace fundamental system change. This is necessary, as we need a comprehensive transformation of

the electric power system, from public policy to markets to infrastructure. But energy storage has never been part of the core "toolkit" of load serving entities and other stakeholders. As a result, there are barriers to bringing energy storage resources online – including the inability to have ALL the benefits provided by an energy storage asset fairly accounted for in system planning and procurement. A procurement target will help overcome status quo inertia and more quickly bring about the change we need: a more efficient electric power system.

The importance of procurement targets is demonstrated by California's renewables portfolio standard (RPS) adopted in 2004. With the RPS, load serving entities are directed to procure increasing levels of renewable energy over time. Renewable generation capacity in California increased by 77% from 2004-2011, compared to 33% from 1996-2003. In 2011, California generated almost 12% of all energy needs from renewable sources, and is on track to achieve the targeted 33% RPS by 2020. The California RPS is achieving its goals, and an energy storage target will do the same. Better yet, energy storage resources procured as a result of Commissioner Peterman's proposed target must be cost-effective by law, so there will be no additional burden on ratepayers.

### Encouraging industry

Installation targets (not just procurement targets) also provide a much-needed market signal to energy storage manufacturers, developers, installers and investors. This clear market signal is needed to justify vital investment in technology development and deployment, including many locally-sourced high skill jobs. With a constantly-evolving technology class such as energy storage,





In the case of energy storage, this market development is timely - to help address California's major near and long term grid challenges, including for example, once-through-cooling plant retirements and permanent closure of the San Onofre Nuclear Generating Station. Energy storage will help bring more renewable energy resources online, reduce pollution, increase system efficiency and reliability, and decrease costs for ratepayers

widespread investment is key to increasing cost-effectiveness, performance, deployment, and related grid benefits. Investments and related societal benefits occur throughout the value chain - in design, manufacturing, installation, commissioning, and maintenance.

Policies impacting energy storage abound - and procurement/ installation targets will help focus them for the greatest societal benefit. With concrete targets, government agencies and utilities statewide will appropriately prioritize energy storage as part of their core toolkit for electric system planning and procurement. Cost-effectiveness evaluation and procurement processes will become standardized, installation and interconnection policies will become refined, and appropriate contracting mechanisms will be developed. Targets encourage focus - a pre requisite for any new market development.

In the case of energy storage, this market development is timely - to help address California's major near and long term grid challenges, including for example, once-through-cooling plant retirements and permanent closure of the San Onofre Nuclear Generating Station.

Energy storage will help bring more renewable energy resources online, reduce pollution, increase system efficiency and reliability, and decrease costs for ratepayers. Because any new energy storage added to the system must be cost-effective by law, everybody wins. For this reason, we applaud Commissioner Peterman's vision - and encourage all stakeholders to consider her proposed target as a floor, rather than a ceiling.

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MICRO INVERTER TECHNOLOGY has the potential to attract a new swathe of residential investors to solar power. The technology generates more yield, reduces installation costs and lasts longer than string inverters.

One of the largest manufacturers of micro inverter technology recently announced that it sold more than three million units in just five years. But the company is one of just a handful of companies that produce micro inverters.

So why does the number remain surprisingly low?

A major reason is the reluctance of the industry's established string inverter companies to enter the field of micro inverters, which might be by individual market strategies and related R&D budgets. The knock-on effect is that the market potential as well as the technical superiority of micro inverter products is being overlooked.

Another key reason is the lack of education. Many companies are unsure about the differences between the two technologies and the benefits they give to customers.

### What's the difference?

The main difference between micro inverters and string inverters is that one micro inverter is used per PV module whereas one string inverter is used per system. This makes for a number of

differences between the two technologies, from their installation and maintenance to lifetime and performance. "It's all about reducing costs for the life of the PV system, not just for the system owner but for the installation company as well," explains Florian Dieckmann, marketing manager at ReneSola. "The costs are comparable to string inverters and yet the benefits are so much greater. A micro inverter system will generate more revenue and last longer. So it's a no-brainer and we need to educate people to that fact."

ReneSola aims to be the world's leading supplier of solar inverters by 2015. The company's Micro Replus micro inverters will contribute significantly to this ambition. Launched in 2012 as the leading product of its comprehensive Replus inverter family, Micro Replus was designed from scratch by two teams, one in Silicon Valley and the other in Chicago. The teams included veterans from GE Corporate R&D and Motorola who set out to develop an innovative new micro inverter.

### Easier and safer to install

Rather than visiting the site, surveying the rooftop, creating a design and returning to install it, a micro inverter PV system offers installers the flexibility to visit the site, and then design and install the system on the same day. This helps the sales process and enables smaller installation companies or local electrical contractors with little experience to install a system quickly and



## Micro managing expectations

Despite the claims of technical superiority micro-inverters have been much slower in uptake in the solar market than their manufacturers would have imagined. Producers of the devices are now looking to highlight the benefits they provide and tackle market opportunities they provide. ReneSola discusses the benefits and looks at how micro inverters could be the tipping point for investors still unsure of a solar investment.



easily. A micro inverter also holds less risk for installers and owners as it runs on a far lower DC input, so the risk of injury caused by electrocution is reduced.

ReneSola's Micro Replus is designed as a one-box solution that contains a standardized cable harness and all connectors needed for installation. There is also an anti-islanding and automated grid connection device already built in, as required in markets such as Germany.

"There is no need for time-consuming planning, configuration and logistics. Electrical wiring gets a lot safer and easier, and almost anyone can install it," states Güven Altun, sales engineer at ReneSola's European technical support squad. "And the system is fully prepared and certified to work with any grid code around the world."

The decentralised concept also gives owners far more flexibility, as they can add new PV modules with ease.

### More yield

The Replus system is able to generate up to 16% more yield when compared to a string inverter, and operate at an overall efficiency of more than 96.5%.

This increase in yield, which means increased revenue, is mostly thanks to reduced shading problems. A common issue with many rooftops, shading can dramatically reduce a PV system's power production due to overhanging trees or nearby buildings, which are often impossible to avoid.

In fact, just 9% shade can influence up to 54% of the total system's output. Micro-inverters significantly reduce this power loss by managing each PV module individually, so if one module performs poorly it has a far less dramatic effect on the overall system. This also helps to prevent expensive breakdowns.

The use of one inverter per module also aids system management. Micro inverters can be connected to a web management interface through an inexpensive communication gateway that allows owners to monitor individual modules, allowing any weakness to be easily spotted and fixed.

To further protect both the PV module and inverter, each unit has an in-built fire detection system that recognises hot spot issues or overheating and can cut off the individual module, allowing the rest of the system to continue generating electricity without risk. But if an inverter were to fail, the owner need only replace a single unit rather than an entire string inverter.

### Longer lifetime

Micro Replus inverters are guaranteed for 25 years, far more than the average 10 years for a string inverter and the same length of time as most good PV modules. "It's a fit-and-forget concept where a one-off investment is followed by decades of revenue,"



says Dieckmann. This impressive longevity is partly due to the use of epoxy resin, which seals the device from moisture, dust, water and any ingress of dirt that could potentially cause a component to fail. It is also down to the use of generic components that are found in many electrical devices around the world, which keeps costs down and ensures their reliability, as all components have a proven track record of long service.

"Keeping costs down is key," Dieckmann says. "The R&D behind Micro Replus is similar to that used to create smartphones: innovative U.S. design mixed with high-quality Chinese production to give the required economies of scale."

### Differences to string

Compared to string inverters, the electrical components used in the micro inverter share similarities, such as the DSP, MOSFETs, SCR and transformers, but the topology is different and the devices are scaled down. It also includes features like an isolation transformer, which most string inverters, particularly in Europe, do not have.

Where some inverters produce a loud buzzing noise from the electrical current, Micro Replus is virtually silent. As a result of its design, the entire device is IP68 rated, which guarantees integrity even in extreme climates. During testing, Micro Replus inverters continued to function in temperatures down to -40°C and up to 65°C.

"While string inverters will remain a popular choice for large-scale and industrial PV systems, the huge benefits that micro inverters bring to residential systems cannot be ignored," says Dieckmann. "Giving installation companies the tools to build a more efficient PV system faster will allow them to sell more systems. It is a slow process, but the more we can do to promote and educate on the benefits that micro inverters bring, the better."

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## System Integration Award

Trinasmart

TRINASMART is a performance optimiser integrated into Trina Solar's monocrystalline Honey M module range. It enables the monitoring and control of arrays at a modular level and increases system performance by up to 20 per cent.

Power optimisers enable each individual panel in a PV array to operate consistently at its maximum possible power output, which may be affected by shading or differences in peak power even within the same nominal power bin. Panels with output powers that differ from others in the same string will have a negative impact on all panels in the string (secondary loss).

One alternative to string or central inverters are micro-inverters, which are integrated into each individual module within a string or array. Trina Solar noticed a trend in the industry towards micro-inverters. They also noticed that the performance levels of these module-integrated inverters were very low in terms of the conversion efficiency that they achieve, and have to dissipate more heat and possibly overheat areas of the solar module. Trina Solar wanted to ensure that arrays of their modules were able to operate consistently at peak efficiency. After evaluating about six solutions available on the market for functionality, price, and features, Trina Solar decided to embark upon a development of their own in partnership with Tigo Energy.



Dr. Pierre Verlinden, VP, Chief Scientist and Vice-Chair of State Key Lab (PVST) with David Ridsdale, Editor-in-Chief, Solar International

One of Trinasmart's distinctive features is that the optimiser electronics are integrated into the module junction box in the factory, resulting in no extra wiring or mounting of optimisers to the array. The built-in design enables the Smart Curve technology, a joint development with Tigo Energy that allows the installations of module strings that are up to 30 per cent longer without any dip in module performance. This has the effect of reducing the number of balance of system (BOS) components required per array, while also making the installation faster and easier. BOS costs are reduced by up to three cents per Wp, and energy yields are increased due to lower resistive losses in the wire.

Using Trinasmart, array designers are able to use parts of roofs that are prone to shading and would not otherwise be viable locations for PV modules, as the entire system would lose power as a result of the excluded panels. The overall performance of such arrays can be increased by up to 20 per cent. Trinasmart incorporates power optimisation and monitoring systems in a complete solution allowing users to monitor and control their arrays at a modular level, and is compatible with any inverter.

Users have real-time access to all module data through their smartphone, tablet, or laptop, with the ability to switch off the entire array with a single click in case of emergency. Trinasmart also improves the safety of the PV system: in cases of electrical failure (e.g. flashing arc), Trinasmart shuts down the affected modules automatically. Moreover, in the case of an external fire the modules can be totally deactivated, eliminating high voltages and improving the safety of firefighters during an emergency. Trinasmart increases building security and complies with current and future European regulations demanding low voltage shut-off capabilities.

At Trina Solar, we believe that module-integrated electronics solutions such as Trinasmart will soon become an industry-standard offering in a number of regions, including the UK, Germany, Austria, France, and the US. Solutions like this are not only improving efficiency, but setting new standards for the safety of PV installations, and within the next couple of years most solar modules are likely to contain some sort of "smart" features.



## PV Tool Award

### Apollo

APOLLO is an integrated cell manufacturing metallization platform designed to help manufacturers to meet the future challenges of the solar industry and improve production performance. Renowned for its precision and flexibility, the Apollo platform offers  $\pm 10$  micron accuracy @ 2 Cpk capabilities. Its advanced automated features deliver repeatability, accuracy and high performance. The industry-leading platform offers a breakage rate of less than 0.15% and can process 1,450 wafers per hour.

Apollo delivers these increased capacity features whilst maintaining a small factory footprint in a single line configuration. It is fully optimised for Print-on-Print and Selective Emitter processes. Featuring topside cameras for fiducial or pattern alignment, as well as incorporating handling systems, conveying, drying equipment and the ability to integrate directly with other photovoltaic production processes, Apollo is the foundation for DEK Solar's new generation of solar cell metallization solutions.

With the addition of Apollo, DEK Solar is able to offer a comprehensive portfolio of metallization platforms and support



the complete spectrum of PV customers, from entry level start-ups right through to multi-national cell manufacturers. Apollo is designed to meet a range of challenges, including the demand for increased cell efficiency in the PV industry. Faced with future demands, DEK Solar developed the Apollo platform as a practical solution for customers looking to improve products and processes in high efficiency cell manufacturing. It overcomes challenges in throughput, alignment, wafer handling and breakage.

Modular and flexible in configuration, Apollo is future-proofed to meet PV Industry Roadmap requirements and it exceeds demands for increased cell efficiency. Its innovative wafer alignment system was designed specifically for the selective emitter, print on print and MWT process which delivers exceptional alignment accuracy and makes these next generation technologies practical.

The state-of-the-art print engine design delivers the highest level of print quality by using a unique closed loop control system and precise paste delivery systems. Print results are monitored through an SPC software suite for optimal performance. Apollo offers higher throughput, improved wafer handling and lower breakage rates.



Dr Xiao Chen, DEK Solar, Chief Technology Officer and Darren Brown, DEK Solar, Alternative Energy Business Manager with David Ridsdale, Editor-in-Chief, Solar International





# 3DMICROMAC

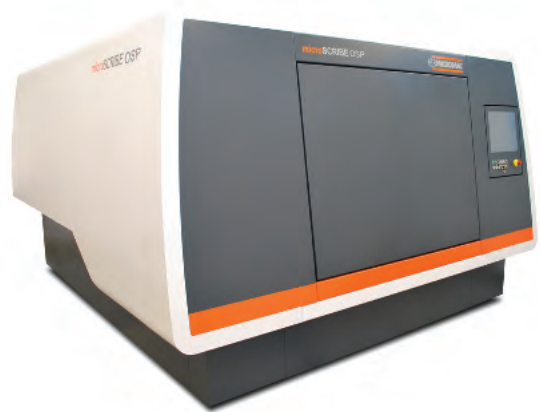
## Thin Film Innovation Award

### microSCRIBE OSP

3D-MICROMAC AG developed a new machine for structuring of thin-film modules. Its One Stop Patterning tool microSCRIBE OSP deploys a combined laser and inkjet application, which facilitates integration of three classical structuring steps on one single platform. Classical single laser scribing after every thin-film deposition is not necessary any more with this tool, which now completely series-interconnects a thin-film module after full deposition of all functional layers.

Classical thin-film structuring requires three scribing steps between the vacuum depositions of the individual functional layers. This results in large dead zones, extensive cleaning procedures, reduced layer and interface quality, longer throughput times and yield losses. The dead zones defined by the full width of the three typical structuring lines, considerably decreases module efficiency.

Due to inaccuracies between different scribing tables, tolerances have to be implemented, which further enhance the dead zones and directly lead to efficiency losses. Furthermore due to the scribing steps, considerable efforts have to be incurred for bringing substrates in and out of vacuum after each thin-film deposition.



Why does it stand out? The microSCRIBE OSP is the first production equipment worldwide that can conduct the integrated series-connection of a thin-film solar module on one single platform and in one single production step.

The microSCRIBE OSP from 3D-Micromac AG integrates all three classical scribing steps on one tool and in one process. This is accomplished by employing a combination of ink-jet and laser scribing steps after the deposition of the full layer stacks. 3D-Micromac AG leverages hereby its wide expertise on such combined tools from other application fields. Thereby dead zones can be reduced drastically down to 100  $\mu\text{m}$  from today's typical 200 – 400  $\mu\text{m}$ . This increases efficiencies by up to 0.8% absolute.



Thomas Kiessling (left), Product Line Manager, Photovoltaics and Dr Wilhelm Stein with David Ridsdale, Editor-in-Chief, Solar International



## Energy Usage Enabling Award

### Smart Modules

UPSOLAR'S SMART MODULES feature on-board power optimization from industry-leading technology providers. Traditional PV systems are configured in series circuits to either a central or string inverter meaning a system will instinctively lower its output to that of the worst performing module – impacted by issues like partial shading and varying tilts or orientations.

Smart modules in contrast ensure that customers achieve ideal power output levels by using maximum power point tracking (MPPT to increase output at the module level and mitigate module mismatch. By integrating quality PV modules and power optimization technologies Upsolar's smart modules offer a host of benefits to system owners and installers:

- **Better system performance:** up to 99.5 % conversion efficiency to help customers get the most out of their PV systems at all times.
- **Greater design flexibility:** Smart modules enable customers to install solar PV systems in otherwise undesirable locations from partially shaded rooftops to uneven natural terrains and to install multiple facets and different types of modules on the same string.
- **Slashed installation times:** By providing an option for a “plug-and-play” solution Upsolar allows system integrators to reduce the resources required to get systems up and running.

Real-time system monitoring: customers can track the performance of their PV systems at the module level to quickly and accurately identify and correct performance issues minimizing maintenance costs by enhancing understanding of the cause of the problem from the outset. Upsolar's smart module systems are equipped with remote shutdown capabilities



Giuseppe D'Elia, European Distribution Channel Manager and Italy Country Manager with David Ridsdale, Editor-in-Chief, Solar International

ensuring greater installer safety and protecting first-responders in the event of a fire. Combined the many attributes of Upsolar's smart modules create a more attractive return on investment for global customers.

In addition to design and performance benefits Upsolar's smart modules are helping make solar ownership a more transparent reliable experience. With real-time performance monitoring apps that allow owners and installers to check in on their systems anytime anywhere smart modules make solar ownership more transparent enabling owners and installers to identify and correct issues immediately. Not only can owners save money by monitoring and maintaining systems more easily they can also share their system's progress with their social network helping demonstrate the benefits of solar to others.





## Industry Development Award

### Atacama Slate

THE INNOVATIVE concept presented by Meyer Burger, the solar module "Atacama Slate", meets the need of cost-effective solutions for producing electricity in regions with high solar irradiance, sand storms and high temperatures (i.e. deserts). The Atacama Slate is based on a combination of high efficiency technologies and innovative module design adapted to the specific requirements of desert regions.

The Atacama Slate consists of a bi-facial, frameless, glass/glass module design combining the high efficiency heterojunction and SmartWire connection technology. The combination of all factors leads to an optimum energy yield while lowering the total cost of ownership.

The challenge in desert regions is to achieve an optimal energy yield given the delicate climatic conditions. High solar irradiance, high environmental temperatures, sand storms as well as a different light spectrum need to be considered in the design and technology of solar modules.

The Atacama Slate module is the solution for reaching maximum energy yield by combining high efficiency technologies with a dedicated module design adapted to desert regions.

Heterojunction cells have a low temperature coefficient of approx. 0.20% and are designed for high irradiance conditions. The SmartWire Connection Technology is a cost efficient method based on cell connection by wires instead of bus bars which are capable of reaching up to 5% higher power output compared



Sylvère Leu, CIO and Philippe Baur, CEO Division Module with David Ridsdale, Editor-in-Chief, Solar International

to best-in-class bus bar technology. In addition, the Atacama Slate offers the possibility of bifacial use thanks to its vertical installation. Sand and dust retention is countered by a frameless design, while the glass/glass construction enables the long module endurance.

The Atacama Slate combines existing high efficiency technologies with a dedicated module design which takes the climatic conditions into consideration and thus delivers a product specifically adapted to these regions but also a cost-effective solution for producing electricity.



## PV Materials Enabling Award

### isishape SolarEtch

IF FUNCTIONAL LAYERS on solar cells need to be structured, alternative patterning methods such as photolithography, laser ablation, or plasma etching have certain disadvantages: They are rather expensive and can cause damage due to particle generation on the surface of the substrates. Merck researchers are therefore using etching pastes from the isishape range, which comprises products that have already been successfully used to mass produce touch panels and high-efficiency solar cells.

Merck's unique isishape SolarEtch concept offers screen-printable and dispensable etching materials allowing easy, efficient and fast patterning.

They are HF/HNO<sub>3</sub>-free and require neither solvents nor detergents for rinsing - only water.

With the isishape SolarEtch product range, Merck has developed a broad portfolio of etching pastes that address different layers commonly used in solar cell manufacturing: silicon dioxide (SiO<sub>2</sub>) and silicon nitride (SiN<sub>x</sub>), amorphous and crystalline silicon etc.

isishape materials only require three process steps:

- Printing of a small amount of etching paste on the substrate where material is to be removed
- Heating of the substrate with the printed paste pattern or etching at room temperature, where applicable. Etching only takes place where the paste was printed.
- Cleaning of the wafer by rinsing in DI water and removing the etched layer material and etching paste followed by drying the substrate to finish the structuring process.

Merck's isishape concept gives a technological edge and offers an unique, comprehensive platform for the manufacture of the solar cell technologies of today and tomorrow, e.g. PERC,

IBC, Bi-Facial, Hetero-Junction etc. In addition to increasing cell efficiency, the three-part structuring process also allows economical and environmentally friendly mass production with standard equipment.

isishape SolarEtch enables etching for antireflective coatings and passivation layers on solar cells. The technology will likely replace current technologies with a less expensive and environmentally friendly alternative.



Mr. Hans-Jürgen Lemp, Director, Head of Structuring Solutions, Performance Material Division with David Ridsdale, Editor-in-Chief, Solar International





## Module Manufacturing Innovation Award

### Double 85 PID-free EAGLE Module

THE EAGLE SOLAR MODULE -- is the world's first potential induced degradation (PID) free polycrystalline module to be certified by TÜV under weather conditions of 85 Degrees Celsius 85% relative humidity with peak power output of up to 265 Watts (panel with 60 cells). A PV power plant strongly affected by PID may lose 70% or more of its power output thus turning into a disastrous investment.

Under long-term impact of high negative voltage for P type cell or positive voltage for N type cell leakage current through the front glass and encapsulation material lead to accumulation of motion ions at the cell surface. The surface passivation provided by the front surface field of the cell degrades. The fill factor, short-circuit current density and open-circuit voltage are significantly reduced resulting in the decline of module electrical performance a phenomenon known as Potential Induced Degradation (PID).

Once a module is PID affected the output power will decrease to approximately 20-70% of its original power. Thus the entire solar system will suffer from a tremendous

power loss. It is reported that some PV installations have lost more than half of their power output over time in extreme cases some installations even measured power losses of up to 80% due to PID.

Many credit institutions have already adopted PID-free as a key bankability criterion which developers have to comply with when applying for project financing.

The high-power EAGLE module contains many innovative characters including wafers with low dislocation and small uniform grains cells with selective



Frank Niendorf, Jinko Solar, Director Europe

emitters and double printed contact as well as newly-designed modules with improved temperature co-efficiency and weak light effects. The improvements in wafer- and cell-processing and module encapsulation all contribute to the anti-PID effect which will guarantee higher power output especially under extreme environmental conditions.

JinkoSolar are the first company in the world to attain PID-free certification under 85% humidity and 85 degree conditions by TÜV (August 2012.) In January 2013 they unveiled the worlds first PID-free mass-produced 'EAGLE' modules which are PID-free under weather conditions of 85 Degrees Celsius 85% relative humidity.



## PV Balance of System Award

### TRIC F Box

MOST SYSTEMS will be fixed onto the roof as this ensures the highest degree of certainty. Not all roof types have a suitable surface type to be punctured for traditional roof mounting. As a result, manufacturers have developed 'ballasted' solutions where the system is weighed down onto a roof with bricks/gravel, to stop them from moving when faced with extreme wind/snow.

This will add weight which causes problems since not all buildings can take the structural load burdened by a PV system fixed with bricks to weigh it down. We have developed the TRIC F box as a low 'ballast' fixing solution to increase the number of possibilities for commercial system integration.

Wagner's innovation has been achieved through a total innovation of the panel arrangement together with a lower inclination which together allows our system to be fixed down with less ballast (weight) as low as 12kg/m<sup>2</sup>. The panels are arranged in a portrait (vertical) arrangement as opposed to



landscape (horizontal). This means that the panels can sit at a lower inclination – 10 degrees, which makes the system less sensitive to wind/snow loading, and thus allows it to be placed with a lower amount of ballast.

The most important benefit arises from the fact that our system has a lower inclination for the panels. By having an inclination of just 10degrees, the impact of shade is much lower, which means that the inter-row spacing is significantly lower than with other systems, meaning that the installer can now design systems which a higher amount of panel array.

This helps the property owner by maximising their roof space to generate more energy.

Even more noteworthy, the system can be placed back-to-back in an East-West arrangement which reduces the shading impact to almost zero and allows in some cases, up to 95% of the usable roof space to be covered in PV.

The system is designed with only 3 components, meaning that installers can easily fix the system together using pre-assembled components to improve the reliability of the installation and save large amounts of time during the installation process.



Mark Osborne, Managing Director at Wagner Solar UK Ltd with David Ridsdale, Editor-in-Chief, Solar International





## Rural Electrification Award

### Steca Tarom 4545

IN THE RURAL AREAS where the Steca Tarom 4545 is commonly in use, many end users are not able to read or write. Thus technical aspects are difficult to understand and need to be conveyed to them on a different way. Moreover the installation of solar charge controllers is tricky because of the lack of space and size of the connection terminals at the charge controller.

Rising costs for external accessories like data logger programmable switches etc. is another challenge products in this area have to face. The new Steca Tarom 4545 provides a solution to all those problems.

The new device has been equipped with a large multifunctional LCD with graphics capabilities so that the user can easily understand the system by the use of self-explanatory symbols. New connection terminals also make the installation much easier.

Thanks to integrated functions like data logger generator start and excess energy management timer's costs could be reduced to a minimum. A nightlight function as well as 2 programmable switching contacts and an open communication interface amplify this effect. The new design for the Steca Tarom sets new



standards in this power class. A graphic display informs the user about all important system data and enables configuration and adjustment of the controller to the specific requirements of the individual system.

Numerous clever functions allow the user to adjust the controller to the particular features of the system in question. Thanks to the significantly improved state of charge determination the system is optimally controlled and the batteries are protected.



Dr. Huguette Kolb-Aust, Steca Elektronik, Sales Director PV Off Grid with David Ridsdale, Editor-in-Chief, Solar International



## Solar Award for Excellence - Individual

Jeremy Leggett

JEREMY LEGGETT describes himself as a social entrepreneur and throughout his working life he has worked on environmental and energy issues from almost every perspective.

As a student at Imperial College in London, his research on the geological history of the oceans won him international awards and being appointed a reader at only 33 years of age. Throughout the 1980s he taught and consulted widely through the oil and gas industries. One of his projects was to explore the possibility of extracting gas from shale. His growing concern that there was a growing imbalance between global oil demand and supply led to him setting up a UK industry task force.

Jeremy decided to do something with his concerns and began to make plans that would have an impact on the energy resource discussion. He initially became an environmental campaigner and his efforts were recognised when he won the US Climate Institute's Award for Advancing Understanding for his work in the 1990s.

He went on to form Solarcentury, a UK based solar and PV supplier and installer. His goal was to build a company that could tackle global energy issues and be profitable. Jeremy began Solarcentury at a time when solar was not fashionable and profits were initially hard to find.

The company is now the UK's fastest growing player in the global solar market and has stuck to its initial purpose of making a big difference in the fight against climate change through widespread adoption of solar power.

Part of the company's remit was to develop a charitable arm and Jeremy is also a founder and chairman of SolarAid, an African



solar lighting charity set up with 5% of Solarcentury's annual profits and itself parent to a social venture, SunnyMoney, that is the top-selling retailer of solar lights in Africa.

As can be seen from this brief peek into Jeremy's achievements he tends to take anything he does very seriously. He has become one of the key speakers and supporters of the global solar industry and is also an author who writes and blogs on occasion for the Guardian and the Financial Times, lectures on short courses in business and society at the universities of Cambridge and St Gallen, and is an Associate Fellow at Oxford University's Environmental Change Institute.





**SOLARRESERVE®**

## Solar Award for Excellence Product

### Molten Salt Power Tower Technology

SOLARRESERVE'S concentrated solar thermal power (CSP) plants utilize the world's leading solar thermal technology which features integrated energy storage. This revolutionary technology which solves the problem of intermittent renewable energy generation is unparalleled in the industry.



the "cold" tank at 500 degrees Fahrenheit up to the top of the tower where it is circulated through the receiver to collect the sun's thermal energy.

The "hot" salt at 1050 degrees Fahrenheit is then pumped back down the tower to be stored in the insulated "hot" storage tank where it is reserved until electricity

is needed. When power is needed the hot salt is sent to a heat exchanger to produce steam which in turn drives a standard steam turbine electrical generator. The cooled molten salt is then pumped back to the "cold" tank where it is stored, ready to be reheated by the sun and used again as part of a continuous closed loop. The system is completely zero-emissions and requires no fossil fuels at all.

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With inherent large-scale energy storage, SolarReserve's CSP plants operate just like a conventional power generator such as coal, natural gas and nuclear plants, providing reliable, predictable energy on-demand. But unlike conventional fossil fuel generators, SolarReserve's CSP plants are not only completely emissions free, but also have a limitless and free fuel source – the sun.

A robust and diverse energy portfolio is critical to solving global energy security, economic and environmental challenges. And solar is a strong part of the energy mix that will reduce reliance on finite sources for power generation. However, electricity from traditional solar technologies is intermittent and unreliable which puts a strain on the grid and requires back up conventional generators using fossil fuel to firm up the electricity generation.



Jose de Santiago with David Ridsdale, Editor-in-Chief, Solar International

SolarReserve has solved this problem. With its use of integrated energy storage SolarReserve's plants provide firm reliable zero-emissions electricity on-demand day or night whether or not the sun is shining.

SolarReserve is deploying breakthrough technology to efficiently and cost effectively store energy from the sun so electricity can be dispatchable to meet demand whenever needed, day or night. SolarReserve's technology captures and stores the sun's thermal energy and operates on demand just like conventional coal natural gas or nuclear power plants but without the release of harmful emissions or hazardous wastes associated with conventional power plant technology. SolarReserve was formed to solve two of the fundamental barriers of renewable energy: scalability and dispatchability, through the use of integrated energy storage.



## Turnkey Supplier Award

### Turnkey Design/Build Services

M W Group covers the complete added value chain for Photovoltaic manufacturing facilities on a global basis with consulting design construction and project management services from poly silicon plants to ingot/wafer cell and module manufacturing as well as thin film module manufacturing factories. The scope offering also includes turnkey design/build responsibility from smaller pilot lines through to large-scale PV plants. Having already designed and constructed a manufacturing capacity exceeding 11GWp M W Group is the global market leader in this sector.

With a staff exceeding 7700 people spread throughout five continents M W Group is able to keep pace with their clients' growth strategies and to offer localized expertise around the world. M W Group has had the honour of providing continuous design/build services and accompanying a number of their PV customers on their path from a start-up company to one of the top ten PV players. The high %age of repeat customers emphasizes clients' satisfaction with M W Group's performance and commitment.

The former trend for scaling up to GW scale manufacturing in the years 2006 to 2010 has changed. It turned out that cost savings due to scaling effects decrease or are even neutralised at annual manufacturing capacities of or above approximately 600MWp. currently we have observed that market conditions for PV manufacturing facilities have changed with respect to local content regulations in certain countries. M W Group has addressed these requirements by defining modular and scalable design concepts that can be adapted to the required manufacturing capacities and copied to new locations. Especially for downstream products such as cells and modules demand for smaller (up to 600MWp capacity manufacturing facilities has increased that are located in the proximity of the end market.

The current challenges for the PV manufacturing industry are: - Cost pressure - The main user markets are shifting from Europe to Asia and the Americas - Requirement for increased local content Due to the overcapacity in the PV industry only few new manufacturing sites have been erected within the last 2 years.



Dr. Klaus Eberhardt, Technology Manager PV and Harald Friedrich General Manager & CSO with David Ridsdale, Editor-in-Chief, Solar International

As a result new technologies could not be fully implemented into mass manufacturing and the further potential for cost reduction is somehow limited in existing facilities. In order to introduce such new technologies to drive down costs into new markets new facilities with advanced design concepts that satisfy local needs codes and regulations will be required.

M W Group is working close together with leading edge equipment and technology suppliers to enable advanced cost-effective solutions for the PV industry. With this integrated project approach M W Group can tackle challenges such as: -Value engineering and benchmarking using the lessons learnt from previous projects -Modular and expandable building concepts -Manufacturing capacities scalable between 100MWp 200MWp 300MWp 400MWp and 600MWp. -Advanced energy supply concepts -Mass and energy flow modelling to reduce overall life cycle costing With its long-term experience M W Group provides best-in-class solutions with optimum flexibility to future expansions minimum operating costs and fast time-to-market.





## Silicon Innovation Award

### DSS™ 450 MonoCast™ monocrystalline growth system

GT ADVANCED TECHNOLOGIES' DSS™ 450 MonoCast™ monocrystalline growth system can achieve mono volume yield that is greater than 80% of the ingot. That translates to more mono region per wafer which helps drive even higher efficiency at the cell and module level. And for customers that seek uncompromised quality, the DSS™ 450 MonoCast™ can produce up to 50% more Grade I wafers (>90% mono area) than other industry solutions.

Cells made with MonoCast wafers have lower Light Induced Degradation (LID) and offer additional area from their full square form. This can produce higher efficiency modules comparable to monocrystalline modules made from boron-doped batch CZ monocrystalline material.



GT's market-leading expertise in crystal growth processes, mechanical design, vacuum and high-pressure chambers, control system design, and crystal growth modeling, provide customers with a technologically advanced system with production proven repeatability.

The DSS450 MonoCast features an industry first automatic seed retention feature that eliminates operator intervention at the end of melt and the start of growth. Coupled with GT's Acuity™ software, the DSS450 MonoCast can produce high quality ingots from run to run and furnace to furnace.



Brandon Brooks, GT Advanced Technologies, Global Sales Manager with David Ridsdale, Editor-in-Chief, Solar International



## PV Process Award

### InPassion ALD

INPASSION ALD FROM SOLAYTEC has the solution for Lab-to-Fab ALD for mass production. InPassion ALD uses spatial ALD for Al<sub>2</sub>O<sub>3</sub> deposition. This technology is based on the spatial separation of precursor gases instead of time-based separation (temporal ALD). For spatial ALD the different gases are confined in specific process areas as the wafers pass by. Every point on the wafer is sequentially in contact with the wafers deposition rate 1nm/sec. This creates the real ALD effect and reaction.

In the SoLayTec machines the process takes place in the core deposition units where a wafer is moved upstream and downstream through an injector head twice per second resulting in eight layers per second, deposition rate of 1nm/sec. The number of modules of a SoLayTec machine can be up to 10 units. The InPassion ALD can change the Al<sub>2</sub>O<sub>3</sub> layer thickness very easily via the user interface. When adapting the layer into less nm's, the throughput will increase (maximum of 4500wph).

In the case that one deposition unit (1 of 10 needs to be stopped for service or caused by an error the other nine deposition units will continue production whereas tools of competitors will be completely down. The ALD process only needs about 5-10nm which saves the user significantly on TMA usage and the cleaning off such an InPassion system is one hour per week.

InPassion ALD can be scaled in throughput by adding deposition modules up to a number 6 or 10 delivering the maximum capacity. For your first pilot line this means you order the InPassion ALD platform including gas cabinet abatement and choose the right number of throughput with e.g. 4 modules you can reach a throughput of 1440 wph.

At a later stage you can add throughput by adding more modules.



Roger Görtzen, Manager Marketing and Sales, Co-founder of SoLayTec with David Ridsdale, Editor-in-Chief, Solar International

Modular deposition unit is field replaceable unit if one of the deposition units is not working properly and cannot be fixed by the customer or SoLayTec service team this module will be replaced by another one. In this way the tool will be running as fast as possible at 100% capacity again. At the same time this module will be sent to a SoLayTec service station to be refurbished.



# 4<sup>th</sup> CS International Conference Agenda Announced!

## 7 themes and 30 inspiring presentations\*

Gain a comprehensive overview of the entire compound semiconductor industry at the industry's leading international conference.

The 4th CS International conference will be held at the **Sheraton Frankfurt Airport Hotel in Germany over two days on Tuesday 18<sup>th</sup> & Wednesday 19<sup>th</sup> March 2014**. Delegates will have the unique opportunity to network with the world's top executives in compound semiconductor technology. Hear about the breakthroughs in device technology; insights into the current status and the evolution of compound semiconductor devices; and details of advances in tools and processes which could help boost fab yields and throughputs.

This event is held once a year and brings together the best in class of the compound semiconductor industry. **Book your place before the 6<sup>th</sup> January 2014 and take advantage of our early bird discounted rate.**

## Book your place **NOW**

Please visit [www.cs-international.net/register.php](http://www.cs-international.net/register.php) for further information

### Chaired by



Dr Andrew Nelson



### Front Ends for Mobile Devices

Handset front-ends are becoming more complex, due to an ever-increasing number of bands used for mobile communication. Will this trend play into the hands of GaAs chipmakers? Or is silicon CMOS technology going to grab market share?



**Keynote presentation: Jeremy Hendy**

Envelope tracking - transforming the performance of CMOS and GaAs PAs



#### Other speakers



**Asif Anwar**

Coming full circle - will Si CMOS burst the GaAs bubble?



**Thomas Meier**

GaAs & Silicon: Co-existence in a wireless world



**Brendan Timmins**

Minimizing the cost of precious metals used in compound semiconductors



**Dr Dirk Schumann, CSO/CTO**

Waterbased stripping innovation for wafer stripping and metal lift-off



\* All speakers and presentations are subject to change.

## Wide Bandgap RF Devices

GaN and SiC have a great set of attributes that make them very promising materials for producing RF devices. But are they now fulfilling their potential and netting substantial sales?



### Keynote presentation: Andrew Barnes

Overview of GaN reliability improvement activities at the European Space Agency



### Other speakers



#### Chris Horton

Enabling material solutions for GaN in the RF arena



#### Mike Mallinger

Microsemi's SiC for long-range radar



#### Marc Rocchi

100nm GaN/Si mmW foundry service and MMICs



## Solar

Triple-junction solar cell efficiencies are increasing steadily. Will this help to spur rapid growth in the concentrating photovoltaic sector, or will it be more valued by those requiring a power source for satellites?



### Keynote presentation: Vijit Sabnis

Setting a new benchmark for space solar cell performance



### Other speaker



#### Rainer Krause - Soitec

Wafer bonded 4-junction GaInP/GaAs//GaInAsP/ GaInAs high performing concentrator solar cells



## LEDs

LEDs are the dominant source for backlighting screens of all size. So, to penetrate new markets and grow revenues, can chipmakers now trim the cost-per-lumen of the LED or equip the device with additional features?



### Keynote presentation: Young Soo Park

Slashing LED costs with 200 mm silicon substrates



### Other speakers



#### William Henry

Applications and opportunities for MicroLED emitters



#### Pallavi Madakasira

LED light bulbs: When and how will the lighting of tomorrow become the lighting of today



#### Ulrich Steegmueller

Success factors in the increasingly competitive LED ecosystem



#### David Kepniss, Director of Sales and Marketing

Sub Part-per-Billion Analysis of High Purity Hydrogen - Process Improvement Applications with the HEMSTM Analyzer



Continues on next page



## Power Electronics

Silicon has dominated the power electronic market for decades, but wide bandgap semiconductors will soon replace this material. What's the primary role for SiC, and where will GaN feature?



### Keynote presentation: Ming Su

Can SiC or GaN power the next-generation hybrid electric vehicle drive systems?



### Keynote presentation: Mike Briere

Pioneering GaN on Si power devices on large diameter substrates



### Other speakers



#### Michael Weirich

Why JFETs can be a success in the power electronics market



#### Philippe Roussel

Vertical integration vs outsourcing in the wide bandgap sector



#### Marcus Behet

SiC and GaN/Si for power electronics – niche forever?



#### Denis Marcon

200mm GaN-on-Si CMOS compatible platform



## Laser and PICs

Rocketing levels of internet traffic are putting greater and greater strain on optical networks and data centres. Can this be addressed by advancing the performance of conventional lasers, or does the market need to turn to greater use of PICs?



### Keynote presentation: Michael Lebby

Photonic integration in InP: A regrowth-free platform for fabless manufacturing model



### Other speakers



#### Gregory Fish

III-V heterogeneous photonic & electronic integration on silicon



#### Petteri Uusimaa

RGB laser solutions to display and projection application



#### Hong Lin

Bulk and free-standing GaN substrate technologies and industry status in the LED, laser diode and power applications



## Integration of CMOS and III-Vs

Silicon is running out of steam, and the future is widely tipped to be high-mobility channels made from germanium and III-Vs. But how will these materials be introduced in the world's leading silicon foundries?



**Keynote presentation: Dr Jean Fompeyrine**  
Co-integration of III-V and Ge CMOS



### Other speakers



**Dr. Thorsten Matthias**  
Direct wafer bonding: Enabling technology for future photonic and electronic integration



**Shinichi Takagi**  
III-V and germanium FET technologies on Si platform

The University of Tokyo



**Aaron Thean**  
Beyond silicon CMOS: Transforming transistors with heterogeneous material integration



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# CS INTERNATIONAL CONFERENCE

Connecting the leading compound semiconductor industry insiders





Announcing the Solar Industry Awards

23<sup>rd</sup> September 2015 in Amsterdam

Call for nomination's open April 15<sup>th</sup> 2015

# Sunset For Silicon?

Lux Research recently reported which up and coming solar technologies will succeed. Analyst Fatima Toor discusses the future possibilities.

As venture capitalist funds for up and coming photovoltaic start-ups dwindle, corporations are already tapping into the wealth of innovation pouring from academic institutions, worldwide. In her recent report - 'Continuing education: Going back to school for photovoltaic innovation' - business analyst Fatima Toor from Lux Research, outlines how Dow Chemical, for example, has formed myriad partnerships with companies developing novel CIGS solar modules. Meanwhile US-based solar electricity group, REC, is forging links with developers of III-V nanowire-based cells.

"Venture capital funding is on the decline for solar start-ups but the market opportunity is too big to miss," she says. "A select group of far-sighted companies have already engaged with academic institutions to find growth opportunities."

According to Toor, come 2030, current research will have found its way into commercial systems, so PV modules will be much more 'technologically diverse' than today. This spells good news for III-V and CIGS systems, but not all disruptive PV technologies are equal.

As part of her research, Toor looked at a wealth of technologies

including next generation crystalline silicon modules, novel III-V based cells and thin film CIGS alternatives, including tandem CIGS and low-cost CZTS. Heavy metal PVs, such as CdS nanowire cells, as well as organic photovoltaics and dye-sensitised solar cells were also considered.

Not surprisingly novel crystalline silicon cell designs held the greatest promise for commercial success, but Toor asserts industry can also expect to see more multi-junction or tandem cells based on III-V and CIGS materials in the modules of tomorrow.

## Hitting targets

Toor predicts that come 2030, only the novel crystalline silicon PV module designs will have reached, or be getting very very close, to \$1/W system price target set by the US Department of Energy Sunshot Initiative. "At almost 90%, crystalline silicon modules have the largest manufacturing capacity in the world, and this infrastructure isn't going anywhere," she adds. "To manufacture [novel] crystalline silicon, it will be a case of upgrading your lines... it will be easier to integrate these new designs than alternative long-term technologies."



Cost will always be an important factor so solar has to become cost competitive compared to other technologies. Most of the time if you can improve efficiency then you reduce the dollar per Watt. So cost, efficiency and lifetime will all play important roles in the future.

But silicon aside, III-V on silicon designs that make the most of existing silicon manufacturing capacity to cut costs, also have potential. Here, Toor believes planar multi-junction or tandem junction cells are a safer bet than, for example, GaAs or InP nanowires on silicon.

“Planar III-V on silicon will have lower process costs because no cleaving of the III-V [layers] off the substrate is necessary and the substrate is a cheap silicon wafer compared to expensive GaAs substrates,” says Toor.

In contrast, and despite promising research, III-V nanostructures - such as GaAs or InP nanowires - on silicon are not slated to reach commercial viability. According to Toor, nanowire solar cells suffer from recombination losses that reduce conversion efficiencies. Toor is also watching so-called parallel HCPV III-V designs that use micro-optical structures to split incident light onto several III-V cells and could boost HCPV module efficiencies to 50% by 2030. “The higher module efficiency will decrease the rest of the stock cost,” she explains. Toor also believes thin film PVs based on tandem-junction CIGS cells hold significant potential, but face significant technical hurdles

including matching lattice constants through the layers. But as she adds: “Many initiatives will be able to borrow research from other fields such as [conventional] CIGS, multi-junction III-Vs, enabling rapid improvements in efficiency beyond 2030.”

As well as tandem-junction CIGS systems, Toor believes modules with CZTS-based cells -that replace relatively expensive indium and gallium active materials with zinc and tin - will reach the necessary cost and efficiency targets to attain commercial success. Meanwhile, relatively low efficiencies will impede the progress of SnS-based thin film PV technologies.

“Cost will always be an important factor so solar has to become cost competitive compared to other [power generation] technologies,” says Toor. “Most of the time if you can improve efficiency then [you] reduce the dollar per Watt. But now durability per kWh is also becoming important. So cost, efficiency and lifetime will all play important roles in the future.”

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# Verifying potential

The solar and PV industries are a global venture and growth opportunities are to be found in areas that may not be as equipped with infrastructure and support than some companies are used to. It is vital that operators in emerging and developing regions have the capacity to provide evidence of product veracity to ensure good will and future growth. Advanced Seaward Solar PV recently helped Comet Systems in Anguilla set up a test verification programme to determine product shipped to the region met the expected standards before installation.

ADVANCED SEAWARD SOLAR PV test instrumentation is helping a successful Caribbean based reseller and installer of solar photovoltaic and thermal systems to verify the quality of PV modules and the performance of installations.

Comet Solar is an established solar installation company based in the British Overseas Territory of Anguilla. With some of the best beaches in the world, the local economy is largely focused on tourism and Comet has been successful in encouraging local

hotels, resorts, property owners and businesses to invest in solar systems as a means of helping to offset the effects of the economic downturn on tourism levels and rising energy costs.

Chris Mason, owner of Comet, explains: "Cost is very important to our customers and so we tend to look for PV modules at bargain prices. Without any subsidies or incentives and facing aggressive resistance from the utilities, solar has been a difficult sell. It is only because the cost of electricity is US\$0.433 / kWh





that we have any customers at all. At that rate and if we had net-metering, our payback on solar PV systems would be about 3 years.”

Comet customers therefore tend to focus on price and return on investment, with aesthetics often being low on the list of purchasing factors. However, buying bargain priced solar PV modules brings its own challenges; second hand or refurbished modules are often used, but, in some cases the life history of the modules or the original manufacturer is not always known.

### Regional variation

Another issue is the lack of formal installation standards or regulations. For example, operating in a Caribbean jurisdiction means that Comet is not specifically required to perform the same tests that a UK or US based installation company would be faced with.

However, in spite of this, in the interests of maintaining installation quality, Comet always aims to apply and meet the existing standards of the US NEC code and to perform to the best practices of the industry.

To help achieve this the company recently invested in a Seaward Solar PV150 solar installation test kit, along with a 200R irradiance meter, to enable it to carry out effective quality control and customer reassurance testing on its products and installations.

The Seaward Solar PV150 is a dedicated multi-function PV electrical tester designed specifically for solar panel system installation. It performs open circuit voltage measurements (Voc), short circuit current measurements (Isc), earth continuity, insulation resistance, operating current (via AC/DC current clamp).

With the push of a single button the new combination tester carries out the required sequence of electrical tests in a safe and controlled manner, avoiding the risk of contact with exposed live DC conductors. Results can be recorded and stored in the tester for subsequent USB downloading to a PC. Chris Mason, explained: “In order to ensure the quality of the products we sell to our customers, we feel it is important to carry out testing thoroughly and effectively.

“We owned standard test instruments and DC clamp meters but found that these manual methods were prone to error and were not particularly practical to use in the field. There is also no efficient way to record the results. We therefore decided to



find a portable but capable test system that would document the performance of each module in a recordable way.”

### Knowing the outcome is vital

Recently Comet was offered a container of 170W used monocrystalline solar panels and used them on a 12 kW commercial flat roof top system.

These PV units had been replaced on their original system due to yellowing of the backing but were in perfect electrical and mechanical condition. As the modules were used, Comet tested every unit prior to installation to make sure of the quality and safety of the modules and also to prevent any subsequent dismantling of the installation for any troubleshooting required.

To do this Comet set up an improvised test bench at the installation site and tested every module as it came out of its packing. All testing was carried out during the middle of the day so as to make use of full sun for testing. Every one of the 66 modules were tested individually and no issues were found, with all units performing as expected with little variation between the modules and no ground faults or open circuits.

Importantly, the speed of the test system allowed comet to perform full tests on each module without impairing the workflow of the installation crew. The test data for each module was downloaded and given to the owner as a system spreadsheet to reassure him that testing had been carried out thoroughly to verify the quality of the modules and to confirm the anticipated performance levels of the system.



### Building on experience

Comet’s latest solar PV installation project is much larger and so requires a different test regime. The company is currently installing 500KW of Canadian Solar 240W modules, purchased directly from the manufacturer.

As these are Tier 1 Grade A modules, Comet won’t be pre-testing every module, but will test each string at the combiner before installing fuses.

Working to US NEC requirements does not allow for easy testing of the installation in the way that typical UK systems do. The wiring is always in conduit and the combiner circuits are hard wired, so there is no easy way to test installed strings on larger systems.

For these larger projects, Comet will therefore be using 1000V rated test leads with alligator clips. Chris Mason said: “Using the PV150 system on an installation in front of the client gives a sense of security that the installers are professional and are doing the project properly.

“We are seeing the emergence of some less than professional installers in the region who perform poorly crafted installations, test nothing and do not give the customer any comfort that the work is being done properly.

“We invite our customers to witness the commissioning tests with the PV150 so they can see how much work goes into our quality assurance procedures. This is both a marketing tool to enhance word of mouth referrals and protection against liability from call-backs.

“Documenting system performance at commissioning gives us a baseline against which to retest in the case of a complaint or problem, both with customers and manufacturers. For this use alone, the test kit and reporting system is invaluable.”

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# The future of energy is efficiency

October marks the 40th anniversary of the event that changed the USA's approach and attitude to energy. A great deal has changed since the Arab Oil Embargo and Sun Day is an event that remembers how it triggered a renewable approach to energy.

FORTY YEARS AGO, the U.S. economy was dominated by fossil fuels (i.e., oil, coal, natural gas) which accounted for 93% of the nation's energy consumption. Petroleum - more than 30% of which was imported - accounted for almost half of fossil fuel consumption with roughly half used in the transportation sector and 17% burned to generate electricity.

In 1973, conventional hydropower generated almost 15% of the nation's electricity and provided 3.8% of total energy consumption. Biomass claimed a 2% share of energy use but, like geothermal, provided less than 1/10th of a percent of electrical generation. Energy produced by solar, wind, and biofuels was essentially non-existent. The 42 nuclear reactors operating in 1973 provided 4.5% of U.S. electrical generation and satisfied just over 1% of the nation's total energy demand.

Four decades later, U.S. energy use in some areas appears to have changed only modestly. Fossil fuels, for example, still dominate and, in 2013, will account for roughly 82% of total energy consumption.

However, other energy technologies have experienced significant growth. Nuclear power has increased nine-fold and now provides over 19% of U.S. electrical generation - roughly 8.2% of total U.S. energy use. The mix of renewable energy technologies now accounts for 10% of energy consumption, 12% of domestic energy production, and 14% of net electrical generation. Perhaps most significantly, major gains in energy efficiency mean that the energy intensity of the American economy today - measured as energy use per unit of GDP - is less than half of what it was forty years ago.

## Energy Efficiency

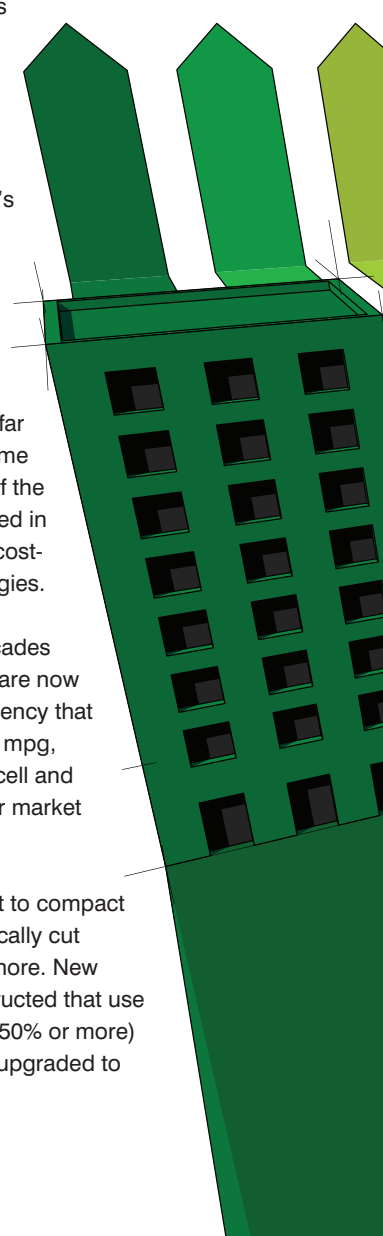
Over the past four decades, U.S. energy use has increased by 28% from 75.6 quads in 1973 to about 97 quads in 2013. However, during that same period the nation's population has grown by 50% (from ~210 million in 1973 to ~315 million in 2013) and the nation's GDP (constant prices) grew from less than \$6 trillion in 1973 to about \$16 trillion in 2013.

Thus energy intensity, measured as energy used (thousand Btu)/real dollar of GDP (2009 chained dollar), dropped by more than half from 13.97 in 1973 to 6.15 in 2012 due to a combination of energy efficiency legislation, agency regulations, price signals, technological advances, and changes in consuming habits. Had energy growth continued at the rates after World War II until 1973, energy use in the U.S. today would be at least 40% higher than it actually is making energy efficiency, in effect, the nation's largest "energy resource."

Yet, study-after-study suggests that the United States has still not picked all of the low-hanging fruit, much less implemented the more complex structural changes that could secure far greater gains in energy efficiency. Some analysts argue that energy intensity of the U.S. economy could be further reduced in the near term by 30% or more using cost-effective, currently-available technologies.

For example, after more than two decades of politically-based stagnation, gains are now finally being realized in auto fuel efficiency that could ultimately lead to a doubling of mpg, especially as hybrid, all-electric, fuel-cell and other alternative vehicles expand their market share.

A complete shift in the lighting market to compact fluorescents and LEDs could theoretically cut energy use in that sector by 75% or more. New buildings can be economically constructed that use 30% less energy (some would argue 50% or more) while existing buildings can often be upgraded to achieve gains almost as large.



Far greater use of cogeneration and waste heat recovery as well as smart grid and new transmission line technologies could greatly reduce energy losses in electrical generation, which typically wastes nearly two-thirds of the fuel consumed.

### Renewable energy

In 1973, renewable energy sources (i.e., biofuels, biomass, geothermal, hydropower, solar, wind) accounted for 6.9% of domestic energy production comprised of hydropower (65%) and biomass (35%) with a trace contribution from geothermal. There was essentially no contribution from biofuels, solar, or wind. In the electricity sector, hydropower accounted for 99.2% of all power generated by renewable sources.

By 2013, renewables accounted for almost 12% of domestic energy production with a mix of hydropower (29.7%), biomass (25.4%), biofuels (20.0%), wind (19.3%), solar (3.2%), and geothermal (2.4%). By mid-2013, renewables accounted for 14.2% of U.S. net electrical generation, with almost half coming from non-hydro renewables.

Renewables have now emerged as a major contributor to the nation's overall energy supply. Yet, it can be argued they are still well short of their real potential. For example, in 1980, a lengthy,

inter-agency analysis conducted by the Carter Administration concluded that renewables could meet 20% of the nation's energy needs by the year 2000 (and some members of the task force argued a goal of 25% was doable). Yet, 33 years later, renewables have only reached the half-way point of the 2000 goal.

Recent growth rates and price drops do suggest, though, that the use of renewables could greatly accelerate in the near-term. Between 2003 and 2012, for example, energy produced from wind increased by a factor of 12, biofuels output grew more than five-fold, and solar generation quadrupled. Geothermal also expanded by more than 30%. Only hydropower and biomass (other than biofuels) remained essentially unchanged.

Photovoltaic (PV) cell costs today are 1% of what they were in 1973. Wind energy costs have declined by as much as 50% in just the past four years. Combined with recent developments in a number of energy storage technologies, wind and solar are now either at, or close to, "grid parity" with fossil fuels -- and, in some instances, actually cheaper. Moreover, the first significant amounts of cellulosic biofuels have been produced in just the past two years with production levels expected to ramp up significantly in the near term.





### Nuclear Power

In 1973, the U.S. had 42 operating nuclear reactors that generated 4.5% of the nation's electricity. In response to the oil embargo, then-President Nixon called for the construction of 1,000 nuclear reactors. The resulting expansion in the 1970s came to a screeching halt with the 1979 Three Mile Island nuclear accident and subsequently resumed at a slower pace. By 2010, nuclear power had peaked when 104 reactors provided 11.3% of domestic energy production and 19.6% of the nation's electricity.

Nuclear generation has dropped each year since then and is likely to see further declines - at least for the next several years - in light of the recently announced closures of five reactors. While five new reactors are now under construction, their eventual contribution to the nation's electricity supply may well be off-set by retirements of other older uneconomic reactors.

Domestic production of coal has increased by over 40% over the past four decades (13.99 quads in 1973 to 19.79 quads in 2013) but its share of the nation's overall energy consumption has remained relatively unchanged (17.1% in 1973 vs. 17.6% in 2012).

Further, its role in electrical generation has dipped in recent years from about 45% in 1973 to about 39% in 2013, reflecting increased competition from both natural gas and renewables.

### CO<sub>2</sub> Emissions

Carbon dioxide (CO<sub>2</sub>) emissions from energy consumption today are about 15% higher than they were in 1973. The 2013 figure actually represents a drop of 11% from the peak level recorded in 2007 with the decline attributable to the economic recession, some displacement of coal by natural gas, increased use of renewables, and improving energy efficiency.

The recent downward trend, however, is almost certainly not

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The resulting expansion in the 1970s came to a screeching halt with the 1979 Three Mile Island nuclear accident and subsequently resumed at a far-slower pace. By 2010, nuclear power had peaked when 104 reactors provided 11.3% of domestic energy production and 19.6% of the nation's electricity

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### Oil, Gas and Coal

The total amount of oil used in 1973 (34.8 quads) has changed little over the past four decades (34.7 quads used in 2012) but its share of the nation's energy mix has declined from 46% to 36%. Notably, oil use for electrical generation has changed from 17% in 1973 to less than 1% in 2013. Roughly half the oil used in 1973 was for transportation; it is over 70% today.

Net oil imports (imports minus exports) rose from roughly 30% in 1973 to a high of over 60% in 2005 and have since been declining; the U.S. relied on net imports for about 40% of the petroleum (crude oil and petroleum products) that was consumed in 2012. Contributing to this decline has been:

- increased domestic oil production,
- an increased use of biofuels (primarily ethanol) - now representing about 10% of the nation's motor fuel supply, and
- improvements in motor vehicle fuel economy (e.g., from an 11.9 mpg in 1973 to 17.5 mpg in 2011; further, the average rating of purchased new vehicles in August 2013 reached 24.9 miles per gallon).

Domestic consumption of natural gas has increased by 26% over the past four decades but remained at about 29% of the total energy mix. Its use in the electricity-generating sector has tripled since 1973 and its share of net electrical generation has increased from 18.3% in 1973 to 26.2% in 2013. (By comparison, electrical generation more than doubled between 1973 and 2013.)

large enough or fast enough to counter global increases in CO<sub>2</sub> emissions or to substantially reduce the risks posed by climate change.

Coal accounted for about 25% of CO<sub>2</sub> emissions from energy consumption in 1973 but its share had risen to almost 30% by 2012 with actual CO<sub>2</sub> emissions from coal rising 37.3% over the past four decades.

By comparison, petroleum was responsible for ~40% of CO<sub>2</sub> emissions in 2012, natural gas for ~24%, and biofuels/biomass for ~5%.

### Conclusion

There has been a massive change in the USA's approach to energy creation and consumption but there is plenty of room to improve on its current status. The USA is still a global leader and how they react to energy concerns will guide many other country's policies. As the industrial giant of the world for over 60 years it has led the world in carbon activity and pollution.

Energy remains a critical component of government decisions around the world and there is a general move towards decentralised energy creation but in making policies that encourage renewable energy sources such as solar there is a need to include the energy savings and benefits of improving our energy usage.

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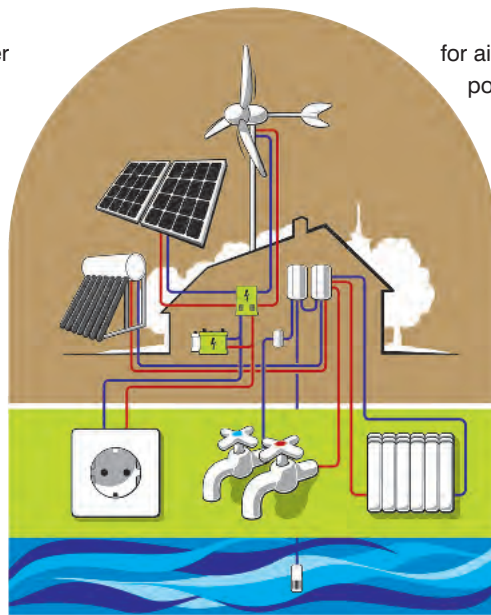
# Solar panels for heating and air conditioning

THE USE OF SOLAR PANELS for hot water in the bathroom is standard practice, but researchers at the Madrid Universities Carlos III and Politécnica suggest that they may also be used to provide large offices with heating in the winter and air conditioning in the summer. Their proposal involves the incorporation of solar collectors into a gas-based co-generation system with an absorption machine, which would reduce both energy expenditure and CO<sub>2</sub> emissions.

They may still be few, but a number of shopping centres and major stations, such as Atocha Train Station in Madrid, house tri-generation systems responsible for the production of electricity, cool air and heat. A gas engine generates electricity and, in winter, the residual heat produced is used directly for the heating circuit whilst in summer, this heat powers an absorption machine which cools the water used to provide air conditioning.

Now engineers from the Madrid Universities Carlos III (UC3M) and Politécnica (UPM) have designed a model which makes the best possible use of this system in order to allow maximum reductions in energy expenditure and CO<sub>2</sub> emissions. Furthermore, the model's ability to accommodate solar collectors is a feature new to the field. The system, the details of which appear in the journal *Applied Thermal Engineering*, has been designed for large office blocks.

Pedro A. Rodriguez, UC3M professor and primary author of the study, explains: "current regulations state that the installation of solar panels in buildings is only compulsory in order to meet the demand for domestic hot water, but very few offices have either showers or kitchens. Consequently, the idea behind our proposal is that a part of the demand for heating in winter and



for air conditioning in summer be met with solar power."

In order to create the model, the team considered the energy needs of the buildings within the Madrid region, as well as monthly climatological data- temperatures and solar radiation- pertaining to the area. The system makes it possible to provide air conditioning or heating according to the specific daily needs of each office- which may vary particularly in spring and autumn. The researchers apply a 'coefficient of merit' as a decision-making tool in order to save energy and to operate the hybrid tri-generation plant. This plant supplies 1.7 MW of electricity, 1.3 MW of heating and

2 MW of air conditioning. It can be installed in a business park of 50,000 m<sup>2</sup>, whose offices are linked together with two rings, each a kilometre in length. These rings follow the path of the sewage works or other underground pipes.

According to Carmen Rodriguez Hidalgo, UPM researcher and co-author of the study, "the size of the investment necessary for the installation of a solar power plant means this hybrid solution takes longer- more than 14 years- to pay for itself. However, the system allows greater reductions in CO<sub>2</sub> emissions, ranging from 1, 527 tonnes to 1, 760 tonnes per year. It also produces primary energy savings and a slight increase in annual profits."

The engineer recalls the fact that the need for energy for heating and air conditioning in Spain's buildings is of crucial importance within the context of a European roadmap whose aim is to move towards a CO<sub>2</sub>-free environment.

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## Journal Reference:

Pedro A. Rodriguez-Aumente, María del Carmen Rodriguez-Hidalgo, José I. Nogueira, Antonio Lecuona, María del Carmen Venegas. District heating and cooling for business buildings in Madrid. *Applied Thermal Engineering*, 2013; 50 (2): 1496 DOI: 10.1016/j.applthermaleng.2011.11.036

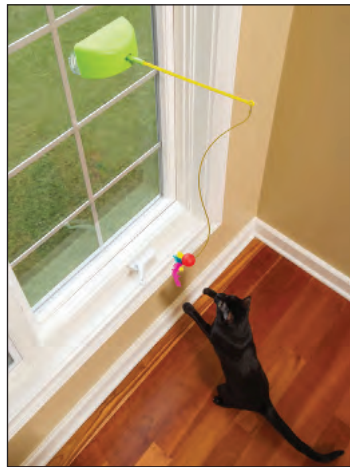


# Tat for your cat

THE WONDERFULLY NAMED Solar Powered Cat Tantalizer is a brand new solar powered product that is taking the cat world by storm and available on online services. Having already being named Best Cat Product of the Year by Cat Fancy magazine the Solar Powered Cat Tantalizer, this innovative feline toy is showing a new side to solar's potential.

Any pet owner knows the benefit of a happy animal and this goes for cats as well despite their independent nature. Many owners have to leave their pets at home while they attend to everyday events of life. Many times pet owners come home to find their bored pets have left a message in the form of something destroyed or little presents around the house to let you know of their displeasure.

Now cat owners can leave their pets at home knowing they will be tantalised and entertained by this clever little device that sticks to your window allowing the sun's energy to power this moving toy. The



attachments are industrial strength suction cups that resist the hardest tug from your dear beloved moggy and become enough of a distraction to prevent a bored pussy from storming through an empty house.

The device simulates the behaviour of prey with a dangling ball and colourful feathers keeping your cat amused for hours and preventing the loss of local wildlife while ensuring your cat gets its natural predator exercise without the mess of a present on your doorstep.

When direct sunlight strikes the device's solar cell, it activates a motor that moves a rod back and forth. The spontaneous, unpredictable motion transfixes cats, prompting them to exercise and practice their hunting skills. The rod detaches for play with a human partner, and a power switch deactivates the toy when not in use.

With no batteries required this is a toy that will be welcome in every cat household.

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