

SOLAR

M A G A Z I N E

September 2013
PV SEC Paris

Crisis-beating innovation
with Dutch solar technology



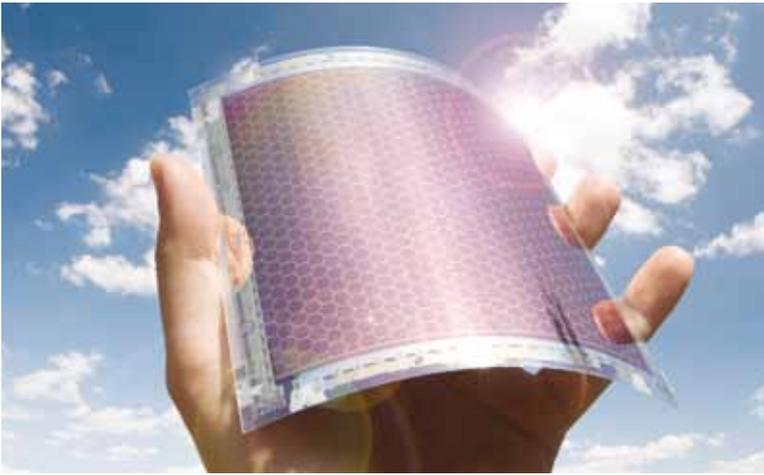
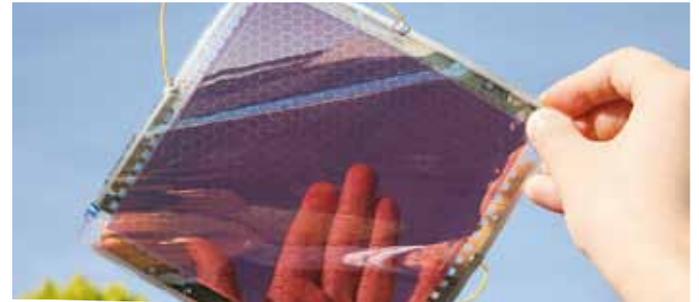


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Solar energy

High Tech Campus Eindhoven is a recognized centre for solar excellence, not just in the Netherlands but internationally. Traditionally, systems and technology involving semiconductors on thin film have been strong fields on the Campus. The Campus companies are especially working together in the areas of Thin-film silicon, CIGS, Organic photovoltaics and Generic technologies.

Partnerships & community

Several players in the solar energy business such as ECN, SunCycle, Solliance, TULIPPS Solar, SEAC and KIC InnoEnergy already enjoy the advantages of being located at the Campus. With knowledge providers such as Holst Centre and Philips Innovation Services, the expertise is enriched. Finally, the state-of-the-art technical facilities complete the high tech ecosystem in the field of solar.

Open Innovation

The Campus' Open Innovation R&D ecosystem with more than 120 companies and institutes, and some 8,000 researchers, developers and entrepreneurs is all about sharing knowledge, resources and networks. Campus companies share knowledge, skills and R&D facilities in order to achieve faster, better and more customer-oriented innovation. This makes the Campus the place where companies turn technology into business.

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“Innovation comes when different groups with different visions and ideas come together around a common goal. New thinking takes place at the boundaries of those groups. That’s what I see on the Campus – lots of skilled people with similar goals in close proximity.”

Paul Stassen, CEO, TULIPPS Solar



High Tech Campus Eindhoven

Beyond the crisis...

For many years, the Photovoltaic Solar Energy Conference and Exhibition (PV SEC) has been the platform for presenting innovations. This is the reason why we have chosen the title 'Crisis-beating innovation with Dutch solar technology' for this magazine. Indeed, it is up to the Dutch solar industry to put into practice new technologies and corresponding opportunities to get beyond the crisis. After all, there can only really be talk of innovation once the new technical opportunities have led to market opportunities and sales.

Dutch companies, knowledge institutes and government authorities are still working flat out on new technologies and countless innovations in the field of solar power. They are deeds and answers appropriate for the global push for power transition. They are deeds that will not just shape the future of the Netherlands, but the future of the entire world.

A future in which the Netherlands will hopefully lead with innovations. In which dependency on fossil fuels will decrease. A future in which the Netherlands will globally play a role of crucial importance. The potential is there. The Netherlands does not just have a knowledge institute in the Energieonderzoek Centrum Nederland that enjoys global status, it also has companies like Tempres Systems, Smit Ovens, Rimas, Lamers High Tech SYstems, DHV and many others that score high internationally. And that is without even mentioning the promising start-ups like Levitech, SoLayTec, HyET Solar, RGS Development and Heliox. You can read more about them in this special English edition of the only Dutch magazine for the solar industry. The sound journalism and editorial approach of this magazine sketches the full spectrum of the Dutch solar industry.

The Dutch solar industry – although with less companies, but still present in great numbers during the PV SEC – will demonstrate during this event that they are able to transform opportunities into business. There is a lot of positive news to report on regarding knowledge, abilities and sales. Like the establishment of VDL Flow, which you can read all about in this

magazine. It is one of the large numbers of Dutch knowledge institutes and companies that have joined hands within Solliance, which facilitates the solar industry in the Netherlands. Within the world of thin film technology, Solliance is involved in the development, scaling-up and demonstration of manufacturing technologies.

There is also a part for the Dutch government to play in the marketing of new technologies through the creation of an industry-friendly home market and the stimulation of innovation. The Dutch government increasingly supports test and demonstration projects within the field of solar power. A step that hopefully the Dutch authorities will take in the foreseeable future will be the step towards a sound grants scheme that will stimulate people to purchase a solar panel. It can facilitate the acceleration of new technologies that make a sustainable future possible all the sooner. Providing we all continue to innovate and providing we manage to continue to raise the level of the development of knowledge. At any rate, the Dutch solar industry is well on its way.

Now all that remains for me to do is to wish you, on behalf of the entire team behind the Solar Magazine, an enjoyable read of this special PV SEC edition of our magazine and every success at the PV SEC 2013. Hopefully, when you reflect on this week, you will remember the Netherlands when you are looking for an innovative partner for your business in the solar industry!

Edwin van Gastel
Solar Magazine editor in chief and publisher



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One hundred thousand euro grant from the Province of Groningen for new support systems

The project 'Development of a Support System for Land-based Solar' from Trundholm BV based in Groningen is to receive a one hundred thousand euro grant from the Province of Groningen. These funds come from the programme Sustainable and Innovative Small and Medium-sized Enterprises (SME). Trundholm BV wants to develop and manufacture special support systems for solar panels intended for solar

panel parks in the Netherlands. The grant is targeted at facilitating the manufacture of the first pilot versions of these support systems. The grant programme Sustainable and Innovative Small and Medium sized Enterprises Groningen began on the 1st of January 2013. In these times where it is difficult for many entrepreneurs to get credit from banks, the provision of this grant is a significant form of support.

Weka Daksystemen sells its first fifty solar carports

Weka Daksystemen (roof systems) recently marketed fifty solar carports. The systems are of differing dimensions, providing cover for a single vehicle up to an entire car park. Electric vehicles can be charged directly with the solar electricity that is generated and logically buildings could also be supplied with electricity. The entirely prefab systems are built with German Schüco solar panels.



More than one hundred certified solar electricity fitters in the Netherlands



The Dutch industry organisations Vebidak, Het Hellende Dak, Uneto-Vni and Holland Solar have been very successful in their joint campaign to encourage fitters and roofers to attain certification and, in doing so, professionalise the solar energy industry. More than one hundred fitters have attained their CITO certificates 'Zon PV'. This certificate proves that a fitter is competent in the area of solar power and has the corresponding theoretical and practical knowledge. This allows him to provide better assistance to (potential) customers. The municipality of Heerlen for example consciously selects certified fitters. The sun PV specialist certificate assures customers of good quality. It also offers fitters and roofers the opportunity to set themselves apart from the crowd.

Dutch researchers make hydrogen with a solar cell



A solar cell was developed in which solar light was used to split water into hydrogen and oxygen. This is a new discovery made by Dutch researchers. They claim to have managed to store solar energy fairly simply using 'artificial photosynthesis'. Two teams, from the TU Delft and the Helmholtz-Zentrum Berlin, have developed the solar cells. A thin film silicon cell is combined with a hydrogen producing cell. Using the electric energy generated by the solar cell, water in a reservoir is split into hydrogen and oxygen. The hydrogen gas can be collected and stored or used immediately to drive a fuel cell. With the storage of the hydrogen that is produced, solar energy is simple to store for later use.

Housing corporations fitted 11,500 solar panels in 2012

In 2012 Dutch housing corporations had 11,500 homes fitted with solar panels. This was practically a doubling of the previous year when just 5,900 homes were equipped with solar panels. Housing corporations improved the energy performance of their homes across the board in 2012, as reported by SHAERE, the energy performance monitor for the Dutch housing corporations' umbrella association Aedes.

Certified fitters are included in the national quality register QBISnl.nl. The Stichting Kwaliteitsborging Installatiesector (KBI) (Association for Quality Assurance in the Installation Industry) provides a list of approved courses and certified fitters who followed these courses. The register helps customers and consumers find a skilled fitter.

New nano material increases solar cell yield

Researchers from Stichting FOM, the Delft University of Technology, Toyota Motor Europe and the University of California have developed a nano structure with which they can make extremely efficient solar cells. The researchers published their findings today in the online edition of Nature Communications. Smart nano structures can increase solar cell yield. An international team of researchers, including physicists from Stichting FOM, the TU Delft and Toyota, have optimised the nanostructure in such a way that the solar cell produces more electricity and loses less energy in the form of heat.

A conventional solar cell contains a layer of silicon. As sunlight strikes this layer, electrons in the silicon absorb the energy from the light particles (photons). With this energy, the electrons jump over an 'energy gap', allowing them to move freely: electricity starts to flow. If the energy from the photon is equal to the energy gap in the silicon, the yield is maximised. Sunlight, however, contains many photons with energy charges larger than the energy gap. The excess energy is lost as heat, which limits the yield of a conventional solar cell. Several years ago researchers at Delft University of Technology demonstrated that the energy surplus could after all be put to good use. In minute balls in a semiconductor material the energy surplus allows extra electrons to jump over the energy gap. These nano balls, the so-called quantum dots, are no more than a ten thousandth of a human hair in diameter. As a light particle moves an electron in a quantum dot over the energy gap, the electron moves around in the dot. This, in turn, ensures that the electron collides with other electrons, which subsequently jump over the energy gap. This allows a single photon to start other electrons moving, increasing the volume of electricity.



Mastervolt starts the manufacture of Soladin WEB and is developing a storage system

Testing of the new Mastervolt transformers Soladin WEB 1000 and 1500 models is complete and certification attained. Which is why serial production was started in Eindhoven in July. The manufacturing process is almost



completely computerised: the location of components, soldering, programming and testing all takes place devoid of human hands. This allows Mastervolt to achieve consistently high quality and a high degree of reliability at low cost. The Soladin WEB series comprises three models of 700, 1000 and 1500 Watt. The transformers are equipped with the latest IntelliConcept innovations and guarantee a five-to-ten percent higher yield. The products have WLAN free IntelliWeb monitoring. The Soladin WEB operates almost silently and is one of the only transformers that is capable of supplying full capacity all day long, even in high environmental temperatures. The intelligent cooling also ensures a long life span. Mastervolt also presented an actual working solar electricity storage system at the InterSolar 2013. This system is based on existing Mastervolt products that have been installed in the maritime sector for many years, supplemented with their own Lithium Ion battery technology. The expectation is that Mastervolt will already be in a position to launch a wide range of storage solutions on the market by the end of the year. Various solutions for various sizes of systems.

Student team from the TU/e unveil the world's first solar powered family saloon

The student team Solar Team Eindhoven (STE) at Eindhoven University of Technology has presented the world's first solar-powered family saloon (also viewed at the cover of Solar Magazine). 'Stella' is the first 'energy positive car' that seats four, has a boot, intuitive steering and a six hundred kilometre range. The team is going to take

this car to the World Solar Challenge in Australia in October 2013 to participate in the Cruiser class. 'Stella' - Latin for star and also with a nod to the family saloon character - generates more electricity on average with its solar cells than it uses. So the car can return its surplus electricity to the national grid. The bottom line is that this car produces more power than it consumes, making it 'energy positive'. Solar Team Eindhoven has set itself the objective of designing the car of the future. Combining an aerodynamic design with lightweight materials such as carbon and aluminium has resulted in an exceptionally low-consumption car. The car is also equipped with ingenious applications like a LED strip and touchscreen, making unnecessary buttons a thing of the past. In addition, Intuitive driving is possible thanks to a steering wheel that expands or shrinks to indicate if you are driving too fast or too slowly.

Utrecht Photovoltaic Outdoor Test facility taken into service

The experimental set-up of solar panels on the roof of the University of Utrecht has officially been opened. With the 'Utrecht Photovoltaic Outdoor Test facility' (UPOT) university researchers can test the yields of different types of solar panels: which of the solar cells has the best power yield with Dutch weather. The UPOT initiative is the brainchild

of university lecturer Wilfried van Sark with the faculty Geo Sciences. The test bed has a surface area of thirty square meters, comprising twenty-four solar panels from nine different manufacturers and materials, including various types of mono and polycrystalline silicon cells, thin film silicon cells, thin film CIGS & CdTe and so-called HIT solar cells.



Wageningen is proclaimed Dutch Solar City 2013

During the Dutch National Solar Energy Debate that took place during the European Solar Days, it was announced that Wageningen had been selected by both the professional jury and the public as Solar City 2013. In the three-way battle, Wageningen managed to beat the Friesland municipality of Leeuwarden and the Zuid-Holland Goeree-Overflakkee. The jury declared Wageningen the winner for the following reasons: 'The municipality of Wageningen doesn't just have a high density of solar panels, but is also very close to its residents. Not solely in the form of informative meetings with residents that the association Solar Energy Wageningen organises, but more especially through the diversity of the initiatives. The jury was most appreciative of the way in which Wageningen actively tackles obstacles in the market, such as the 'split incentive' and the problems associated with balance. Last but not least, the jury liked the architectural integration of PV (BIPV).'

Fujifilm and FOM institute DIFFER link up in functional films for sustainable power

How flickering plasma channels lead to functional films for sustainable power: that is the key question facing the new FOM Industrial Partnership Programme, a Fujifilm and energy institute DIFFER initiative. Through tackling challenging research on fundamental plasma processes in the coming years, the partners will

develop advanced materials with an extensive range of applications, one of which will be the protection of organic solar cells. The new research group is to start with a senior scientist and two PhD students. In the long term, the partners intend to expand the group by two to four post-graduate positions and doctoral

positions. The group will be accommodated in the Plasma Competence Center at Fujifilm in Tilburg, where researchers will have access to Fuji films' unique equipment for atmospheric plasma deposition. The research programme is to last five years with a total budget of three million euro.

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Heineken 's-Hertogenbosch takes 3,632 solar panels into service to produce Sun Beer

The brewer Heineken instructed SolarAccess to install 3,632 solar panels on the brewery roof in 's-Hertogenbosch. The power is used for brewing its 'sun beer'. Heineken had previously commissioned the installation of 4,251 solar panels and

central transformers in Bergamo, Italy, with a total capacity of one megawatt peak. SolarAccess also installed this system that is the largest solar electricity project for a brewery in Europe after the Heineken system in Belgium of 1.43 megawatt peak.



ReRa products facilitate further professionalization solar research

In the last 5 years, ReRa Solutions has grown to be one of the main suppliers for photovoltaic R&D. Leading universities, institutes and industries all over the world use the instruments, software and sensors of ReRa Solutions. The third version of its flagship 'Tracer' will be released during the PVSEC 2013. The Tracer software is the 'de facto' standard to measure and analyze solar cell IV curves. The extensive support for most electronic curve tracers is extended and now incorporates support for outdoor module measurements.

Another newly supported electronic load is the EKO MP-180 I-V Tracer, which has an amazing current range of 20 μ A – 16A for single solar cells. The ReRa Reference Cells always have been a good and affordable choice to accurately measure the irradiance level of solar simulators. The reference cells are manufactured according to the IEC-60904-2 standard and are calibrated in the PV Calibration lab of the Radboud University Nijmegen. The last broadband inter-comparison in Castilla-La Mancha (Spain). proved the



Sunweb Solar in Finnish hands

Last spring Henk Roelofs (former CEO at Solland Solar) managed, after a search that lasted almost an entire year, to sell Sunweb Solar to the Finnish Cencorp Corporation. Sunweb Solar – a remaining part of Solland Solar that, following a previous management buy-out, was sold to the Italian Pufin - was the Netherlands' pride with regard to solar energy innovation. The Sunweb solar cell was developed by Energieonderzoek Centrum Nederland together with Solland Solar. Cencorp director Iikka Savisalo is happy with the purchase and claims that the Sunweb manufacturing technology will be employed for a new module production line. At the high point, Savisalo expects to achieve sales of no less than fifty million euro. The first orders are expected at the end of this year.



ReRa Reference Cells to be well within $\pm 2\%$ uncertainty. As the demand for outdoor spectrally matched irradiance sensors is increasing, ReRa Solutions will introduce a new outdoor Reference Cell by the end of this year. This Reference Cell can be spectrally matched to a specific PV material by high quality spectral filters. SpeQuest, the turnkey Quantum Efficiency system for research applications, has been updated this year to version 2. This system was developed in strong cooperation with LOT Quantum Design and their customers. The main changes are dual light sources support to cover both the UV and NIR wavelengths in one system; true reflective optics to remove the wavelength dependency on the focal length; and faster monochromator. The ReRa Solutions products are demonstrated during the PV SEC at the booths of Abet Technologies and LOT Quantum Design GmbH.

The Dutch PV cluster has recommenced its climb to the top

The Dutch track record of ground-breaking innovation takes another leap

Where the international solar industry is still experiencing turbulent times, the Dutch solar-energy community is torn two ways. Positive and negative news have followed each other in succession during the last year. A number of national investments in the knowledge infrastructure contribute in one way or another to the anti-cyclical investment in machine building being continued. Above all, the machine builders dispose of a substantial home market that is attracting a growing number of players from neighbouring countries.

The years 2011, 2012 and unfortunately 2013 too can be described as years in which the international solar industry was shaken to its foundations as never before. On the one hand, the price for solar panels reached grid parity in many places around the world, but on the other hand the same price drop (a consequence of global overproduction) led to the collapse of countless international manufacturers. The Netherlands did not escape this either. Scheuten Solar went bankrupt again this year following a restart

under a Chinese flag. At the same time, there is positive news worth mentioning from other Dutch PV companies. The research initiative Solliance is running flat out, the Smit Ovens thin film production machines are very popular, as too are the ALD machines built by Levitech and SoLayTec.

Silicon Competence Centre

Although the Dutch PV companies suffered many years of not having a home market, this is – partly due to the falling module

prices – now definitively established. Within Europe, the Netherlands is one of the few explosive growth markets. In 2012 the country welcomed a new installed capacity of at least 195 megawatt, which is adjusted upwards each quarter.

One of the major advantages for the Dutch machine builders is that investment continues here in research and development facilities. Investment is taking place in both crystalline silicon and thin film technologies. For instance, within the Silicon Competence Centre (SiCC) – a Dutch cluster with the aim of creating better and cheaper silicon based solar cells and solar panels – investment is taking place in the existing local knowledge infrastructure. Tempres, Levitech and Eurotron are companies that want to expand and improve the infrastructure together with research institute ECN. The focus is on equipment for plating, masking, printing and module testing. But also other equipment that can contribute is welcome. Interested parties that enter can become important links in the chain in the coming 2 – 3 years in the development of state-of-the-art technologies for the latest generation of solar electricity products.

Solliance and SEAC

Committed investment is also taking place across the thin film landscape. This under the Solliance flag. Currently, six research institutes (ECN, TNO, Eindhoven University of Technology, Holst Centre,



imec and Forschungszentrum Jülich) are bundling their efforts in Solliance in the fields of thin film solar cells. Dutch industrial participation comes from Smit Ovens, Meco, Roth & Rau (formerly OTB Solar), Philips Innovation Services and OM&T. Last year, Thyssenkrupp Steel Europe from Germany joined. Solliance is going to investigate with this German steel manufacturer how steel strips can be provided with an organic photovoltaic coating during production. This produces ready for use constructional elements. Solliance recently announced two significant investments, in an OPV pilot line (awarded to the Dutch start-up VDL Flow) and an ALD development tool for the CIGS-CZTS-programme (to be supplied by SoLayTec and Smit Ovens). Finally, there is the Solar Energy Application Centre (SEAC). This organisation saw the light of day in 2012 as a consequence of the cooperation between Energy Research Centre of the Netherlands (ECN), The Netherlands Organization for Applied Scientific Research (TNO) and industry organisation Holland Solar. SEAC promotes the development of solar systems and applications in urban environments. One of the most recent achievements is taking its test field into service where among others Femtogrid Energy Solutions power optimizers, Mastervolt transformers and Heliox micro-inverters are being tested. All in all, turbulent times for the Dutch solar industry too, but it has seen the light at the end of the tunnel for some time now and

the front runners have already reached it. It is the start-ups especially who are currently scoring heavily, whereby the established players like Smit Ovens and Tempres Systems are already taking the first orders, proving they are a cut above the rest.

Overview Dutch solar landscape

Research Institutes:

- Solliance
- Energy Research Centre of the Netherlands (ECN)
- Foundation for Fundamental Research on Matter (FOM)
- The Netherlands Organization for Applied Scientific Research (TNO)
- Holst Centre
- Dutch Polymer Institute
- Solar Energy Application Centre (SEAC)
- Stichting Monitoring Zonnestroom

Universities:

- Delft, Eindhoven, Utrecht, Nijmegen, Groningen, Wageningen and Amsterdam

The physical infrastructure includes:

- High Tech Campus Eindhoven
- Energy Valley in the North of the Netherlands
- Application Centre for Renewable RESources (ACRRES)

Leading companies in the Dutch solar industry:

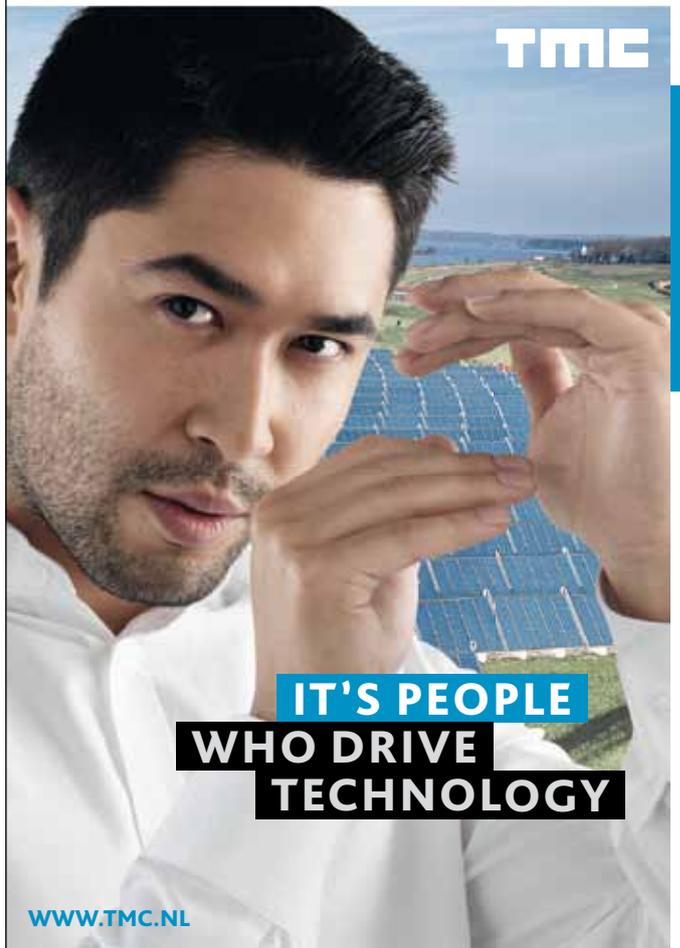
- Eurotron, Mastervolt, Oskomera, Tempres Systems, Meco Equipment Engineers, Smit Ovens, Philips, OM&T, Lamers High Tech Systems, DSM, SunCycle and DHV
- Solar start-ups like HyEt Solar, RGS Development, Levitech, SoLayTec, ProxEnergy, PeerPlus, Heliox, Alinement and TULiPSS Solar, CelSian Solar & Glass, Femtogrid Energy Solutions and VDL Flow.



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Looking beyond cost reduction

The PV sector is obsessed by costs and prices. This is understandable if one considers where it comes from: an energy technology that could only grow substantially by market intervention, that is, by financial incentives of different kinds. I know, there is severe market failure in the energy sector, so intervention may be fully justified, but it has made PV highly dependent on policies and that is an undesirable situation. Moreover, it led to a rather one-sided focus on cost reduction in the development of PV.

Prices of modules and systems have come down rapidly in recent years. Although this has been a disaster for the upstream part the PV-sector and bad news for innovation, it has generally been welcomed by the downstream part, for obvious reasons. When looking at the learning curve of PV modules we see that we have been experiencing price levels that 'belong' to 2018 or 2020 rather than to 2013. It is clear that sustainable pricing is a prerequisite to build a large, sustainable PV market and to ensure the necessary further technology development and innovation. Therefore margins should be restored somehow. Further cost reduction is a natural way to increase margins, i.e. the difference between costs and prices. Since all low-hanging fruit has been harvested over the past decade, this is a very challenging task. Efficiency enhancement is a lever for cost reduction at all levels (cell/module and system) and is a key element in the strategy of companies and institutes. The introduction of new, lower cost materials or drastic reduction of the amount of materials used is another. In the long term the combined effects of these efforts are

expected to allow a further reduction of costs by a factor of 2 to 3 at system level. Although this may not seem impressive compared to the factor 10 or more that was realized over the past decades, it is enough to allow competition in all major electricity markets worldwide.

However, cost reduction is not sufficient for PV to move into the multi-terawatt regime and to become a major source of electricity in all parts of the world. Although PV is inherently renewable, it is not automatically fully sustainable. We have to make sure that the materials needed for the huge volumes of PV we strive for are available at costs compatible with the ambitions outlined above. Also, the sector will gradually have to adopt a cradle-to-cradle approach. Since PV systems are designed to 'last forever', this is far from trivial. Moreover, we need to develop solutions for the triple integration challenge that we are facing: electrical integration into the electricity (or even broader: energy) system, physical integration into buildings, infrastructure and landscapes, and societal integration.

One cannot hide terawatts of PV and public and political support are crucial for very large scale roll-out. Some of the measures we need to take may, at least temporarily, lead to cost increase rather than cost reduction. Reason to adopt an integral approach towards research, technology development and innovation as soon as possible. The global PV sector and its customers has made the first steps in this respect, but needs to go much further. We have to look beside and beyond cost reduction.

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DRIVING INNOVATION INTO OPERATION



VDL Flow: new player that seizes the role of system integrator

VDL Flow is the name of a new VDL Enabling Technologies Group (VDL ETG) business unit. VDL ETG established its name in the international solar industry through the supply of equipment to various leading manufacturers in the world of thin film. VDL Flow focuses on the supply of production machines for printed electronics. The first major customer is Solliance. For the research joint venture VDL Flow's general manager Huib van den Heuvel is to supply a pilot production line for organic solar cells along with other suppliers.

VDL Flow is a new original equipment manufacturer (OEM) that focuses on the development and supply of high-performance sheet-to-sheet (S2S) and roll-to-roll (R2R) production equipment for printed electronics. Van den Heuvel: 'We don't just see our market as being confined to (organic) PV, but we target flexible displays, large surface OLEDs and thin film batteries too.'

System integration

'VDL Flow links the technology specialists present in the Eindhoven-Leuven-Aachen region through a robust and industrial production platform', states Van den Heuvel. 'The expertise we supply is in substrate and web handling, knowledge of control systems and finally the capacity to create a robust production system through integration. We focus here on the roll-to-roll (R2R) and sheet-to-sheet (S2S) market. With our experience of the semi-conductor industry, we can design a platform that meets the strict purity requirements with regard to particles; this is an area in which our machines are miles ahead of the competition.' The development of the new, completely integrated R2R production system for the test production of organic solar cells at Solliance is the first major order. 'The machine has to be installed in the first quarter of 2014', explains Van den Heuvel. 'The greatest technical challenge is maintaining the tension evenly along the entire length of the foil through all the bends it negotiates. And logically the foil has to remain clean the whole time.'

Costs

VDL Flow employs a dozen or so people in-house and has another dozen whose services it calls upon when required. Each employee within the company has their own area of expertise, from physicist to system, mechatronic or software architect. According



to Van den Heuvel, VDL Flow's systems are constructed as modularly as possible. 'We have consciously opted for modular features that have demonstrated their worth and this is the reason why we're working with a whole range of suppliers. The objective is to create standard interfaces for the industry. On the one hand, it is pioneering work because organic PV is a new industry; on the other hand it's about the immediate standardisation to set out a fixed line.' 'It's all about capturing the new film processes for ourselves – and seizing our role as OEM – and we will focus especially on the atmospheric processes. This will lead to higher performance at lower costs and to inspection systems that contribute to higher production yield', continues Van den Heuvel. 'We can assist the ultimate users who are present in finding solutions if they want to develop new applications for their existing production equipment. For example, we are researching for a manufacturer with facilities in America

and South-Korea what needs to be changed in their production line in order to achieve higher specifications. Step by step we are discovering the problems faced by the market and where our company's added value is to be found.'

Key competences VDL Flow

Next generation roll-to-roll manufacturing for printed electronics:

- Fixed line length, independent of the curing time in drying ovens
- Independent usage of each individual line module
- Small footprint suitable for optimized manufacturing facilities
- Perpendicular process extension or replacement capability
- Seamless X-Y integration with other manufacturing processes

Tempress Systems introduces PECVD, anti-reflective coating and ion implant

Last year Tempress Systems director Albert Hasper announced that his company had a number of new and promising irons in the fire. These included the introduction of a PID-free PECVD solution, an anti-reflective coating and the development of the ion implant technology. One year on, the wait for the recovery of the equipment market continues, but the Dutch company Tempress has seen an upturn in sizeable orders coming in.

Tempress has more than forty years of experience in the development and manufacture of diffusion equipment and related processes. The company leads the solar diffusion manufacturing equipment market. During the last few years it has stood out through its cooperation with research institute ECN, which has allowed it to supply the Chinese manufacturer Yingli Solar with n-type silicon solar cell production machines.

PECVD

The continued roll-out of the n-type solar cell is going according to plan. Hasper: 'We are ramping up the focusing on the promotion of n-PASHA bi-facial modules, for which we already guarantee a 19.5 percent yield. In addition, there is a roadmap for yields of well over twenty percent.' In the meantime, the Chinese subsidiary Kingstone's work on the development of the new technology ion implant has continued unabated. 'The objective is highly efficient solar cells and, with that, ion implant is going to make an important contribution to achieving the objectives set in our roadmap', Hasper states. 'This will eventually create a proven concept for a new type of production machine incorporating all our expertise.'

Turnaround

Hasper and his team are currently experiencing a visible rise in the demand for PECVD equipment. 'This is particularly due to the fact that we can offer a PID-free solution. Our solution has no yield loss. This means that customers don't need to choose between reliability and yield.' However, we have the n-PASHA technology to thank for one of the larger orders last year. Wafer manufacturer Nexolon purchased production equipment from Tempress for its advanced n-type solar cell technology and related bi-facial module manufacture. The manufacturing



equipment will be accommodated in a new factory in America. 'It isn't so much the order that is important to us, but the sign that there is a new player appearing in addition to Yingli that believes in the n-type solar cell technology. Moreover, this confirms the strategic turnaround we initiated some time ago; we no longer supply manufacturing machines, only but a technology through turnkey solutions. Our ambition for the coming years is to introduce two or three customers to n-PASHA technology each calendar year.'

Sunbelt

At the same time, Hasper is candid about the fact that the market will have to recover first. 'If the current downturn lasts until 2017, not a single machine manufacturer will survive. But I can see positive signs, certainly as countries in the Sunbelt are now really embracing solar energy and correspondingly the demand for production capacity is increasing.

Nevertheless, the record year 2011 is not likely to be repeated for machine builders. Thanks to cost reductions, we're confident that Tempress will ride out the downturn. Fortunately, the availability of capital continues to support technology development and positions us for taking the lead again in the future.'

Key competences Tempress Systems

- Development and manufacturing of vertical and horizontal diffusion furnaces and related processes, PECVD furnaces for the application of AR coatings and integrated full automation systems
- The product range encompasses R&D, pilot to fully automated production systems.

Smit Ovens scores first orders and reaps the rewards of anti-cyclical investment

'The first projects for machine building for thin film solar cells are starting to appear. It's fascinating to see who is picking up these orders. Now the wheat is really being separated from the chaff and it's clear who has made sensible anti-cyclical investments.'
Says Wiro Zijlmans, director of the machine manufacturer Smit Ovens.

Smit Ovens designs and manufactures thermal process solutions. The company does this for three solar thin film technologies: Transparent Conductive Oxide (TCO), Copper Indium Gallium Selenide (CIGS) and Cadmium Telluride (CdTe). Zijlmans: 'It isn't really important to us which of the three technologies wins the largest market share. I'm convinced that they will all survive and that in each of the three domains we'll be able to play a significant role. We're currently experiencing rapid development in higher yields in CdTe especially. It's remarkable that developments in international laboratories mean that the efficiency of CdTe is catching up with CIGS at an alarming rate. Considering module efficiency, CdTe has already overtaken. It's perhaps not so surprising to learn that we're currently developing two CdTe machines for customers.'

Wealth of opportunity

Although again it has been no easy year for the machine manufacturers involved in the film solar cell sector, Zijlmans sounds satisfied that the world's largest thin film module manufacturers First Solar and Solar Frontier are already making a profit. 'The hurdle for entering the thin film sector is a high one, make no mistake. It's good to see that those who have been investing in thin film technology for many years are solid. Above all, I expect new parties will get on board in the coming years that are either relatively large scale or will serve niche markets and, in doing so, will not have to compete on price from day one. I can imagine this could be a Chinese glass manufacturer who envisages a future in the joint development of solar parks with the Chinese government. Such a party need not immediately encounter the global competition. Only the really enormous players with staying power can afford to take on the competition.'

ALD

In our own country, Smit Ovens is currently reaping the rewards of the investments in the regional ecosystem. It has consequently been selected together with the newcomer VDL Flow to supply the cooperative venture Solliance with an organic PV pilot line. This line will be supplied in the first half of 2014 for the Solliance new building on the High Tech Campus Eindhoven. Above all, Smit Ovens won the tender from Solliance for the manufacture of an Atomic Layer Development (ALD) tool for larger glass substrates. Zijlmans: 'We have plans to utilize this machine in the future for both the PV and the display markets. This is an adjacent market that can be served with the same technology.'

According to Zijlmans, the first international orders in the market for thin film manufacturers are starting to be placed again. 'Of course, it isn't full speed ahead straight away, but a number of projects are starting to appear. It's fascinating to see who is picking up the orders. Now the wheat is really being separated from

the chaff and it's clear who has made sensible anti-cyclical investments. We've already sold three machines for the CIGS technology this year and there are still several orders in the pipeline. This puts us definitely with the wheat, because the chaff is still stuck at zero. Safe in the knowledge that the shakeout in the equipment market is still not finished.'

Key competences Smit Ovens

- Thermal process solutions for high-volume manufacturing
- Thin-film solar solutions:
 - Crystallization for CIGS
 - Selenium deposition for CIGS
 - Activation and deposition for CdTe
- Contact firing
- Glass for solar:
 - TCO for CdTe and thin-film silicon
 - Strengthening and toughening





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Our aim today is to help suppliers and end-users in the photovoltaic sector, to produce cost-effective, robust solar equipment and technologies. With a focus on thin film CIGS, TNO offers the combination of materials technology, process development and modelling, and developing high-end equipment with industrial partners.

TNO is a partner of the Solliance initiative, a R&D cluster bringing thin film solar energy technology to excellence.
More information: tno.nl/thinfilmechnology



Lamers High Tech Systems shifts investment in R&D capacity up a gear

'Our R&D capacity has increased by another thirty to forty percent this calendar year with the recruitment of new process- and development engineers.' An interview with Nico Nieuwland, managing director of Lamers High Tech Systems.



In the last few years Lamers High Tech Systems has specialised in cooperation with major customers in the design, building and qualification of installations and control systems for high purity gases and chemicals. These are sold to companies involved in high tech industries like semiconductors, LED, research and universities, space and aviation, chemicals, food and pharma, and last but not least the solar industry. For some time now the company has been part of Aalberts Industries and is currently expanding its capabilities in the domain of infrastructure and delivery systems for high purity chemicals and precursors. 'It's a clear indication that our company still believes firmly in the future of the solar industry', Nieuwland states.

Gas cabinets

As the sentiment in solar machine building has been on a downturn for a while, Lamers High Tech Systems has benefited from its diversity strategy. 'We're active in a large variety of industries and that has an added advantage if a certain market is experiencing a temporary drop in demand, as is still the case in machine building for the solar industry. Currently we rely on orders from other industries. This allows us to continue our investments in R&D activities. This year, for example, we have appointed a number

of new R&D engineers. This gives us the opportunity to serve other OEM companies in machine building as well as the further development of other specialty gas- and chemical delivery systems.'

And crisis or not in solar machine building, thanks to increased sales efforts in a larger variety of industries, continuity has been secured and now (solar) business starts picking up again. The company has also entered into an agreement with large ALD manufacturers to supply them with gas cabinets in the coming years. 'The number of gas- and chemical supply cabinets in the field continues to increase, now more and more solar manufacturers are investing in ALD technology. We hope and expect this market to really take off in the coming years.'

Thin film

Lamers High Tech Systems does not want to just feature in the crystalline silicon market. 'We also see opportunities in thin film technology for our company', continues Nieuwland. 'We enable new innovative processes for customers through resolving their problems in the distribution and control of gases and chemicals. We have demonstrated this with the development of gas cabinets for various Solar OEM's and we are currently investing in R&D to be able to also serve the rapidly changing requirements

Key competences Lamers High Tech Systems

Turn-key installations:

- Gas & chemical infrastructures, distribution and control panels
- Turn Key installation & hook-up of equipment
- Gas cabinets and chemical supply Systems

(Sub)assemblies for OEMs:

- R&D for custom products and assemblies
- Engineering and manufacturing from prototype to production systems
- Purification and assembling under cleanroom conditions
- Supply subassemblies and vaporizer solutions for liquid precursors
- Testing (FAT/SAT), qualification and certification

of the thin film technology. We are currently engaged in consultations with a number of newcomers and established players in this market about further cooperation. We expect to see the emergence of a certain market maturity in this segment of the solar industry in the coming year.



A world without national grid coupling...

Sometimes I dream of a world without national grid coupling for solar panels. In my ideal world every household in Europe would have a meter cupboard in which power could be stored (in the form of batteries), which could be addressed when the sun was not shining or not shining brightly. The unprecedented bother that many people encounter in our country when coupling solar panels to the national grid would be a thing of the past.

Presently the majority of solar panels in Europe (but also elsewhere in the world) are connected to the national grid. Through a transformer, the generated electricity is turned into useable electricity, just like we are used to from the electricity company. If the solar panel owner does not use all the solar electricity, the electricity is supplied to the national grid. At the moment that the solar panels produce less electricity than is required (for example at night), the extra necessary electricity is drawn from the national grid.

But how long can this situation of so-called balance be maintained? In countries such as Belgium (where solar panel owners pay tax to be permitted to put solar panels on their roofs) and Germany it is clear that national grid coupling is reaching its limit. Germany and Belgium are among the nations with the highest capacity of solar-power generated electricity. Both countries experience days in which more sustainable electricity is generated than the entire country consumes. On days like this electricity is exported to the surrounding countries like the Netherlands. A situation that would not be necessary if Belgium and Germany had energy storage systems at their disposal. It is for this very reason that Germany has established a grants scheme to promote the storage of solar electricity in battery systems.

These days our company comes across many off-grid systems. For example, stand-alone 'solar panels' along road sides, on remote golf courses or at a home that is too far from the national grid. In such situations an off-grid solar energy system linked to a battery storage system is a good solution.

How the energy storage market will develop in the coming years is anyone's guess. Whatever happens in many countries, a time will come when it is no longer permitted to return electricity to the national grid. You might have fantastic solar panels on your roof, but you will no longer be able to pluck the fruits of peak performance. It is for this reason that it would not come as a surprise to me that within three years or so countless European countries would have many thousands of electricity storage systems.

The European Community has a role to play here. Once all the arguments about Chinese solar panels have disappeared once and for all, the explosive growth in solar power will continue to advance in the Netherlands. For the Netherlands in particular the point at which balance will no longer be supported will then be reached sooner. Because it does not really matter how you look at it, in the (medium) long term balancing is unsupportable.

And will battery technology be ready in time? You bet it will. The current generation of lithium-ion iron phosphate batteries will serve trouble-free for fifteen years in the meter cupboard storing solar-generated electricity. So what are we waiting for? The objective of the solar panel is after all to be independent of the energy company and the network operator?!

Erwin van Heijningen
TOP Systems

SoLayTec celebrates the definitive breakthrough of ultrafast ALD

At the end of last year, ultrafast ALD specialist SoLayTec launched its mass production machine called InPassion ALD for the deposition of aluminium oxide (Al_2O_3). The first two models have already been sold and, together with the six already supplied InPassion LAB machines, the installed base comprises eight machines. This company is actually growing in a time in which the majority of machine builders in the solar industry have been hit by the continuing global crisis.

Spatially separated ALD technology and the related production machines have been stealing the show with the international solar industry in recent years. Various start-ups around the world saw the light of day. SoLayTec from Brainport Eindhoven was one of the parties that scored very well indeed. Following the successful market introduction of a research tool, the mass production tool arrived in the 3rd quarter of 2012. Last year, SoLayTec announced that the InPassion machines can be expanded in modules. According to the marketing and sales director Roger Görtzen, this has been rolled out further since. 'Anticipating difficult times ahead for the solar industry, customers can now opt to make a start with just one or two modules and to expand the production to four or six modules at a later stage.'

Variable

'Perhaps most importantly, during the weekly cleaning or other servicing of the machine, it is not necessary to stop the machine. Only the module where this work is taking place is interrupted. This allows us to guarantee an extremely high up-time for the machine,' continued

Görtzen. 'The most significant gain is, however, that companies don't have to first order a lab tool and then later on a production tool. The InPassion ALD is actually a production-ready machine and can be used "from Lab-to-Fab".' Worldwide, SoLayTec has already sold and installed six lab and two production tools. The majority of the machines were sold to East Asia. A major benefit for all the customers is, according to Görtzen, the option of varying the thickness of the deposition layer without having to make adjustments to the machine hardware. 'In the case of a ten nanometre deposition layer, a single module can process 360 wafers an hour', explains Görtzen. 'Two modules can produce 720 wafers and four 1440 wafers, etc. If the thickness of the deposition layer is reduced to five nanometres, then four modules can process 2500 wafers in an hour. The thickness of the layer is often ten nanometres when a machine is first installed at a customer. Together with the customer we work as quickly as possible towards a thickness of only five nanometres to achieve the lowest cost of ownership.'

Cell efficiency improvement

In the meantime, Görtzen tells us that SoLayTec customers are getting good results with the machines. The Flemish research institute imec has made Al_2O_3 the standard for all its research processes. Imec has already achieved a cell yield of 20.6 percent, with deposition of Al_2O_3 . The Chinese manufacturer in Xi'an named Huanghe too has managed to increase the efficiency through Al_2O_3 -deposition from 18.5 to 19.5 percent in a module of 270 watt peak. 'These are two significant results for us, because they demonstrate that our ultrafast ALD technology can increase the efficiency of solar cells considerably both in the laboratory and in scaled up manufacturing', says Görtzen. 'These are encouraging results that bolster our conviction that ultrafast ALD technology has most definitely broken through and now leads the competition with PECVD and batch ALD in terms of costs and efficiency.'

Key competences SoLayTec

Ultrafast spatial Atomic Layer Deposition for Al_2O_3 , benefits:

- Lowest Cost of Ownership
- Atmospheric pressure
- Less process chamber cleaning compared to PECVD
- Deposition at edge of non-coated side < 1mm
- Deposition rate 1,0nm/sec per module
- High uptime because of modular design, production during cleaning
- Flexibility in layer thickness
- Scalable from Lab to Fab
- Throughput up to 3,600 wph, based on 5nm Al_2O_3



Dutch solar community starts twenty-four new innovation projects

Last year, the Dutch government introduced the national Top Sector policy, following the wishes of the European Union to actually select a limited number of industries for investment through the Top consortia for Knowledge & Innovation (TKIs). The following twenty-four solar projects have started since the PVSEC in Frankfurt.

TKI High Tech Systems and Materials

1. Surface engineered iron and tin sulphide nanoparticles as cheap solar cell materials: chemical process research to find cheap solar cell materials under the auspices of the Delft University of Technology;

TKI Solar Energy

The TKI Solar Energy has three themes. 'Systems & Applications', 'Thin film PV Technologies' and 'Wafer based Silicon PV Technologies' are those themes of the TKI Solar Energy.

TKI Solar Energy – Thin film PV Technologies

- 1. 'Light Management through nanotexturisation using Nano Imprint Lithography':** OM&T, C-Coatings, NTS Group, ECN, TNO, Eindhoven University of Technology and Delft University of Technology are working on a new light management technology for thin film PV.
- 2. Roll-to-roll organics for PV (R2RO4PV):** Smits Ovens, Maan, SPG Prints, Bosch Rexroth, VDL Flow, Holst Centre, ECN, Eindhoven University of Technology and imec are improving the quality and reliability of solvent based roll-to-roll (R2R) deposition for organic PV devices and modules.
- 3. All-Atmospheric Absorber formation for CIGS and CZTS (Triple A):** Smit Ovens, Meco, TNO, ECN and imec are developing a rapid 'all atmospheric absorber' process for the 'roll-to-roll'-manufacture of CIGS.
- 4. Solarrok:** ECN, Solliance and Smit Ovens are operating as the linking pin for the European Solarrok project that

aims to foster cooperation between the European solar-energy clusters.

TKI Solar Energy – Systems & Applications

- 1. Advanced Solar Monitoring Phase 1:** Soluzon, Aurum Europe, SEAC and Utrecht University are working on an advanced solar monitoring system.
- 2. Smart Energy Windows:** Peer+, SEAC and ECN are aiming to develop the first generation of product smart energy glass as an autonomous and cable free system.
- 3. A Novel Concept for an Aesthetic Energy Roof (AER):** Mate4Sun, Photovoltaic Professional Management and SEAC are developing building integrated solar panels that comply with all aesthetic requirements.
- 4. Module Level Power Management:** Femtogrid, Heliox and SEAC are developing heterogeneous PV systems employing power optimizers and micro-inverters.
- 5. Light weight Rooftop BIPV System:** a consortium clustered around TULiPPS Solar is working on the development of a light weight bipv-system for sloping roofs; a 'glass roof' system.
- 6. Portaal Zonnestroom:** DNV KEMA, Milieu Centraal, Utrecht University, Stichting Monitoring Zonnestroom, Wepro Special Projects, Sun Projects, Solar Insurance & Finance and Alliander are working on the improvement of the provision of information regarding solar energy.
- 7. Suncycle 2nd Generation:** Suncycle, Radboud University and SEAC are working on a specific 'cell assembly' for the optimisation of Suncycle

concentrated PV systems.

- 8. SolarBeat:** SEAC is building a 'field test infrastructure' for the testing of innovative PV products in a 'real life environment'.
- 9. Low-Cost Prefab Roof-Integrated PV System (LOCI):** SEAC, Solar panels Parkstad and Opstalan are developing



a 'low-cost prefab PV system' for 'residential houses'.

TKI Solar Energy – Wafer based Silicon PV Technologies

1. Duchness: Tempress, ASM, Levitech, Roth & Rau and Meco are researching and developing new technologies for

the manufacture of extremely efficient crystalline silicon n-type solar cells.

2. Silicon Competence Centre: Tempress, Eurotron, Levitech, Roth & Rau, FOM Amolf Institute, Energieonderzoek Centrum Nederland, Delft University of Technology and imec aim to expand the starting position in crystalline

silicon solar cells through bundling and updating facilities.

3. TOP-products: under the auspices of Roth & Rau, the options for the 'Interdigitated Back Contact Hetero Junction' production technology are being evaluated for the manufacture of extremely cheap solar cells with a twenty-five percent yield.

4. EcoPV: Eurotron, Levitech, OTB, Meco, DSM, Alinement and ECN are developing equipment and processes for the manufacture of ecological, innovative solar cells and module concepts.

5. NanoPV: ASM, ECN and Eindhoven University of Technology are exploring thin film technologies for advanced crystalline silicon solar cell designs.

TKI Switch2SmartGrids

1. EVPV-Grid: Power Research Electronics is developing and testing with ABB and Delft University of Technology voltage conversion and energy management technology to employ the batteries in electrical vehicles as a temporary solar energy storage buffer.

2. PV Storage integrated Multi agent controlled Smartgrid (PV SiMS): Mastervolt, Eindhoven University of Technology, Alliander, AmsterdamSmartCity and Greenspread InEnergie are working on the successful integration of solar energy systems.

3. Solar Forecasting & Smart Grids: Ecofys, KEMA and Utrecht University are developing a tool for improving the prediction of the production of solar electricity.



HyET Solar starts the manufacture of solar cell foil

'In the first quarter of 2014, we will reach a production capacity of one hectare of solar cell foil, which will allow us to facilitate large demonstration projects with a product that has an eight percent efficiency.' Pieter Veltman, HyET Solar CEO explains.

As early as in 1997, the former Helianthos began the development of a technology for manufacturing flexible solar cell foil 'on a roll'. Last year, the Dutch entrepreneur Rombout Swamborn took control of the company. Helianthos also has a new name: HyET Solar. This summer, Pieter Veltman succeeded his ad-interim predecessor Frans Mulder as chief executive officer.

Commercial radar

The commercial exploitation of the solar cell foil is Veltman's number one priority. 'The organisation is in place, the factory and technological development are on course. Now it is important that we focus our commercial radar', says Veltman. 'The immediate future is all about mapping out the investment opportunities for the expansion of our manufacturing facilities. We're going to have to look carefully at the feasibility of a medium or a high-efficiency product.' According to Veltman, many decisions at HyET Solar will be guided by the opportunities in the Netherlands for securing finance. Constructive consultations with the municipality of Arnhem and the Province of Gelderland are currently underway. 'We're fairly confident that we'll be able to make a sizeable investment at the present location. The crux of the matter is really how much do we want to invest and with what objective. Do we want to be a manufacturer or a technology company that licences to third parties? This is a decision that still needs to be made.'

Finance

Many factors influence investment decisions, according to Veltman. Like a preference for operating from the Netherlands, proximity to the market for the foil, government incentives for adoption of the foil and incentives to invest in manufacturing. 'In any case, in the first quarter of 2014 we will reach a production capacity sufficient to facilitate large demonstration projects with a product that has an eight percent efficiency. If we continue to develop this product technology – the question



being, does the market consider this necessary – a tandem material can be made with an efficiency of ten to eleven percent.' 'We want to prove our production technology on a larger scale. Therefore, in the short term we want to find the finance for a medium-scale factory with a production capacity of ten hectares of solar cell foil, in other words ten megawatt peak', adds Veltman. 'Once the financing has been settled in the third quarter, manufacturing can start in the summer of 2015. To support a large-scale factory with a two hundred megawatt peak capacity, structural changes need to take place in the Netherlands' investment climate. From a technology and production (cost) perspective, I envisage almost no obstacles for the completion of a large-scale factory in the Netherlands.'

Market applications

Veltman believes the final important objective for the future is the demonstration of the foil in market applications. 'This is something that we need to work on in the short term. There are cooperations with two market parties with which we're working on the demonstration of our products. They are both parties from the world of roofing. One is a manufacturer of corrugated materials and sections; the other is involved in bitumen roofing materials. We are looking

for other partners. We made significant progress over the last year on product and production technology as well as lowering product cost. This excellent starting position gives us great confidence in the future.'

Key competences HyET Solar

HyET Solar develops a technology for the manufacturing of flexible, light weight, silicon based solar modules. This unique technology enables a solution which is flexible solar cells, main benefits:

- Light weight: the laminate weighs only 600 grams per square metre;
- Flexible: flexible and unbreakable, easy to handle, transport and install;
- Ideal for BIPV: easy to integrate into building materials for roofing and facades;
- Durable: TÜV approved, very strong, weather-resistant and anti-soiling encapsulation;
- Performance: easy and cheap to install, generates more kWh/m² roof in real world conditions.



New building will be taken into use in Q1 2014

Successes are really stacking up around Solliance

A lot has gone on in thin-film research at Solliance since the PVSEC in Frankfurt. It is not just that the new building on the High Tech Campus Eindhoven is well underway, but the CIGS pilot line has been taken into use, Forschungszentrum Jülich and Thyssen Krupp have joined as research partners and a world record for CZTS solar cells has been broken.

Three years have already elapsed since the arrival of Solliance was widely publicised. Energieonderzoek Centrum Nederland (ECN), Eindhoven University of Technology (TU/e), TNO and the Holst Centre announced that they had joined forces in Solliance. In the meantime, the research institutes imec and Forschungszentrum Jülich have entered the stage. In addition to the initial industrial partners as for instance Smit Ovens, OM&T, Roth & Rau and Philips Innovation Services, amongst others, the German steel giant ThyssenKrupp and VDL Flow from the Netherlands joined in the last year.

Scalability

VDL Flow is a new company operating under the VDL Enabling Technologies Group (VDL ETG) banner. VDL Flow became partner of Solliance to develop a completely integrated 'roll-to-roll' (R2R) pilot production line for organic solar cells (OPV). The development will be, in close cooperation with Solliance researchers, executed by a consortium including Smit Ovens and Bosch Rexroth. Smit Ovens is also involved together with fast ALDexpert SoLayTec in the

development of a fast ALD-CIGS-pilot line. Solliance director Hein Willems said in a previous interview with Solar Magazine that his organisation did not just want to be famous for breaking world records for solar cell yields in a laboratory. 'We strive to increase the efficiency of the process steps in production processes', Willems claimed at the time.

Operational

More recently, Solliance transformed these words into deeds. Research partner imec attained a European yield record with Copper Zinc Tin Sulphide (CZTS). 'The technology employed here is completely scalable and the scaling up is taking place on the Solliance CIGS pilot line. The technology employed by imec is already being used for the manufacture of CIGS solar panels and has demonstrated its scalability', according to Willems. 'This result doesn't just confirm the strength of Solliance as a vehicle for innovation, but it also underlines that cooperation is more important than ever. This is the only way to maintain sufficient focus and mass as a thin film cluster, so that you'll be in the starting blocks as the machine building market

recovers.' The cooperation is to commence in April next year in the new Solliance building on the High Tech Campus Eindhoven. The building has a two thousand square metre production hall and an additional eighteen hundred square metres of office and lab space and will accommodate thin film silicon, CIGS/CZTS and organic PV research. 'One of the most important objectives for 2014 is to get the operation of the organic PV line up and running', continues Willems. 'Once this is functional, it will immediately be the best production line in the world. Secondly, with our CIGS pilot line we want to achieve a yield that can be used on a semi-industrial scale worldwide. Finally, we want the scaling up of the Copper Zinc Tin Sulphide (CZTS) to achieve the highest yield in the world. With the retrospective interconnection that is applied to the cells of different types we will create a truly flexible cell that can be made in any desired shape.'

And the cooperation with industry? Willems concludes: 'It's our ambition in the coming year to commit another five industrial partners to us so that the chain in each programme line enjoys optimum representation.'



Contact

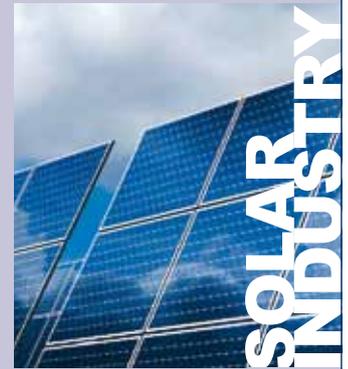
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New Solar Business Development

The Brabant Development Agency (BOM) joins relevant parties in the solar value chain to develop initiatives and projects to build a strong international PV cluster. Industry partners include NTS Group, OM&T, OTB Solar, Smit Ovens, Solaytec, Tulipps, VDL and more. BOM is business development partner for Solliance (ECN, Holst Centre, Imec, TNO, TU/e).

Brabant Development Agency

BOM offers access to its network with the local SME's, national industry and European business communities as well as with universities, research centers and financial institutions. BOM initiates and accelerates innovative projects, spin outs and multiparty deals and has its own financial instruments including equity share-holdings.



SOLLIANCE

An R&D cluster bringing **thin film solar energy technology** to excellence



DSM will establish a position as materials innovator in solar industry

Life and Materials Sciences company DSM is steadily increasing its activity in the international solar industry. Some time ago the anti-reflective coating KhepriCoat® was launched on the market, last March DSM took control of the Dutch start-up SolarExcel. Employing this company's technology DSM is to start the pilot production of a solar foil that considerably improves the yield of solar panels.

According to Oscar Goddijn, vice-president of Advanced Surfaces at DSM, there is an unbelievable demand for innovation in the solar market and this is exactly why DSM wants to intensify its offerings to the solar market. 'In addition to the anti-reflective coating and solar foils we have numerous ideas in the pipeline for materials that add new functionalities to solar panels. For example encapsulation layers and backsheet materials are still waiting to be fine-tuned towards active materials to maximise the performance of solar pv modules. You can even compare most of the materials currently used in solar panels with the parts that were used to build the model T-Ford. In ten years' time solar panels will be constructed by using more complex and advanced materials and components designed to deliver higher performance with as an ultimate goal to reduce the kWh cost of solar energy. In the coming years – partly due to failures in the market – a reassessment of the quality of solar panels will take place and as a result people will start to realise that there is an advantage in paying a bit more for a module in exchange for a higher yield and a more durable product.'

Light management

With the acquisition of SolarExcel that took place last spring, Goddijn believes that DSM has armed itself with a new weapon. This company worked on the development of a yield increasing textured foil for solar panels based on a proprietary light management technology. For the next phase, the scaling-up of production and global sales, it was necessary to find



a suitable partner and that was DSM. Goddijn: 'The foil traps the light in the module as it were and we are continuing to develop this technology at high speed. It is fun to see that as you bring all the pieces of the puzzle together – the knowledge present within DSM, SolarExcel and external parties who have a lot of experience with producing and applying films – how fast the product development rate accelerates. In pilot projects to be initiated this year, we want to subject our textured foil to large scale field testing. We will subsequently concentrate on the question of how to upscale manufacturing and what the preferred business models should look like. Through combining our knowledge of machine construction, outdoor performance of materials and

industrial processing we will crack the last remaining complex problems.'

Combined functionalities

Thelight trapping foil and KhepriCoat® are not the only irons that DSM has in the fire according to Goddijn. However Goddijn does not believe that a combination of the foil with KhepriCoat® is likely to take place in the short term. 'Combining our textured foil with an anti-reflective layer is not high on our priority list, but I expect we will commercialize products with combined features in the near future. For example an anti-reflective layer that ensures that a module remains clean, or textured polymeric frontsheets enabling efficient but lightweight solar panels. In brief, there are countless innovative ideas.'

CelSian Glass & Solar continues to invest in solar research and development

More than twenty months ago the TNO Glass Group was transformed into CelSian Glass & Solar. The company now employs more than twenty-five members of staff; almost double the number at the time the company became independent. CelSian is already active in the global solar market and the company still harbours the ambition to make significant contributions to innovations and existing PV technologies. Main driver is the optimisation of solar related production processes, whether they are energy intensive like the production of solar grade silicon, or challenging like the production of ultra-thin glass substrates.

Since March this year Roeland Brugman (Director Sales & Marketing) and his team have been housed in the former technical heart of Philips in the centre of Eindhoven. 'We've returned to a historical patch of ground where the famous Philips glass lab was once located. And today we are the party that forms an important glass centre for the global glass community. Additionally, this location has ideal facilities and infrastructure for large-scale pilot production and R&D activities.'

GlassTrend

It is clear from what Brugman has to say that CelSian is ambitious. The company

is for example the coordinator for GlassTrend, an international innovation platform comprising about fifty internationally operating companies almost all of whom are large producers of float, solar, container, fibre and special glass. The body focuses especially on the various issues concerning sustainability and energy-efficient glass manufacturing within this industry. As all the companies pay annual membership and for optional participation in R&D projects, the expense of high-risk research is shared and solutions for fundamental bottlenecks in glass manufacture are tackled.

One of CelSian's important glass spearheads is the optimisation of the manufacture of ultra-clear float glass. Brugman: 'In the solar industry this low-iron glass is commonly used in order to capture as much of the available light. And another spearhead is three-dimensional process simulation for complex deposition processes. This too is utilised in the manufacture of thin film PV.'

Ambition

In the coming period CelSian is to deliver one of the major R&D efforts for the solar market through a European innovation project. Together with TNO, the Eindhoven based company is preparing for a project that is to focus primarily on CIGS solar cells and research into multi-scale process modelling of the related production steps.

Ultimately, Brugman believes that CelSian has the ambition through such innovation projects to act as a catalyser in the solar market for the regional ecosystem.

'By teaming up with the knowledge institute TNO and local machine builders, comprehensive and innovative solutions for complex deposition processes can be generated. Or, is there a future for the manufacture of flexible glass substrates employing roll-to-roll manufacturing processes? For sure, it will generate new opportunities for building integrating solar functionalities. This region is the ideal location for the development and manufacture of a machine for this type of manufacturing process.'



Heliox presents the first Dutch micro-inverter



Heliox is the first Dutch company to launch a micro-inverter. At the end of September a field test commenced with the first six micro-inverters manufactured by Heliox. This is taking place at the Solar Energy Application Centre (SEAC) on the High Tech Campus in Eindhoven. 'We designed and manufactured the micro-inverters entirely ourselves', relate Heliox directors Rudi Jonkman and Mark Smidt.

Rudi Jonkman and Mark Smidt started Heliox in 2008. Since this time the company has developed high-tech energy solutions: from power supply architecture to converter topologies. With the objectives of higher energy efficiency, low standby consumption, limited weight, small dimensions and flexibility. The development of a micro-inverter is right up this company's street.

Arc

'Now that the micro-inverter has been successfully developed and the first units have been manufactured, comparative measurements are being performed by SEAC with competitors' products', explains Schmidt. 'The major advantage for customers is that a micro-inverter combines the features of a transformer and power optimizer. A micro-inverter creates 230 volts of direct solar electricity that can be supplied to the national grid. Above all, the micro-inverters can be installed on the back of each solar panel, so that customers no longer need to have any equipment in their home.'

From the point of view of safety, the micro-inverters have several advantages, according to Jonkman. 'When a solar electricity system has a single central transformer there is an extremely high DC voltage. This DC voltage can't be removed instantly by switching it off from the national grid, because the solar panels are still there. With a micro-inverter, each individual solar panel is coupled to the national grid. If you switch off from the national grid, the micro-inverter immediately stops supplying solar electricity. So you create a safe low voltage in each solar panel. This is a major benefit if a fire breaks out. The fact that the solar panels with a micro-inverter aren't linked serially means that the voltage is low, and this dissipates the risk of arcing.'

Humid conditions

Jonkman claims that very specific knowledge is required to understand micro-inverter technology. 'A standard transformer can of course be big and is above all installed in a safe indoor environment. A micro-inverter

is to be found outside on the roof and has to be able to cope with temperatures from thirty below zero to seventy degrees Celsius and tolerate wet conditions such as rain and snow. Taking all this into account, it isn't surprising that there are few manufacturers of micro-inverters. We've been able to acquire knowledge and expertise while working for former high-end customers. Our technology ambitions for the coming years include overtaking Enphase in lifespan and yield. Our micro-inverter has to have a lifespan of twenty-five years so that replacement during the lifespan of the solar cell is unnecessary.'

In the business model, Heliox opts to manufacture and market the product independently. Smidt: 'The focus in the first year will be on the Dutch market. In the coming years we plan to further reduce the size of the micro-inverter, which is an important condition for reaching the absolute top. We will only be satisfied once we've developed the smallest and, according to European notions, most efficient micro-inverter.'

Meco ready for market introduction of plating machines for solar cell metallization

Over the last few years, Meco Equipment Engineers has supplied various Asian and European solar cell manufacturers with pilot production lines incorporating a new technology for solar cell metallization. This plating machine really brings down the cost price of crystalline silicon solar cells by replacement of silver with copper. 'In 2014, we expect to sell the first mass production version of this machine', relates Martijn Zwegers, product manager Solar with Meco.

Plating is the wet chemical deposition of a thin metal surface layer to a (conductive) surface. Meco has a worldwide installed base of more than 650 machines for plating applications in various industries and the solar application is expected to become a key market. The company is part of the Besi Group and has more than forty years of experience in supplying plating systems for the semiconductor, automotive, connector and smartcard industries. For several years now the company has also pursued the solar market. The company cooperates with Imec, the Flemish research institute that does have extensive expertise in copper plating, and is also expert in integrating different manufacturing processes into high efficiency solar cells. Imec has developed solar cells that employ plating for metallization with efficiencies consistently beyond twenty per cent. More results will be published on the next EU PVSEC. Meco is also participating in several Dutch TKI projects.

Less affected by turnaround

According to director Ruurd Boomsma Meco has been less affected by the major slowdown in solar equipment investments as compared to other machine manufacturers in the solar industry. The company is serving multiple markets which including the semiconductor market and the smartcard market. 'Recently also our roll-to-roll RFID systems received increased attention and early this year we installed again a mass production RFID machine in Asia. Most recently we see an interest for our equipment for battery applications. Beside the direct sales of equipment also the large installed base delivers a steady stream of service and retrofit revenue which is more and more an interesting part of the business.'

HIT

'We recently supplied several systems for copper metallization of HIT (Heterojunction with Intrinsic Thin Layer) cell technology',

Boomsma continues. 'Demand for such machines is predominantly coming from Japan, South-Korea, Taiwan and China. and it seems the system seems very well suited for this application which does not allow for normal screen printing pastes (which require firing temperatures in the range of 800 C) due to temperature limitations of the HIT layers which requires process temperatures below 200 C. The latest results will also be published on the EU PVSEC.'

For solar cells which use both sides for light-capturing (bi-facials cells) and hence need metallization on both sides, the system seems a natural fit as both sides can be metalized in one run, provided proper care for the initial seeding has been taken. This gives a major financial advantage due to lower capital spending and very efficient process flow.

IBC Cells

Another type of high efficiency cells, the IBC cells seems also a very interesting application as copper plating is already used here, although using more conventional rack type plating. The Meco system was selected by a major electronics company after substantial testing, unfortunately this project was not finalised due to cancelation of the full project. Zwegers: 'The test showed a very good uniformity enabling thinner copper tracks because the overall thickness requirement (to have also on the thinnest locations enough copper) could be lowered. We expect renewed interest in this application.'

Thin Film CIGS

Although copper has been accepted in the semiconductor industry for quite some time ago and despite early good results with BP there is still some hesitation to shift to copper metallization. Work by several R&D teams generates more and more positive data on reliability and long term results of modules equipped with copper metallization. More will be published at the EU PVSEC.

Key competences Meco Equipment Engineers

Designing and manufacturing plating equipment for :

- plating machines for depositing the absorber layers (Copper, Indium and Gallium) of CIS and CIGS thin film solar cells;
- plating machines for metallization of crystalline solar cells;
- applications include plating on printed seed layers, direct plating onto silicon, plating of Interdigitated Backcontact Cells and plating of bifacial cells (HIT).

Although maybe less known, Meco together with TNO and a French customer is making good progress on CIGS thin film technology using plating for the deposition of the active layers. Zwegers: 'Results are very promising and plating is a much more cost effective due to very high material utilization and lower equipment costs. Although vacuum based processes are still somewhat ahead there has been great progress over the last year. 2014 will be the year in which we expect to get the first full production systems in the field. The slowdown in investments gave us somewhat more time to further optimize the systems and we now also see that production software functions and product tracking functions we developed for semiconductor applications are very useful for solar applications. Such systems will be integrated in the production flow and automation and inspection will also be integrated.'

Femtogrid seeks strategic alliance with inverter manufacturers

Over the last few years, Amsterdam based Femtogrid Energy Solutions developed a range of Solar Power Optimizers. The power optimizers – now available in a 2.0 version – maximise the energy yield per system by means of a parallel architecture and by performing Maximum Power Point Tracking (MPPT) per module. These power optimizers allow Femtogrid to generate up to thirty percent more energy per system.

'We are deploying the current 2.0 version of the power optimizer in a large-scale European market launch', Femtogrid director Tom Engbers opens the conversation. 'We presented this product for the first time at the InterSolar 2013 in Munich. This was our opportunity to reappear on the scene for relevant market parties. It is centred around our F2G Interface Unit, because it facilitates the combination of our power optimizers with all known string converters. This places us in an excellent position for seeking cooperation with inverter manufacturers.'

F2G Interface unit

'Unlike some of our competitors, we try to take tangible decisions', Engbers continues. 'The global inverter manufacturing market is in turmoil and under pressure. We are trying to link high-efficiency inverters to our power optimizers at a price this market can afford. We are interested in entering cooperation with three or four inverter factories in Europe and China. Our aim is to integrate our power optimizers in their products through the F2G Interface Unit.' Engbers is dedicated to presenting the 3.0 version of the power



optimizer for Femtogrid in 2014. 'The strategic alliance agreements with inverter manufacturers should be in place by then, so that we can offer a joint solution. That will be the real moment of truth.'

Greentech continues industrialisation of product innovations under Pezy Group

Last summer Greentech Engineering was acquired by the Pezy Group. GreenTech – established in 2011 by the PV expert Marcel Grooten – will continue to industrialise its customers' product innovations under the Pezy Group. 'We support in taking product and process technologies to the market and consult customers with project management, specific methods and process engineering', claims Grooten. 'Thanks to the acquisition by the Pezy Group, we are in better shape to achieve our ambitions for growth and we'll be able to accelerate our performance.'

Tackling manufacturing challenges, yield improvements and supply chain engineering are GreenTech specialities. From its head office in Brainport, Eindhoven, the company has strong links with its suppliers and high-tech systems specialists. 'In the solar industry, especially, we want to facilitate the challenging step from lab to fab for the countless start-ups. E.g. last year we supported successfully the Solliance / VDL Flow cooperation. We can also serve existing PV companies, who are often



confronted with similar challenges.' 'The PV industry is one of the sectors we are

focusing on, in addition to semi-conductors, LED and automotive', continues Grooten. 'The PV industry is continually faced with the introduction of new technologies out of research. Transforming these smoothly into mass production is a daunting endeavour. This is the reason why industrialisation is not just a challenge for start-ups, but also for original equipment manufacturers (OEMs) and their suppliers to get the process equipment running at low cost, high yields and high uptime.'

Levitech takes orders with mass production fast ALD system

So far the year 2013 has been a good year for Levitech, one of the two Dutch ALD start-ups. A world-leading manufacturer of high-performance solar cells has selected the Levitrack ALD System for high-volume production of next-generation high-efficiency crystalline solar cells.



'The selection of the Levitrack by our client is evidence that our mass production solution for fast ALD deposition delivers the right product to meet our customers' needs,' stated Jaap Beijersbergen, chief executive officer of Levitech. 'We know that our aluminum oxide (Al₂O₃) film provides excellent surface passivation resulting in increased cell efficiencies. Particular features of the ALD technique are the deposition of uniform and dense layers with excellent step coverage and no pinholes. In the Levitrack these process qualities are combined with an efficient platform for mass production with a wafer breakage far below the industry average. Since its introduction, the Levitrack has consistently demonstrated its

advanced passivation capabilities at world-leading manufacturers and institutes.'

ISO

Beijersbergen concludes: 'Recently, it has been demonstrated that with the Levitrack ALD Al₂O₃ process the backside polishing can be eliminated, which greatly simplifies the backside passivation process. This process simplification, combined with the Levitrack's high throughput, results in a superior cost-of-ownership of the overall backside passivation process flow.' One of the other successes of 2013 is the achievement of the ISO 14001 certification. Levitech has its long-term corporate commitment to sustainable development

further endorsed by securing the ISO 14001 certification from DEKRA, an internationally accredited firm for management system standards. ISO 14001, the international standard for Environmental Management Systems (EMS), will help organizations to identify, and systematically reduce, any harmful effects it may have on the environment. 'Increased scrutiny of industry's effects on the environment has made compliance with ISO 14001 exceedingly important,' says Beijersbergen. 'This certification demonstrates our commitment to control the environmental impact of our operations and, as importantly, minimizing the environmental impact of the high-tech equipment that we provide to others.'

Royal HaskoningDHV: 'Opportunities in upgrading existing solar factories'

The merger of the engineering firms DHV and Royal Haskoning into a group comprising 8000 employees became official on 1 January 2013. Royal HaskoningDHV has a turnover of more than seven hundred million euros. The company's activities cover areas from delta technology and mobility to airport design. In the solar industry, too, Royal HaskoningDHV is an important player. Recent years have seen the design of solar factories in both The Netherlands, Lithuania and Belgium.

Royal HaskoningDHV was and is heavily involved in the engineering and completion of solar parks. The company is specialised in the design of process and building dedicated utilities, the corresponding architecture and the supervision of the construction of solar manufacturing facilities.

Feasibility studies

Just last year Royal HaskoningDHV provided drawings for the process utilities of a huge project in Lithuania. Together with the architect of the customer and an equipment-line supplier, a new factory with an extremely high level of sustainability was built that runs on geothermal energy drawn from over 100 different sources at a depth of 100 meters. Schrijvers explains that Royal HaskoningDHV is attempting to increase its profile with its investment services department. 'In times of crisis, it is more difficult for solar companies to get banks to finance them. Through feasibility studies, due diligence and access to private investors, this department assists them in sealing the deal on finance.'

'The demand for feasibility studies is currently on the up again', continues Schrijvers. 'This appears to be a result of positive developments in various countries, fuelled by the desire to shake off the yoke of the Chinese. These countries want to introduce measures similar to those adopted in Canada, where the government has obliged manufacturers to perform a large proportion of their manufacturing in Canada if they want their products to qualify for Feed-In Rates.'

New use

Schrijvers only expects to witness a definitive market recovery for factory



development in 2015-2016. 'And in Europe manufacturers will have to pull out all the stops to survive. In contrast, a continent like Africa is advancing. Companies might be smaller, but it is certainly an interesting continent in which to invest. Why else would we have had an office in South Africa for all these years? It is one of the absolute leaders for solar energy in this southern continent.' During the last few years, Royal HaskoningDHV has built 12 solar factories around the world. Schrijvers realises, better than anyone, that the company is unlikely to build the same number of new factories in the coming years, especially as a result

of the continuing overcapacity. 'Where we are engaged, it will most probably be for the expansion of an existing solar factory or the refitting of a solar factory for another purpose. I'm convinced that the cell and module factories that manage to survive will need to upgrade their buildings.' Currently, in Europe, Schrijvers envisages the greatest challenge is in finding new uses for factories. 'Solar factories have a fairly specific set-up, similar to semiconductor factories. In the case of the latter, we have fitted out several properties for new uses such as multi-talent locations for technology start-ups.'



Make hay while the sun shines

While writing this article, I am enjoying one of the many wonderful sunny days during this exceptionally beautiful Dutch summer. Centered in a beautiful blue sky our most sustainable source of energy is shining, performing its daily work. The sun pays no attention to (inter)national political discussions about import duties, grants and the many other challenges of our solar industry.

With a potential of 2,000 times the current annual global energy requirement, there is no discussion that solar energy is the most important source of power for the future. However, at the current time, the solar power market is not only benefitting from this favourable outlook but is also hampered by its current success and by the difficult economic conditions. Take the Netherlands as an example. Over the last twelve months, more solar panels have been installed than ever before in a calendar year. In the Netherlands, housing corporations, associations and various consumer groups are already wholeheartedly exploiting the opportunities for solar energy. The Dutch machine manufacturers, such as Mecco, Smit Ovens, Tempress, SoLayTec, Levitech and many others, have also witnessed how the solar energy market has matured in our own country. It is almost a certainty that the Netherlands will break through the one Gigawatt ceiling and the target of four Gigawatt by 2020 may well be exceeded before that date. However, Dutch machine builders, operating in hard economic times, are also hampered by the success of the market growth as they are faced with global overproduction. At the same time, I am glad to say that many of our members and many other machine builders are doing their utmost to keep their R&D efforts up.

This Dutch open innovation culture has already resulted in extremely advanced manufacturing systems, new materials and reduced manufacturing costs (and consequently lower unit costs). Why wait until tomorrow, better make hay while the sun shines! The step forward can be taken today, thanks to innovative Dutch technology. The latest Dutch achievements are to be found in thin film solar cells with Solliance's successful scaling up and the

founding of VDL Flow. Thanks to its flexible nature, this type of solar cell is ideal for building integrated applications. These and other types of innovative BIPV products will distinguish Dutch solar energy companies in the future. In just a matter of years, aesthetically integrated solar collectors and solar panels on rooftops and in the landscape will become a normal and accepted phenomenon. In practical terms, this means that everyone will understand the benefits of solar power and solar heat. The discussions will no longer be about whether or not to buy a solar system, but about the brand and type of the products and quality of the installation. Creative applications as a result of cooperation between manufacturers of solar products and other sectors will lead to surprising solutions. Large solar energy systems, for example, integrated in the roofs of assembly halls/factories or in the landscape on farming lands, and parts of buildings that are constructed with building elements which integrate solar energy. The key to reaching this success is the bundling of strengths from industry and suppliers within the solar energy sector, and the cooperation with the building and system installation sectors and architects.

The Netherlands has started this process a while ago. As one of the outcomes of this process next to the development of innovative production machines and innovative BIPV products, a large number of parties, including Agentschap NL, Uneto-VNI and industry association Holland Solar, have been working on the national Solar Power Master Plan for quality assurance of solar energy installations, over the last two years. The Master Plan comprises of a three-stage approach: a solar energy manual, a training programme for installers and the regulations for certification of the installers. All three stages have been completed. The manual alone cannot disseminate the sum of collected knowledge among the market parties, which is why a number of independent consultancy firms have developed courses for installers. These courses are concluded by an exam, after which the installers are awarded an official certificate and can apply for the Quality Label ('Zonnekeur'). Last month, one hundred installers had already received certification!

*Arthur de Vries
Member of the Board Holland Solar*

SOLAR

I N D U S T R Y R E G I S T E R

September 2013
PV SEC Paris

The following pages give an overview of organisations and companies active in the PV-solar value chain. In view of fast developments in the PV-solar industry, it was impossible to make a suitable specific model in which all possible PV-solar technologies are mentioned. For this reason a three-step model has been chosen, with each step coupled to equipment and knowledge center. An indication (the red lines) is given per company in which part of the value chain they are active.



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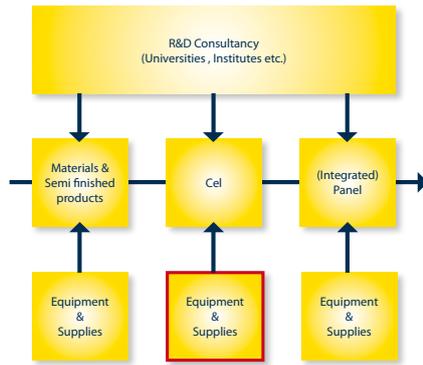


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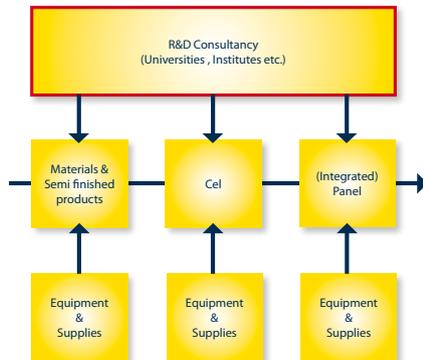
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New Solar Business Development The Netherlands

The Brabant Development Agency (BOM) joins relevant parties in the solar value chain to develop initiatives and projects to build a strong international PV cluster. Partners include companies such as Fujifilm, Philips, NTS Group and academia such as Imec and Eindhoven University of Technology. BOM has helped hundreds of foreign companies initiate or expand operations in Brabant. We provide high quality services free of charge to any organisation interested in establishing solar activities in Brabant. Please feel free to contact us.



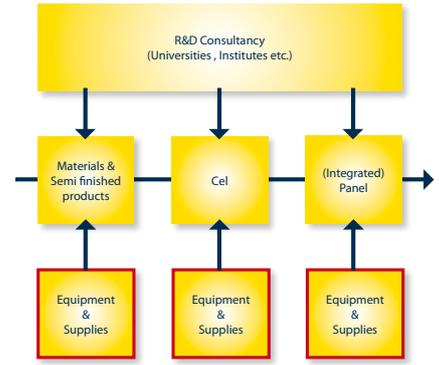
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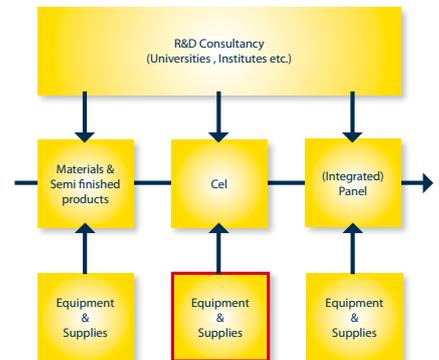
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Wout van 't Wel

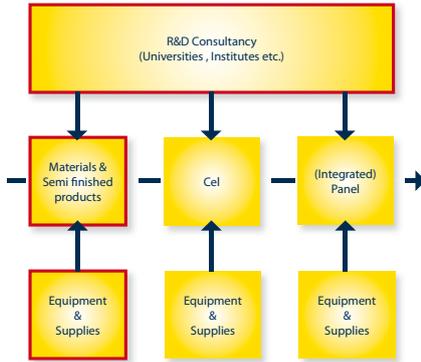
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CelSian Glass & Solar B.V.

As a Dutch technology and knowledge provider, CelSian Glass & Solar B.V. (former TNO Glass Group) assists companies in optimizing their glass and solar production and reinforces the innovation of the needed manufacturing equipment and their final end products. CelSian is globally well-known for their fundamental knowledge on energy intensive and complex multi-physics processes. Industrial producers and the related suppliers of raw materials and machinery are supported by means of:

- Contract research
- Technological innovations
- Industrial services
- IP & software licenses
- Laboratory & pilot facilities
- Knowledge transfer



CelSian Glass & Solar B.V.

Roeland Brugman, Sales Director

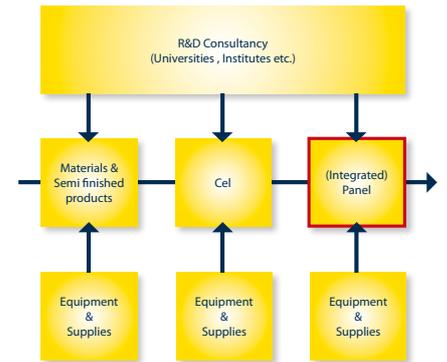
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I. www.celsian.nl

Femtogrid Energy Solutions BV

We are Femtogrid. We provide renewable energy solutions. Our products generate more energy and measurably higher efficiency per system. We achieve these results by applying unique and patented technology in our products. Our products enable module

manufacturers, inverter manufacturers, distributors, integrators, installers and system owners to maximize solar energy generated per system by performing Maximum Power Point Tracking (MPPT) per module and connecting the modules in parallel to the inverter. As a result, Femtogrid overcomes shading conditions, module mismatch, aging mismatch, soiling mismatch and temperature variance. In addition, Femtogrid is able to combine rooftops with different azimuths and/or tilts in one system.



Femtogrid Energy Solutions BV

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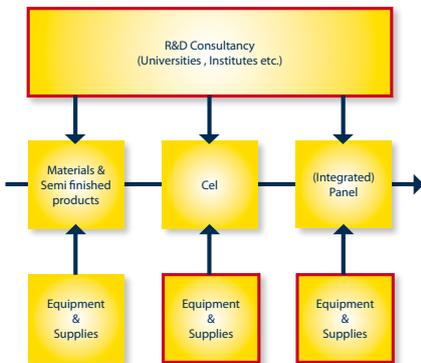
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Greentech Engineering - DRIVING INNOVATION INTO OPERATION

Greentech Engineering is executing industrialization projects. Our core activity is managing and conducting the product generation process into operation. Our company is offering consultancy, engineering services, project realization, specific equipment and process engineering.

Addressing production challenges, yield improvement and supply chain engineering are part of our services. Greentech Engineering approaches the operational challenges in the high tech industry through combined expertise on;

- Process Engineering
- Product Engineering
- Production Engineering
- Application Engineering
- Equipment Engineering
- Supply Chain Engineering



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Greentech Engineering

Marcel Grooten

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High Tech Campus Eindhoven - 'Turning technology into business'

High Tech Campus Eindhoven is the smartest km² in The Netherlands with more than 120 companies and institutes, and some 8,000 researchers, developers and entrepreneurs working on developing future technologies and products. The Campus helps you accelerate your innovation by offering easy access to high tech facilities and international networks. Campus companies (a.o. Philips, NXP, IBM, Intel) strategically decide what knowledge, skills and R&D facilities they share in order to achieve faster, better and more customer-oriented innovation in the application fields Health, Energy and Smart Environments. Located at the heart of Brainport Campus companies are responsible for nearly 50% of all Dutch patent applications.



High Tech Campus Eindhoven

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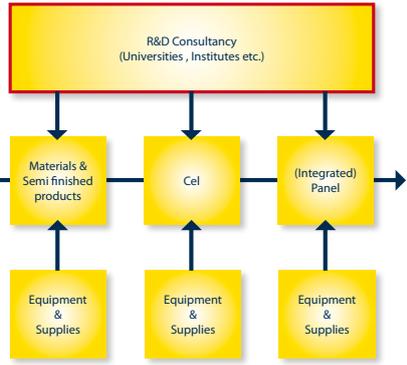
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Holland Innovative

Integration of Six Sigma, Project Management and Reliability! Holland Innovative is leading when it comes to supporting organizations in product & process improvement, reliability engineering and project management. In Solar industry we actively participate in development project teams and running-in activities of solar production facilities worldwide.



Always a solution! For yield improvement, production process development, reliability design or any other complex process, our multidisciplinary professionals of Holland Innovative will offer a sustainable and reliable solution! Challenge us!



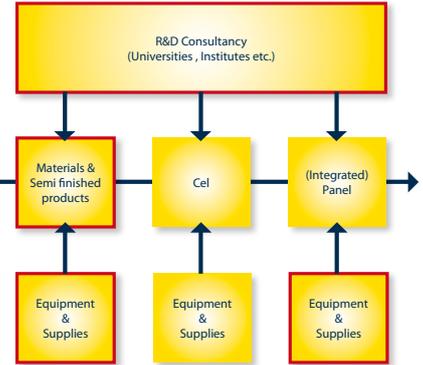
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HTR Rubber and Foam

The HTR Group, since 1953 a leading company in the supply of rubber and foam products. HTR has developed a plasticizer blocking foam for the use of roof in combination with solar panels.



The brand name for this unique material is Bafosal®. It protects the roof from direct metal contact when installed directly under the construction, and it blocks plasticizer migration when used under rubber protection tiles. Off course HTR can supply the whole system: rubber in combination with Bafosal: the unique flexible solution!



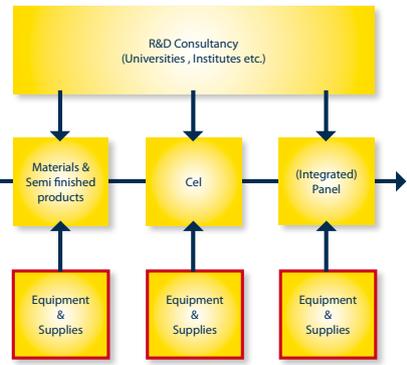
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Lamers High Tech Systems

Lamers High Tech Systems is a leading supplier to technology driven markets for over 25 years. Main activities in the solar market are: *Turn key installation consisting of:* Gas & chemical infrastructures (SS or Plastics); Gascabinets and Bulk Chemical systems; Hook up of production



equipment incl. vacuum; Hot commissioning, qualification & validation. *Subassemblies for OEM's:* R&D&E of custom & standard products and assemblies; Purification and assembly under clean room conditions (>1000 m2); Bulk Chemical systems for POCL3/BBR3; Stand alone Evaporator Systems for DEZ, TMA, TTC; High Purity vacuum & process piping; Contamination (RGA,TOC,etc), particle and moisture analysis.



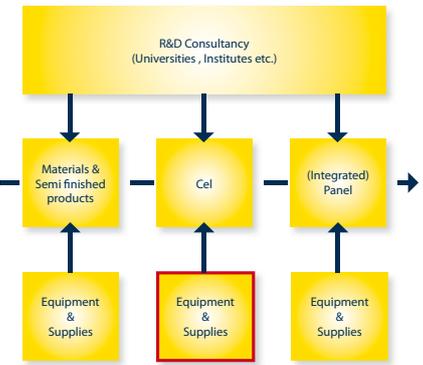
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Meco Equipment Engineers BV

Meco has more than 30 years experience with designing and manufacturing plating equipment for various industries such as solar, semiconductor and connector. Meco supplies, installs and services its plating machines worldwide with a current installed



base of > 650 plating machines. For the solar industry Meco delivers plating machines for depositing the absorber layers (Copper, Indium and Gallium) of CIS and CIGS thin film solar cells and plating machines for metallization of crystalline solar cells. Applications include plating on printed seed layers, direct plating onto silicon, plating of Interdigitated Backcontact Cells and plating of bifacial cells (HIT).



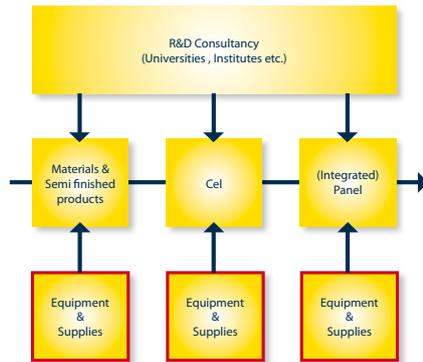
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Mevi Group BV

Mevi can offer engineering, manufacturing and assembly of parts, modules and machines. We are a creative and skilled team and realize tools and machines for various purposes, from concept up to installation. We are a vertical integrated organization and control the complete supply chain which benefits the customer in quality, manufacturability and lead time. High precision milling (0,3 um) repeatability and clean room facilities help to get the requirements you need.



Mevi Finemechanical Industries BV

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Royal HaskoningDHV BV

Royal HaskoningDHV is an independent, international engineering and project management consultancy with more than 130 years of experience. Its head office is in the Netherlands, other principal offices are in the United Kingdom, South Africa, and India. We also have established offices in Indonesia, Thailand and the Americas; and we have a long standing presence in Africa and the Middle East. Backed by the expertise and experience of 7,000 colleagues all over the world, our professionals combine global expertise with local knowledge to deliver a multidisciplinary range of professional engineering and project management consultancy services in aviation, buildings, infrastructure, industry, energy and mining, planning and strategy, transport and asset management, rivers, deltas and coasts, and water technology all over the world from 100 offices in 35 countries. By showing leadership in sustainable development and innovation, together with our clients, we are working to become part of the solution to a more sustainable society now and into the future. Today, the company ranks in the top 50 of engineering companies worldwide and in the top 15 of Europe.



Royal HaskoningDHV

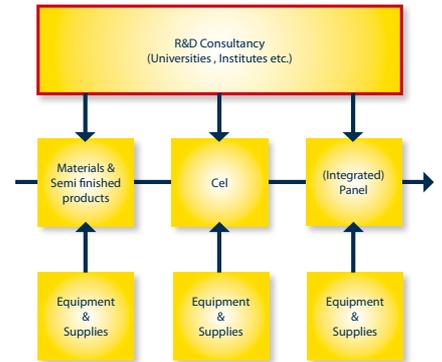
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ReRa Solutions B.V.

ReRa Solutions has built up many years of experience in the development of complete PV Measurement Systems and tooling (IV-curves, Quantum Efficiency, Lifetime). Besides complete systems and equipment, we offer consultancy, software



and measurement equipment design. This unique combination results in excellent measurement systems that facilitate the research on solar cells. The knowledge of solar cell measurement interpretation is what makes ReRa Solutions unique. Products & Services:

- Tracer: all-in-one software solution for IV-curve measurements;
- SpeQuest: Quantum Efficiency measurement system for all types of Spectral Response measurements incl. Multi-junction;
- Lifetime measurement for Organic cells;
- (Customized) Probestations and Reference Cells.



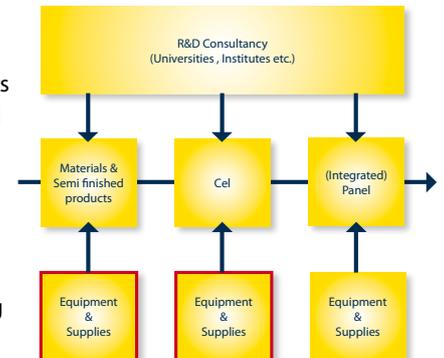
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Sierra Instruments B.V.

With more than 150 locations in over 50 countries, Sierra Instruments is known for the design and manufacture of innovative high-performance fluid flow measurement and control instrumentation for nearly any gas, liquid and steam application spanning across global industries as diverse as scientific research, semiconductor, wastewater treatment, iron and steel, clean energy, aerospace and biotech to name a few. Sierra Instruments designs and manufactures high precision capillary-sensor based Mass Flow Meters and Controllers for gas flow applications. We also design and manufacture Immersible Thermal Mass, Transit-Time Ultrasonic, Vortex Shedding and Multivariable flow instruments in both standard and customized versions for applications in



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industrial and hazardous environments.

Sierra Instruments B.V.

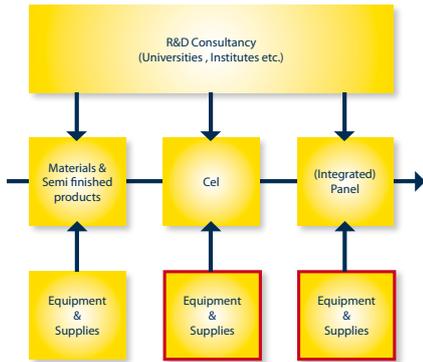
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Sioux – Increase solar cell efficiency

For more than 15 years Sioux is an important partner and supplier for R&D, Sioux has a workforce of 300 engineers experienced in technical software, remote solutions, industrial mathematics and electronics. We are also specialized in embedded in-product software development for manufacturing, semi conductor and solar related industries. Sioux capabilities range from motion control, image processing, machine connectivity for the semi conductor front end production equipment (wafer scanners) to back end equipment (wafer inspection, laser dicing, PCB production and SMT, application of inkjet). Solar is an important part of our project portfolio, e.g. centered around atomic layer deposition to increase solar cell efficiency.



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Sioux

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Smit Ovens

Cost-effective thermal processes for thin-film photovoltaic production. Smit Ovens is a leader in thermal processes for high-volume thin-film solar cell production. We deliver innovative, high throughput solutions based on smart designs and processes.

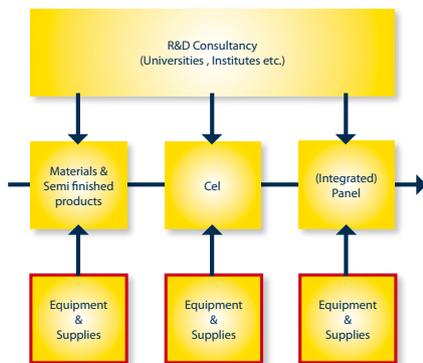
These cover:

IGS: Deposition of elemental selenium; selenization; crystallization; RTP (Rapid thermal processing); activation; conditioning.

CdTe: Deposition; activation; conditioning.

a-Si/μ-Si : Conditioning; Pre-heating.

TCO: FTO - atmospheric pressure CVD; ZnO - atmospheric pressure CVD.



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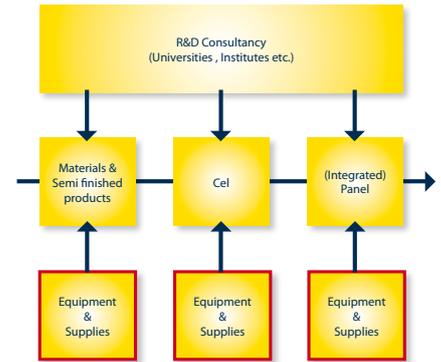
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SMC Pneumatics BV | Worldwide leading experts in pneumatics

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products and static control. SMC is your reliable partner for developing customized solutions.



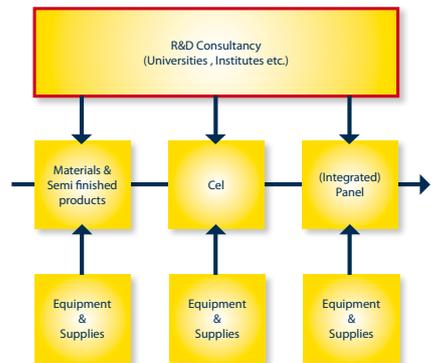
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Solliance

Solliance is a partnership of R&D organizations working in photovoltaic solar energy (PV) in the ELAT region (Eindhoven-Leuven-Aachen). Solliance is creating the required synergy by consolidating and coordinating the activities of industry, research institutes and universities. Solliance partners are: ECN, imec, TNO, Holst Centre, TU/e and Forschungszentrum Jülich. Solliance is supported by the Dutch province of North Brabant. In order to make optimal use of these lab facilities, they are open to valorization programs in joint research with industry. Solliance aims to collaborate with all main companies and institutes in the world.



Solliance

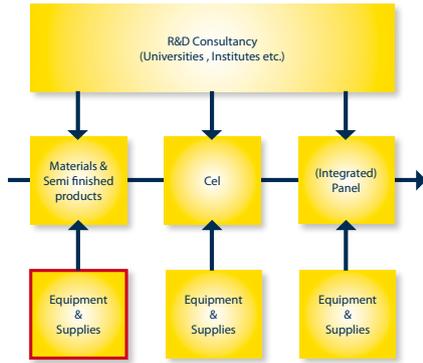
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Technobis Mechatronics BV

Technobis Mechatronics is specialized in carrying out complete development trajectories to come from an idea to a successful turnkey special product, prototype or series product. Technobis Mechatronics successfully operates in the solar market for several years now. Technobis Mechatronics is a supplier of handling systems for silicon solar cells and is specialized in handling silicon solar cell wafers at high speeds (one wafer per second) in harsh environments as high temperature (1000 °C) and vacuum environments. Also systems used to handle peripherals for the manufacturing of silicon wafers at high temperatures have been developed and delivered by Technobis Mechatronics.



Technobis Mechatronics
Passion for precision technology



Technobis Mechatronics BV

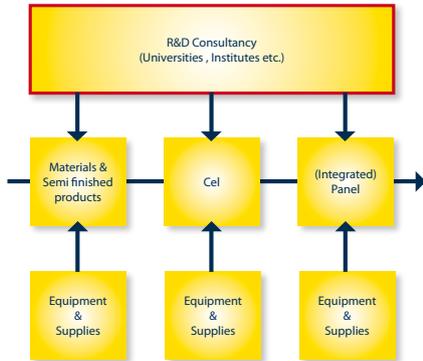
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TNO

TNO is an independent innovation organisation. TNO connects people and knowledge to create innovations that sustainably boost the competitive strength of industry and the welfare of society. TNO's more than 4000 professionals work on practicable knowledge and solutions for the problems of global scarcity. TNO focuses its efforts on seven themes: Healthy Living, Industrial Innovation, Energy/Geological Survey of the Netherlands, Mobility, Built Environment, Information Society, and Defence, Safety and Security (www.tno.nl/themes). TNO is a partner of Solliance. Solliance is a R&D cluster bringing thin film solar energy technology to excellence.



TNO innovation for life

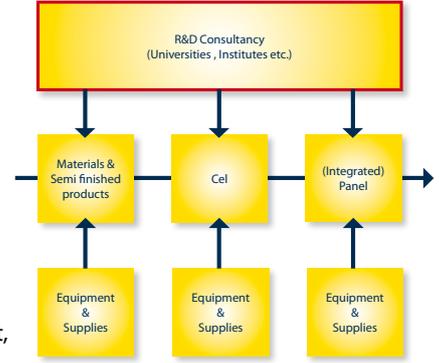
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TMC Solar

TMC is the independent partner, supporting customers with our multi-disciplinary technical expertise and managing skills, to staff projects on the development and industrialization of photo-voltaic (related) products and equipment, and to provide consultancy related to the application of solar energy. By offering fast access to high-level technical and (project-) management expertise, TMC enables customers to keep their critical projects on track and their innovation power competitive. Our professionals combine excellent technical skills with strong entrepreneurial behaviour.



TMC Technology

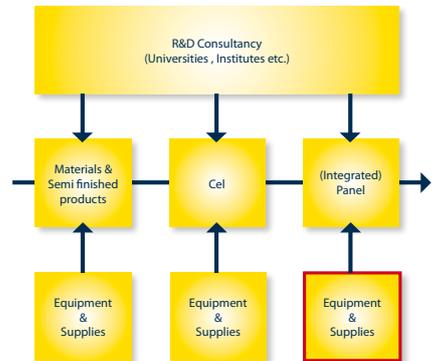
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TULiPPS Solar B.V.

TULiPPS® has invented a new technology for building lightweight glass PV modules. This unique, lightweight solar PV module technology and installation method (COSMOS®) harnesses the benefits of tough, long-lasting automotive-grade composites with the design flexibility and manufacturing efficiency of plastics to solve challenges common to conventional roof-mounted PV modules such as high cost, heavy weight, and installation time associated with traditional PV modules. The COSMOS® module technology can be used for both silicon and thin film PV modules and delivers unique 'Plug-&Play' BIPV products for cladding and pitched roofs. Moreover the technology allows to manufacture exceptionally lightweight and large PV modules for flat roofs.



TULiPPS Solar System Solutions



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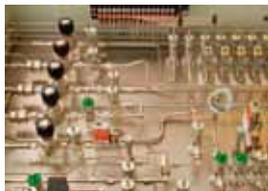
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**www.photovoltaic-conference.com
www.photovoltaic-exhibition.com**



Setting the solar standard in purity

The name of our game is ultra-high purity gas and fluid handling, conditioning and delivery solutions. Clients worldwide profit from our ability to provide minimal TCO while delivering the highest levels of quality and reliability. Our production sites feature certified orbital stainless steel welding, plastic welding, and assembly in over 1000 m2 cleanrooms up to class 10 for high purity manufacturing. R&D, design engineering, global installation and commissioning complete our extensive high level services and leading solutions to the solar industry.



Turn-key installations:

- Gas & chemical infrastructures
- Gas & chemical distribution and control panels
- Hook up of production (vacuum) equipment
- Gascabinets and Bulk Chemical systems

(Sub)assemblies for OEM's:

- R&D&E of custom & standard products and assemblies
- Purification and assembling under cleanroom conditions
- Bulk Chemical systems for POCL₃/BBr₃
- Supply subassemblies for liquid precursors
- Vacuum piping set ups
- Contamination (RGA, TOC, etc.), particle and moisture analysis & Helium leak checking
- Measurement and control equipment for industrial applications



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