Complete cable solutions and services for photovoltaic projects : KEYLIOS™

White Paper

(June 2011)

Photovoltaic installation.
Photographer : ©M.Cristofani Sipa

PRESS CONTACTS

Céline Révillon
celine.revillon@nexans.com
Tel.: + 33 1 73 23 84 12

Pascale Strubel
pascale.strubel@nexans.com
Tel.: + 33 1 73 23 85 28

For more information: www.nexans.com/windlink

CONTENTS

I. INTRODUCTION: TAPPING SOLAR POTENTIAL

1. Recent economic trends and development
2. Technological trends
3. A global scorecard
    - 3.1 Europe
    - 3.2 Asia
    - 3.3 North America
4. New challenges and their impact on cables
    - 4.1 Unpredictability
    - 4.2 Moving with changing global supply and the market
    - 4.3 Meeting certification diversity
    - 4.4 Responding to innovation
5. Incentives and customer expectations

II. NEXANS: KEYLIOS™ FOR PV INSTALLATIONS WORLDWIDE

1. KEYLIOS™ high-performance cables
    - 1.1 For energy transmission
    - 1.2 For data transmission, monitoring and control
2. KEYLIOS™ solutions and services

III. APPENDIX: Some recent Nexans success stories

SYNOPSIS

*This report is intended to give a **general** overview of the global photovoltaic market, and provide information about how Nexans is serving this growing but unpredictable market, where key players come and go with lightning speed.*

The paper opens with a review of recent economic, technological and global trends, and then focuses on several challenges facing OEMs and the installation market, which includes project developers, installers, specialized distributors and wholesalers. It concludes with the expectations they all have of cable suppliers. The second section briefly presents Nexans' overall solutions for module manufacturers and the installation market, and explains Nexans' service approach.

This report is followed by an Appendix containing a list of recent Nexans success stories.

I: INTRODUCTION: TAPPING SOLAR POTENTIAL

"Scientists have confirmed that enough solar energy falls on the surface of the earth every 40 minutes to meet 100 percent of the entire world's energy needs for a full year."

Al Gore, former American Vice President and Nobel Peace Prize winner

1. Recent economic trends and developments

According to several recent studies, PV module demand in 2010 was unprecedented if not unexpected during a period of continuing economic austerity. PV installations of approximately 18 to 19 GW have been added globally in 2010, bringing the world total to about 40 GW. This was a 140% increase over the previous year, and represented investments of over 50 billion €.[1]

2011 may well be another record year. Although Western European markets are still volatile with incentives and feed-in tariffs currently in a state of flux, Europe is still accounting for 75% of the PV market. A global rebalancing could happen quickly in the coming years with EU accounting for less than 40% of the world market by 2015. A number of promising markets are coming on line in the US, Canada, Japan, China, India, Bulgaria and Thailand; and new areas of development are opening up in the "sunbelt" region in Africa, Middle East and South America, the latter largely dedicated to meeting local demand.[2]

The predictions of analysts vary greatly. For example the EPIA's recently released report for the global market outlook pegs growth in 2011 between 13.4 GW and 21.2 GW. Meanwhile, Bloomberg sanguinely expects 2011 to add at least 20 GW of PV modules to world capacity if only minimum expectations in identifiable markets are met, and 28 GW if 2011 turns out to be a boom year. This is a sure sign of the market's current volatility and unpredictability.

Apart from growth in terms of PV installation capacity and financial investment, there are a number of observable trends in the solar environment, itself, which will impact renewable electricity producers (including homeowners, businesses and utilities).

1. a. One trend is that major energy players, like BP and the French oil giant, Total, are buying heavily into green energy. BP Solar continues to be a leading solar electric system manufacturer in its own right, and Total recently offered $1.4 billion for a controlling stake in SunPower, an American solar energy firm and bought a 50% stake in Tenesol held by the EDF Energies Nouvelles Réparties (EDF ENR).

1. b. A second general trend is that one-way, concentrated energy generated centrally and transmitted and distributed over a publicly or private owned grid system is being replaced by two-way, autonomous and distributed energy which will "empower" users in many ways:

- It makes them micro-energy producers themselves
- It frees them from dependence on power utilities
- It allows them to participate directly in renewable energy initiatives
- It protects them from power failures and black-outs
- It encourages the efficient consumption of energy

The obvious problem is storage for daylight production and a vastly reduced power supply during nighttime.

[1] Both *Global Market Outlook for Photovoltaics until 2015*, published by the European Photovoltaic Industry Association (EPIA) and Bloomberg's "PV market outlook Q1 2011" confirm these and the following figures.

[2] Ibid.

However, the challenges will eventually be resolved by a more rational balancing of supply and demand through smart grid technologies and ultra-long-distance power sharing between shadow-and-light zones.[3]

In addition, new generation storage technologies are now being developed, and in some cases are already in production, which include the micro-storage of electricity through pumped hydro systems, thermal storage, compressed air energy storage (CAES), pumped heat electricity storage, large capacity high-voltage lithium-ion batteries, compressed hydrogen storage, hydrogen batteries, and Superconducting Magnetic Energy Storage (SMES).[4]

1. c. A third trend is the growing consciousness of governments worldwide of the potential of PV as part of their environmental commitment, exemplified in President Obama's recently announced plan to install 75 photovoltaic panels on the roof of the White House in 2011 to produce 20,000 kWh of electricity annually.

The European Union is still a pacesetter in terms of directives, stimulus and financial incentives for PV installation. The EU is on track to achieve its targets for 2020 of reducing emissions to 20% below 1990 levels and raising the share of renewable in its energy mix to 20%.

Recently the EC is looking beyond these objectives to reduce domestic emissions by 80 to 95% by mid-century via the "Roadmap for moving to a low-carbon economy in 2050." In parallel, several European countries have formulated their own directives, like Germany's Renewable Energy Sources ACT (EEG), or France's La Réglementation Thermique (RT 2012 and 2020). While RT 2012 specified for low consumption buildings (BBCs), RT 2020 aims at encouraging "positive energy" buildings (Bâtiments à Énergie Positive or BEPOS). These are buildings which produce more energy in terms of electricity and heat than they consume.[5]

According to the EPIA's "Political environment and the potential of PV," The Directive 2010/31EU obliges EU member states to apply minimum requirements for the energy performance of new buildings and building units (both renovated and new buildings), and achieve the cost-optimal balance between the investments involved and the energy costs saved through the life cycle of the building. In particular, by the end of 2018, all new public buildings and by the end of 2020, all new buildings must be nearly zero-energy buildings.[6]

Stimulus policies are moving far beyond Europe, which would seem to suggest steadily increasing demand. At the beginning of 2011, China officially included renewables in its Five Year Plan. As a producer of half of the world's PV modules (mostly for export), the country is aiming at 40% renewables by 2040. It just recently increased the country's target for PV installations from 5GW by 2015 to 10 GW. Meanwhile, Australia is continuing to implement its Solar Flagships program which combines solar thermal and PV technologies.[7]Australia wants 20% of its electricity supply to come from renewables by 2020, although its solar credits scheme has been slashed due to recent floods. Similar PV initiatives are ongoing in Thailand, Taiwan, California, Canada, Eastern Europe and elsewhere.

---

[3] For more information about Smart Grid solutions, consult the *European SmartGrids Technology Platform*, published by the European Commission and available at: http://www.smartgrids.eu

[4] A review of new storage technologies can be found in "Storing up Electricity in a Micro-Generation System" at http://zeroemissionproject.com/blog/article/28/storing-up-electricity-in-a-micro-generation-system

[5] For a brief overview consult Alcor's http://www.alcor-controles.fr/actualites/2-news/68-reglementation-thermique-rt-2012-rt-2020.html.

[6] See the EIPA document entitled "Political environment and the potential of PV" (slide 41)

[7] See "Clean Energy Initiative: Solar Flagships Program" at http://www.ret.gov.au/energy/Documents/Solar%20Flagships%20factsheet%20-%20Oct%202009.pdf and a follow up at http://www.energymatters.com.au/index.php?main_page=news_article&article_id=1353

1. d. A fourth trend impacting the PV environment concerns feasibility in terms of "grid parity" for PV installations. Gird parity is the point at which alternative means of generating electricity – in this case photovoltaic installations – becomes as cheap as commercially available grid power based on coal, natural gas, or nuclear energy.

Back in 2009, energy planners in the EU expected photovoltaic grid parity to be reached around 2015 in Europe's most southerly countries, like Spain, Portugal and Italy. Whether we will reach that goal, or whether it has already been reached in some cases, is currently a point for lively debate and discussion. For example, a recent study by Renewable Energy World calculates that in Germany, installed prices already average 2.77 € (or $4.11) per Watt for small systems. It concludes that with PV-generated energy at $4.00 per Watt, up to 40 million Americans could beat grid prices without a "time-of-use" plan in 16 of America's largest cities.[8]

1. e. A fifth trend is growing evidence that in the dense urban environment, at least, residential and commercial buildings could be more important than distant ground facilities, like solar farms. City structures offer an unprecedented amount of both vertical and horizontal installation space and avoid the wasteful transmission of energy over long distances because of power losses.

Building-integrated photovoltaics (BIPV) are increasingly part of architectural specifications, where photovoltaic materials are used to replace building materials in the roof (both flat and pitched), skylights and facades. Innovative transparent (or translucent) solar panels use a tin oxide coating on the inner surface of glass panes to conduct current out of the cell. These cells use ultraviolet radiation to generate electricity and could be used to replace large areas of conventional window glass, or placed over the glass.[9]

1. f. As a final trend, in broader socio-economic terms, upcoming PV developments will help nations achieve energy independence and free them from costly fossil fuel imports. They will help them to meet their stated goals of significantly reducing the carbon footprint and global warming which has already been causing devastation in some countries. They will stimulate job creation in a vital new sector: in some cases for OEM activities (as in China), but also everywhere, since installation will always remain a local activity. For isolated areas where very little energy infrastructure exists, PV offers a chance to "leapfrog" technologies by making off-grid power possible for village wells, telecommunications, etc. thus allowing developing areas to step firmly into the 21st century.

Photovoltaic installation.
Photographer : ©M.Cristofani Sipa

[8] For the full argument, see "Distributed Solar Nears Grid Parity qwith Fair Electricity Pricing," 21 April 2011 at: http://www.renewableenergyworld.com/rea/blog/post/2011/04/distributed-solar-nears-grid-parity-for-some-values-of-parity

[9] See "Building-integrated photovoltaics": http://en.wikipedia.org/wiki/Building-integrated_photovoltaics

2. Technological trends

The key to achieving PV grid parity is to lower the cost of materials, modules and installations so that solar energy can compete with traditionally produced electricity.[10] Several technological developments have a direct impact on profitability, and also on cable infrastructure:

- Dual-axis tracking has proven that it can improve yields by 40% by physically moving the PV array so that it is always aligned with the sun throughout the day and seasons. This means that you can generate 40% more power with the same panels, or the same power with 29% fewer panels.[11] Dual-axis tracking requires reliable sensor and bus cables for communication and monitoring.

- Solar system installation costs include three main components: solar module, 50%; balance of system (BOS) and labor, 40%; inverter, 10%. (See diagram below.)

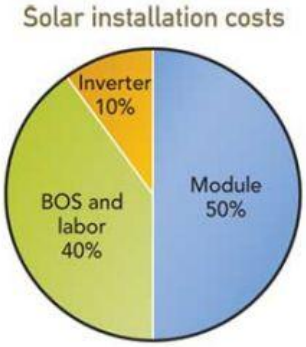


Figure 1. Solar installation costs. Source: http://www.solarbuzz.com/ModulePrices.htm

There has been a move to increase the performance of the inverter, the weak link in solar power systems. Although inverters represent 10% of system cost, they cause about 80% of system downtime due to the harsh outdoor environments they often operate in. There has been a trend towards bigger, more centralized inverters on one hand, and toward decentralized architectures, including DC-to-DC optimizers and micro-inverters.[12] Also, a new generation of smart inverters makes it possible to better monitor, manage and control distributed energy generation centrally by the power utility.[13] This requires high-performance data cables, strategically arranged, and monitoring and control services to gather information on everything from solar intensity, grid conditions, temperatures and the weather.

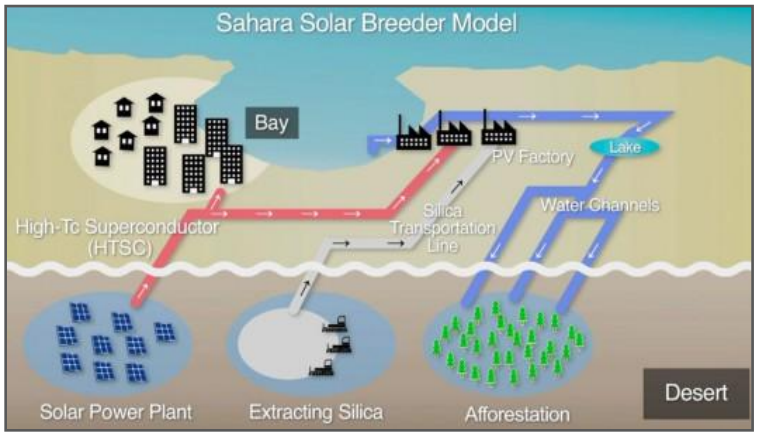
- Grid parity for PV is influenced by the prevailing price of conventionally-produced electricity in a given country, and also depends on installation costs and Balance Of System (BOS) costs for PV. Thus, efforts are being made to prolong the life of all critical elements: wafer, cell, module, arrays, tracking systems, inverters, connectivity, and cables. This not only requires new, more resistant materials for the cable itself (to resist water ingress, UV, movement and vibration, direct burial,

[10] See "Reconsidering solar grid parity" available at www.elsevier.com/locate/enpol
[11] An informative analysis dual-axis tracking can be found in *Photovoltaics World*, Nov/Dec 2010, pp 12-14
[12] For the latest inverter developments see "Inverter technology drives lower solar costs" at http://www.electroiq.com/ElectroIQ/en-us/index/display/Photovoltaics_Article_Tools_Template.articles.Photovoltaics-World.volume-20100.issue-2.features.inverter-technology.html
[13] See *Photovoltaics World* above, pp 18-19 for a full discussion of smart inverters.

etc.), it requires new value-added designs, and easy, efficient and durable connectivity. Finally it requires sophisticated computer-based simulation services to optimize both installation and system infrastructure.

- Because PV modules can operate at extremely low and high temperatures out-of-doors, the insulation of the module interconnection cables must be rated between -40°C and typically 90°C. However, there is a growing need for systems to function safely at even lower and higher temperatures, mainly for installations operating in desert areas. In addition, there are growing safety concerns for both equipment and people, especially in roof-mounted conditions.[14] There is a growing need for Low Fire Hazard (LFH) zero-halogen cables which are low-smoke and flame-retardant, which most certifications now specify.

- Finally, there are a host of technological developments which merge diverse technologies to achieve a synergistic result. Often water and electricity generation are linked together, for example in pumped hydro systems where PV provides electrical energy during the day, part of which is used to pump water to a higher level; then at night a hydro-electric system is used to maintain the power supply. At the high end of such initiatives, are complex "green desert" projects. The Japanese Sahara Solar Breeder Project aims to build a silicon manufacturing plant in the desert for producing solar panels. It will combine PV solar power, superconductors, desalinization, forestation, and housing to achieve a self-sustaining manufacturing unit.[15] Cables are essential to such projects since they provide power distribution, operational control, telecommunications, and the integration of hybrid power production.



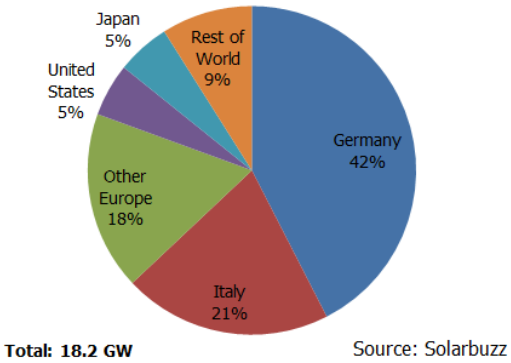
[14] In late 2010 a technical roundtable was held in Paris, France, by Solar with the theme "Fires and photovoltaics" to meet the growing concerns of firemen concerning the risks of fighting fires in buildings equipped with PV installations.
[15] For more information, consult http://causetinnitus.net/tag/photovoltaic-sahara-desert-project

3. A global scorecard[16]

In 2010, the top five countries by PV market size were Germany, Italy, Czech Republic, Japan, and the United States, representing over 80% of global demand.[17]

However, as has been remarked in section 1, there has been a steady growth of solar photovoltaic worldwide: PV installations were 2.826 GW in 2007, 5.95 GW in 2008, 7.5 GW in 2009, and 18.2 GW in 2010. In 2010 alone, the PV industry generated $82 billion in global revenues, compared to $40 billion in 2009.

As a reference point, the share of global PV demand in 2010 showed Germany, Italy and other European countries leading:



However, according to Craig Stevens, President of Solarbuzz, the industry is now in a very volatile situation which will see the scorecard change in coming years:

> *The industry has now entered a phase of tightening incentive terms across important European markets. Cuts in unit tariffs will be far more rapid than the industry's pace of cost reduction. While some key markets will decline in size as a result over the next two years, the US, Canada, China, and Japan are some of the major countries that still offer growth potential. […] Planned manufacturing capacity expansions will ensure the industry has adequate cell supplies over 2011 and 2012. However, the potential for excess supply, taken together with already planned subsidy cuts, will make both years challenging for the industry.*

[16] All of the figures cited are drawn from the Bloomberg's "PV market outlook Q1 2011" with additional information from EPIA's *2015 Global Market Outlook for Photovoltaics until 2015*.

[17] For the foregoing figures, chart and following quote (Craig Stevens), see the recent 2011 Solarbuzz Report: http://solarbuzz.com/our-research/recent-findings/solarbuzz-reports-world-solar-photovoltaic-market-grew-182-gigawatts-20

3.1 Europe

Photovoltaic installation.
Photographer : ©M.Cristofani Sipa

Germany still remains the world's pivotal market for PV, with 6-8 GW of new installations forecast for 2011 (both residential and commercial). The real test will come in 2012 with the entry into force of the new EEG, the framework law governing subsidies to renewable energy. Angela Merkel's decision to take seven of German's nuclear reactors offline for three months will provide some stimulus to PV. All nuclear plants being switched off would have an even more profound effect.

Following the new Fourth Conto Energia, in **Italy** the PV market will probably pick up as large systems are installed in time for 31 August 2011. New installations will be at least 2 GW in 2012, and possibly more. Small systems under 1MW and installed on rooftops are uncapped, and not subject to budgetary limits in 2011–12. The same is true for ground-based systems on government lands or on contaminated lands, which are defined as "small" irrespective of their size. Neither large nor small systems are capped for MW beginning 2013, but if budgets of a semester are exceeded, the FIT of the following semester will be additionally reduced.

In **France**, variable tariffs depending on the number of connection requests and incentives for rooftop systems (over 100 kW) and ground-mounted systems (over 250kW) are likely to see 3.4 GW installed in the next two years.

The credit rating downgrading in **Greece** slowed the take off of PV, despite generous feed-in tariffs. Simplified authorization procedures, especially for residential projects, well encourage 300 MW installed per year in 2011 and 2012.

In **Spain**, low feed-in tariffs and the government's decision to cut tariffs for already commissioned plants has created a climate of discontent among investors which has put new investment on hold. However, nuclear concerns and high oil prices may change this.

Slovakia has overtaken the Czech Republic as the fastest growing Eastern European market, with 600 MW projected for 2011, while **Bulgaria** is encouraging new installations and may soon overtake Slovakia. The decline of Czech investment was due to retroactive tariff cuts in late 2010.

Growth is slow and uncertain in the **United Kingdom** because of low incentives and an in-grown skepticism about the British climate.

3.2 Asia

In **India**, a country with plentiful solar resources, 2010 was a significant year, with nearly 1.14 MW of grid connected PV projects in the pipeline. However, project delays and government uncertainties and bank risk concerns have put further development in limbo.

In **Japan**, residential systems continue to drive the market (approximately 754 MW of residential systems installed in 2010, compared to 184 MW of non-residential systems). With 100% increase in demand annually, the country is well on its way to achieving the government PV target of 28 GW by 2020. The recent nuclear tragedy is bound to have an impact on PV as an environmentally safe alternative.

Feed-in tariffs are not particularly high in **Taiwan** and the island is relatively cloudy; however, 70 MW of installations are currently in the works.
In **China**, the government continues to stimulate PV growth through the Golden Sun capex grant scheme. Thirteen projects totaling 280 MW will be commissioned within two years as part of national bidding, with China expected to install 700–1,000 MW in 2011 and 980–1460 MW in 2012. The new Five-year Plan foresees 15 GW by 2015 and 50 GW by 2050.

In **Australia**, PV is running behind wind as a source of clean energy. Driven primarily by the small-scale PV market, there is expected to be 417–665 MW of small-scale PV installed in 2011. The country's first large-scale PV plant is currently being built in remote Western Australia. The winner of funding for the first PV project in the federal government's Solar Flagships Program will soon be announced.

3.3 North America

With strong growth in California and the Southwest due to utility-scale projects and steady expansion in residential and commercial markets thanks to state and utility incentives as well as solar Renewable Energy Credit programs, the **United States** is expected to install 1.6–2 GW in 2011.

In **Canada**, the Ontario Power Authority's Renewable Energy Standard Offer Program (RESOP) is continuing to stimulate demand. The residential sector shows strong growth while the number of utility-scale projects is increasing. Canada is well on its way to installing 295–394 MW of PV in the coming year.

4. New challenges and their impact on cables

Like wind power which is suited to large landmasses, upland areas, and coastal wind resources, PV solar installations are highly suited to countries and geographical areas endowed with a free and ample resource: sunlight.

Photovoltaic installation.
Photographer : ©M.Cristofani Sipa

Often this fact coincides with the absence of hydrocarbons in developing countries, in Africa, and the Asia Pacific region. And thus, PV solar energy opens up new avenues for economic development, manufacturing, agriculture, education and personal comfort and well-being.

However, in developed countries, too, PV opens up new possibilities. They also have their desert areas, like the Mojave Desert in Nevada, USA, which receives twice the amount of sunlight as other parts of the country, and is located adjacent to large population centers (Las Vegas). Some countries, like Italy, are equally deprived of hydrocarbons, but have an anti-nuclear policy, while others are strongly committed to the environment, or job creation through knowledge-based industries.

According to the recent "Solar Generation 6: solar photovoltaic electricity empowering the world,"[18] the development of PV opens up extraordinary opportunities:

> *The major competitive advantages of PV technology lie in its versatility, i.e. the wide range of sizes and sites, resulting in proximity to electricity demand, in the value of its production profile concentrated during peak-load hours, and in its enormous potential for further cost reduction…PV technology has all the potential to satisfy a double digit percentage of the electricity supply needs in all major regions of the world. Going forward, a share of over 20% of the world electricity demand in 2050 appears feasible, and opens a bright clean and sunny future to all of us.*

To this could be added other obvious advantages:

- No green house gas emissions
- Fewer pollution-related health problems
- A source of power where hydrocarbons are limited or expensive
- Mitigated risk of fuel-price volatility and dependence on foreign oil
- Reduced environmental degradation

However, the opportunities imply a number of challenges that have special implications for a cable and cable solutions provider, like Nexans, and also our customers, who include OEMs, and the installation market: project developers, installers, specialized distributors, wholesalers, utilities, infrastructure engineers, etc.

[18] Available as a PDF at:
http://www.greenpeace.org/international/Global/international/publications/climate/2011/Final%20SolarGeneration%20VI%20full%20report%20lr.pdf

4.1 Unpredictability

The major challenge is the unpredictability of a developing market which has a tendency to globalize.

This requires an understanding of regulations as they apply to individual countries, and intelligent planning so that government policy shifts, economic downturns and catastrophic events do not sidetrack or scuttle long-term PV energy strategies.

Ed Gunther, in his *Gunther Portfolio's "Eight trends to watch in 2011–2"* begins with an apology for miscalculating three of his six predictions for 2010. He was too bullish about the demand for PV installations, and too pessimistic about the overall economic outlook.[19]

However, for 2011, with increasing PV industry scale, supply and price competition, he still expects the number of failing PV start-ups and established manufacturers to accelerate.

Nevertheless, the inevitability of solar energy seems to override the halts, hiccups, and temporary setbacks. In the 26 March 2011 edition of France's *Le Monde* newspaper, the inventor, entrepreneur and futurist, Ray Kurzweil (whose predictions have rarely proved wrong) declared:

> *We are witnessing the acceleration of solar power. It is doubling every two years, and has done so for 20 years now. As for the cost per solar watt, it falls several points each year. These trends are already encouraging many businesses and start-ups who wish to draw on future benefits, while at the same time investing in research on cheaper and better technologies. [Unlike nuclear energy] the arrival of solar energy will be much more rapid, and can be implemented in a decentralized, clean and efficient way, without danger.*

Where a cable manufacturer can be invaluable in this uncertain climate is in helping to understand the most appropriate kind of cable to use in order to achieve optimum efficiency and longevity, to use tools to see what infrastructure solutions are most appropriate for a small network, to do simulation studies so as to fine-tune monitoring and control activities (including communications), and to develop advanced solutions for autonomous operations.

4.2 Moving with changing global supply and the market

China is now the leading world producer of PV modules (producing more than half of the current supply); in fact, eight out of the 12 biggest world manufacturers of photovoltaic cells or modules are either in China or Taiwan. JA Solar is still the leader in PV cells, with 8% of the world market, followed by another Chinese company, Suntech Power. The American company, First Solar, is number three.

China is also a growing consumer of clean energy and is concentrating on its interior market. China's domestic PV market took off in 2010 under the "Golden Sun" program. The 520 MW capacity installed brought cumulative capacity to 893 MW, and China could soon become a gigawatt market. PV installations are expected to grow by between 750 MW and 1 GW in 2011. 5 GW is an official minimum target by 2015, 20–30 GW by 2020.[20]

[19] For the full story, see http://guntherportfolio.com/2011/02/photovoltaics-8-trends-to-watch-in-2011-2

[20] See Stéphane Pambrun: "La Chine investit massivement dans l'énergie solaire"(28.01.2011) at http://www.novethic.fr/novethic/planete/environnement/energies_renouvelables/la_chine_investit_massivement_dans_energie_solaire/132431.jsp and see p. 34 in EPIA's "Global Market Outlook for Photovoltaics until 2015."

Moreover, there is intense activity in other Asian countries, like Malaysia, Korea and Japan, not to mention Australia, the USA and Canada.

Just a few years ago, 80% of manufacturing and installation activity was in Europe; soon, it will be worldwide (see Section 3: A Global Scorecard). Since most module manufacturers subcontract the junction box, which is equipped with cables and connectors, this means that a cable manufacturer must have a global presence, not only to serve OEMs, but to serve the local installation industry which has a growing need for specialized cables, solutions and services.

4.3 Meeting certification diversity

Because PV-generated energy is an important part of a nation's environmental policy, governments have tended to closely control the certification process for cables. This is one reason why there is still no European norm. National standards provide a barrier to cheap imports which could flood the European market. A trans-European standard would mean that only one norm would have to be met for the entire market.

Another factor that complicates certification is that PV integration with buildings means that installations must comply with building standards around the world, which can vary widely according to climate, geological conditions (earthquakes), culture and the availability of building materials.

Photovoltaic OEMs, system designers and installers are looking for top-of-the-line cables and solutions which offer longevity, dependability, enhanced fire safety, outdoor durability, extreme temperature and UV resistance, and adaptability to all connector types.

For eco-conscious countries, there are also important demands for recyclability and guarantees that manufacturing respects environmental directives like RoHS (hazardous substances) and REACH (hazardous chemicals). They are also anxious to see the photovoltaic industry committed to set up a voluntary take back and recycling program for end-of-life modules (typically 25 years) and take responsibility for them throughout the entire value chain.[21]

A serious cable manufacturer would certainly have to comply with the main leading certification bodies, including LCIE (France), TÜV (Germany), UL (United States), CSA (Canada) and IMQ (Italy), in addition to complying with various national standards and recycling initiatives.

[21] As expressed by the PV Cycle Association. See:
http://www.pvcycle.org/fileadmin/pvcycle_docs/documents/membership/PVCYCLE_11_2010.pdf

4.4 Responding to innovation

To arrive at grid parity, photovoltaic technology has to constantly innovate in order to remain competitive. One area of innovation is to increase the efficiency and lifetime of solar modules and reduce overall system costs to help lower the cost of solar energy vs. other forms of electricity.

This drive was strenuously argued by David B. Miller, President of DuPont Electronics & Communications:

> *The sun never sets on DuPont innovation in the solar industry. Our customers and other stakeholders challenge us every day to deliver materials that matter in further improving efficiency, lifetime and system costs to help bring the cost of solar energy down, in line with other forms of electricity.*[22]

Another sign of enhanced innovation is the American Department of Energy's decision to set up the Solar Photovoltaic (PV) Technology Incubator program, a key part of the SunShot Initiative which aims at lowering the cost of utility-scale installations by about 75%, to roughly $1 per Watt by 2020. By providing $50 million to small businesses, the program created 1,000 jobs and generated $1.3 billion of private sector investment, largely in small start-up companies.[23]

Not all technical innovations concern PV cell improvements, like cheaper thin-film production methods. Elsewhere in this White Paper, we have mentioned both dual-axis tracking and "smart" inverters. However,

- Better rooftop site analysis using aircraft and 3D modeling
- Power optimizers that minimize energy losses of PV systems
- Attractive modules for new and old roofs, including roof tile replacement
- Hybrid power plant solutions for rural electrification
- Distributed electronics in PV systems to improve harvesting
- Individualized cell and module management for optimum output
- Pre-assembled racks for fast plug-and-play installation
- Performance data transmission over power lines
- Light Lego-type modules for large roofs[24]

As one can see from the above list, installers, too, want innovations that can help them install their equipment rapidly. Cable solutions include pre-connectorized and armored cables, or cables that can be safely buried without special troughs or conduits for decades of operation.

Finally, power transmission and grid architecture are an important area for innovation, and one that touches the cable business. Here the scope for improvement is enormous: from products, solutions and services (like turnkey installation and maintenance), to simulation to find ideal layouts, sensors to measure hot spots, humidity and monitor current load and congestion, communications to provide real-time command and control, and the incorporation of new technologies, which could include fault current limiters and superconductors for large solar farms.

[22] See Photovoltaic Solutions: News and Events: "DuPont Delivers New Science-Power Innovations for Solar Energy" at http://www2.dupont.com/Photovoltaics/en_US/news_events/article20110221.html

[23] Consult the DOE's website article "Advancing Solar Through Photovoltaic Technology Innovations" at http://blog.energy.gov/blog/2011/04/19/advancing-solar-through-photovoltaic-technology-innovations

24 These are just a handful of recent innovations from www.solarserver.com and www.renewableenergyfocus.com

5. Incentives and customer expectations

OEMs, module manufacturers, engineering contractors and installers all have high expectations of a cable manufacturer:

- A complete range of quality PV cables and accessories
- Light, flexible cables that can handle the outdoor solar environment
- Full system integration, whether for solar farms or for building/rooftop installation
- Technical innovation that keeps pace with the PV industry
- Customized products and services, sets, kits, interconnectivity, etc.
- Easy assembly and installation, low failure rate, and exceptional durability
- Worldwide presence and expertise ensuring steady supply for international projects
- Conformity to national certification and standards
- Advanced Low Fire Hazard (LFH) capability
- A host of services, including simulation, Life Cycle Assessment, and training
- Innovative solutions for the future: superconductivity, active switch systems, monitoring and control services

II. NEXANS: KEYLIOS™ FOR PV INSTALLATION WORLDWIDE

Rather than just provide cables and components, Nexans' widely-recognized KEYLIOS™ solutions can outfit a complete solar installation. Nexans contribution to photovoltaic applications is through high-end, quality products which result in long-term performance, surveillance, monitoring and remote control, operational security and fire safety.

Nexans produces every cable that could be used in ground-based solar farms, or in residential/commercial rooftop and building installations to carry energy and transmit data. Moreover, it manufactures active equipment, like intelligent Ethernet switches that can consolidate diverse monitoring, surveillance, diagnostic and control applications.

Nexans has a proven reputation for cable reliability and technical expertise, and substantial production capacity worldwide to assure OEMs of product availability, especially in emerging markets. It also has addressed the concerns of local designers and installers, which include project developers, architects specialized distributors and wholesalers.

Beyond cable, Nexans is unique in being able to add a number of essential services for solar players: Life Cycle Assessment and simulation (so as to design the right PV architecture).

1. KEYLIOS™ high-performance cables

1.1 For energy transmission

As part of its KEYLIOS™ family of solar energy cables, Nexans provides high-performance cables, like cross-linked 0.6 to 1 kV **Energyflex® photovoltaic cables** which are easy to install and offer long-term reliability for short DC connections. They link photovoltaic panels on rooftops or solar fields, and also connect them to the array box (if one exists), or to the inverter which transforms DC solar energy into usable AC electricity. Resistant to extreme temperatures (-40°C to +120°C), ozone and UV, these zero-halogen cables are low-smoke and flame-retardant for enhanced fire security. LCIE, TÜV, UL or IMQ-certified, they fit main connectors, can be color-striped for easy installation and phase identification, meet RoHS directives, and are fully recyclable. Through its worldwide industrial footprint, Nexans is able to provide them anywhere in the world.

KEYLIOS™ photovoltaic cables
Photographer : ©M.Cristofani Sipa

In the US and Canada, XLPE insulated cables used for ground installations are often referred to as **solar cables**. They connect module strings or multiple arrays to the inverter and are suitable for direct burial. Armored TECK cables can be used in rocky terrain or underneath roads.

Low-voltage copper and aluminum cables with PVC sheathing also provide reliable, durable links between array boxes and the inverter, and can carry up to 1,800 volts of DC current.
For important solar power plants and specific applications, **low-voltage DC busbars** connect the panel arrays and the inverter, or the inverter and transformer, and can replace large cross-section buried cables.
For all ground-based photovoltaic installations, customized **medium-voltage jumpers** (from one to several dozen meters long, equipped on both sides with accessories) connect transformers to switchgears.

For protection against short circuits and fire, copper **earth/ground cables** (either shielded or unshielded) securely ground panel frames, assuring that a uniform earth/potential prevails through the photovoltaic park.

On the equipment side, Nexans supplies **cabinets** for residential and commercial installation fitted with fuses and switches enabling the utility to isolate the network, either from a consumer or producer perspective. These cabinets are a major node between private and public networks and a security point for maintenance.

1.2 For data transmission, monitoring and control

To assure high data transmission capacity for backbones (from solar fields to distant control centers) or for Local Area Networks for monitoring and control, Nexan's Unitube or Multitube **fiber optic cables** can be installed in conduits or directly buried. They are waterproof, rodent-resistant and offer Electromagnetic Compatibility (EMC) in energy-dense areas. Nexans also offers a full range of FO connectors, patch cords and panels, indoor/outdoor closures, cabinets and splicing frames for individual fiber management.

Controlled tracking solutions can provide up to 40% more efficiency than fixed solar layouts. Nexans **sensor and bus cables** (up to 24 V) transmit information so as to constantly adjust solar panels to follow the sun, while taking into account ambient weather conditions. Bus cables connected to a Central Processing Unit (CPU) use established astronomical data and positioning software to follow the sun's course. Nexans rugged and reliable sensor cables eliminate the need for a CPU and extensive data lines. Each panel unit adjusts itself independently for the highest possible yield, and continues to function autonomously if other trackers fail, thus assuring energy continuity.

Nexans also manufactures **active switch systems for communications and monitoring**. These small and rugged iSwitch systems contain up to 3 fiber-optic uplink ports and 8 twisted pair copper ports. With the optical fiber arranged in ring or star structures, they use their copper links to exchange data with and provide Power over Ethernet (POE) to distributed IP surveillance cameras, WLAN access points, VoIP phones or multifunctional terminals. The switches can also be used for control and monitoring applications, and have inbuilt fiber-optic/copper cable diagnostics.

2. KEYLIOS™ solutions and services

Nexans does more than just sell cables and components to the growing PV energy industry; it is continuing to invest heavily in research and development to find ways of improving cable performance. Nexans has the cable industry's most extensive R&D capability, with 450 researchers and technicians trained in all disciplines, including materials science, cable and systems design, and cable/network testing and simulation. Nexans often works alongside customers in our four international Research Centers and three Application Centers. Serving the global PV business is facilitated by an industrial presence in 40 countries. Recent PV achievements include:

- Modifying cables to accommodate large rooftops and solar farms
- Improving flexibility to deal with dual-axis tracking systems
- Creating new insulations for heat/cold/oil resistance and fire performance
- Developing lighter aluminum cables for important cost savings
- Integrating both telecom and energy functions wherever possible
- Increasing the data carrying capacity of all transmission cables

- Creating switch solutions for the new generation of "smart" inverters
- Finding new ways to monitor and manage PV installations remotely
- Developing technical and service solutions for photovoltaic sustainability

Since today's PV developers come from a diverse background, Nexans is increasingly called upon to give its considered opinion and advice concerning cable type, most appropriate design, configuration and so on. This kind of technical support, especially at the project design stage, allows OEMs and installers to choose the best and most cost-effective cable solution according to location and projected use.

Nexans specialized service areas are of special concern to the PV community:

1. Product Environmental Profile (PEP) Ecopassport

Today, customers want to know more about a Product's Environmental performance Profile, or PEP. This requires assessing its environmental impact throughout its life cycle,* which is a long, complex process. In 2010, Nexans France founded an association together with Schneider Electric, Atlantic, Legrand and a few others (involving their professional unions) to help build a referential for the electrical and geni-climatic sectors, called the PEP Ecopassport.

The association will launch its first official PEP via a dedicated website (www.pep-ecopassport.org) during the second quarter of this year (2011). This referential is a tool that adds value and quality to Nexans' offer and that of its customers. Using it intelligently enables Nexans to build its business and differentiate itself for its customers.

> **Life Cycle Assessment (LCA) Services*
> To meet the growing requests from customers for cable evaluations and their impact on the environment, Nexans developed a Life Cycle Analysis (LCA) software program. For photovoltaic cables, LCA analyzes raw materials used and processes involved in manufacturing, distribution and use, including losses from the Joule effect. Knowledge generated by this tool allows Nexans to design greener PV cables from the outset, and reinforces expertise in this field. By offering this service to Siemens and using LCA to assess PV cables according to 11 key indicators (including raw materials, energy, water and ozone depletion, $C0_2$ emissions, air toxicity, air acidification and hazardous waste production) Nexans was able to win new business with them for a major project in the southeast of France.

2. Simulation services

To find the ideal solar park architecture and the right cables, Nexans uses various simulation software programs to provide points of comparison to assure reliability, reduce losses, increase safety and improve power flow. With its simulation software programs, Nexans is able to evaluate different photovoltaic product solutions and thus support customers in finding the most suitable photovoltaic product for any given installation.

III. APPENDIX: Some recent Nexans success stories

- For Schneider Electric, Nexans supplied over 1,000 km of Energyflex® photovoltaic cables in a mere 2½ months for a 56 GWh photovoltaic farm in Sanpietro Vernetico, near Brindisi in southern Italy (Apulia/Puglia region). In Europe, these cables are used to interconnect panels, and also connect module strings to the inverter.

- Nexans also supplied 20 km of cables to Schneider for a photovoltaic park in the Durance Valley, a region which has a dozen major photovoltaic projects underway.

- For a Siemens project on the Puimichel plateau in Le Mées, southeast France Nexans assessed its photovoltaic cable according to 11 key indicators which included raw material, energy, water and ozone depletion, global warming (CO_2), air toxicity, air acidification and hazardous waste production. This first PV order for Siemens from France (planned by Eco Delta Développement) will eventually have six solar power plants with a combined capacity of 30 megawatts peak (MWp)

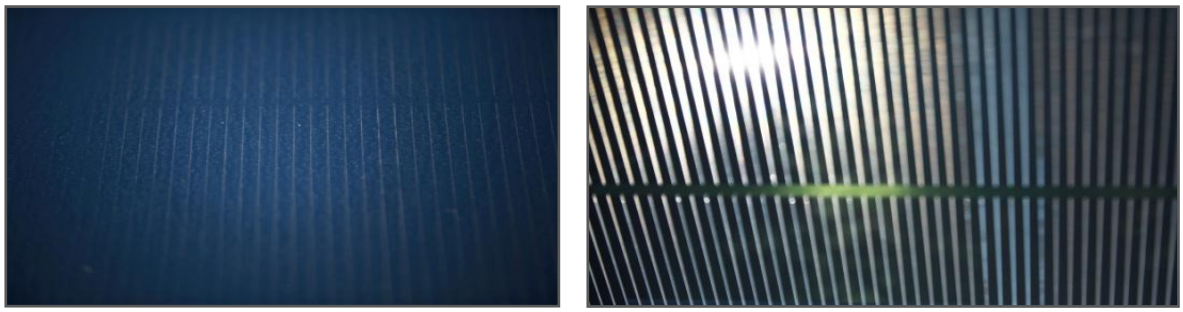
- For Solairedirect, Nexans supplied cables to the Solar Park of Saint Hilaire du Rosier in the Isére Department (Rhône-Alpes Region in eastern France). The installed 6.5 GWh/year will provide 20% of electrical power for 20,000 inhabitants in the neighboring municipality.

- In addition, Nexans supplied Solairedirect with cables for its PV installations in Esparon-de-Verdon (Alpes-de-Haut-Provence) which was the first PV farm in France to have been certified ISO 14001 for environmental management. This 13 MWp plant produces 19 GWh annually for some 14,500 people.

- Nexans provided the LV underground infrastructure, both single and multiconductor, armored, non-armored and bare copper for the First Light Solar Park – currently the largest-scale commercial solar farm operation in Canada. With more than 126,000 solar panels spanning 90 acres, it is expected to generate 10 million kWh of renewable electricity – enough to power 1,000 households.

- Nexans continues to work with Siemens and other solar EPCs on upcoming solar projects in Ontario and other Canadian provinces. A First Solar 80 MW farm in Sarnia, Ontario, was supplied with 69 km of MV infrastructure cable from the Nexans plant in Weyburn, Saskatchewan, and 184 km of LV cables were provided by Nexans plant in Fergus, Ontario.

- EDF EN Canada built a 20 MW solar farm in Arnpior, Ontario, near Ottawa. Nexans supplied 31 km of MV infrastructure cable for this project.



Photovoltaic panels.
Photographer : ©M.Cristofani Sipa