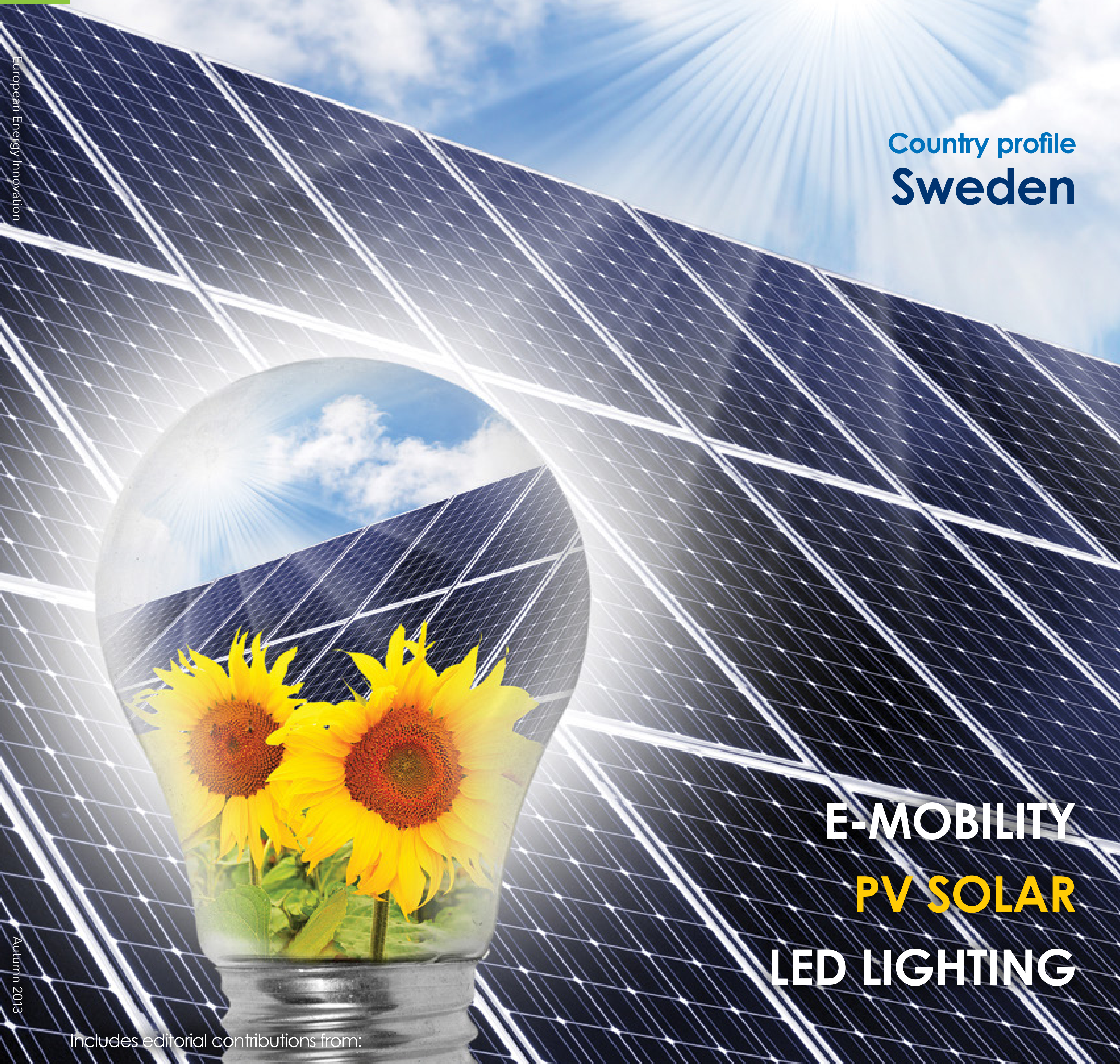
AUTUMN 2013

european energyinnovation

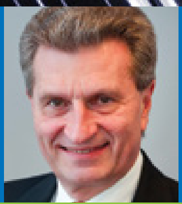
European Energy Innovation
Autumn 2013



Country profile
Sweden

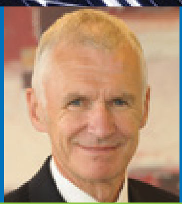
E-MOBILITY
PV SOLAR
LED LIGHTING

Includes editorial contributions from:



Günther Oettinger
European Commissioner for Energy

Anna-Karin Hatt
Minister for Information Technology and Energy, Sweden



Philip Lowe
Director General, European Commission, DG ENER

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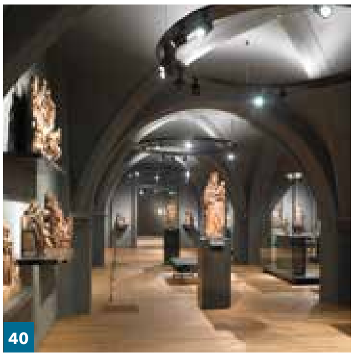
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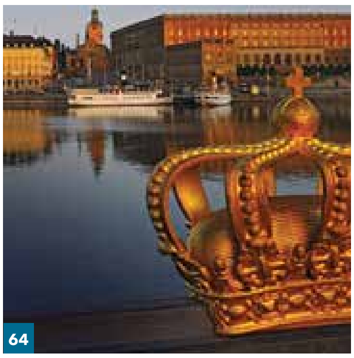
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SOLAR-ERA.NET

TRANSNATIONAL IMPLEMENTATION OF THE SOLAR EUROPE INDUSTRY INITIATIVE

SOLAR-ERA.NET is a network that brings together more than 20 RTD and innovation programmes in the field of solar electricity technologies in the European Research Area. The network of national and regional funding organisations has been established in order to increase transnational cooperation between RTD and innovation programmes, as well as to contribute to achieving the objectives of the Solar Europe Industry Initiative (SEII) through dedicated transnational activities (especially transnational calls).


Courtesy of EPFL IMT PV Lab Neuchâtel

More than 100 MEUR shall be mobilised for transnational RTD and innovation projects for photovoltaics (PV) and concentrating solar power (CSP) through the support of the funding organisations. By identifying and choosing SEII call topics, SOLAR-ERA.NET will select and fund industrially relevant transnational RTD and innovation projects potentially boosting the PV and CSP sectors development beyond "business-as-usual".

The project proposals submitted in SOLAR-ERA.NET joint calls must clearly demonstrate i) potential commercial impact, relevance to industrial and market needs and added transnational value, ii) scientific and technological excellence and iii) high quality and efficiency of the implementation and management. The first set of transnational calls raised great interest in the solar power industry sector and research community. Approximately 60 preproposals, with a total project volume of around 90 MEUR were submitted. Based on the full project submissions, the first projects selection to be funded under SOLAR-ERA.NET is planned to take place towards the end of 2013. The second set of joint calls is expected to be launched early 2014.

SOLAR-ERA.NET is an EU funded FP7 project running from 2012 to 2016 with the mission to implement the SEII on the transnational level. The main activity is the launch and coordination of joint transnational calls for industry oriented RTD projects. SEII is embedded in the European Strategic Energy Technology Plan (SET-Plan).

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Smart Solutions Forum

Smart Integration of Photovoltaic & other Renewable Energy Systems into the Network for a Sustainable Growth

The forum Smart Solutions is a parallel event organized in the framework of the 28th EU PVSEC in Paris, France on 1st October 2013. The forum will consist of two sessions related to the smart integration of Photovoltaic systems into the network by highlighting the use of Information and Communication Technologies (ICT), Storage and Smart Integration Solutions. All sessions will cover examples on technical solutions, an overview on market and economic issues and their benefits. The target group are industrial representatives from the ICT sector, storage, transmission and distribution grid operators, consultancies, RTD research and those who are interested for integrating Photovoltaic in a smart way into the electrical grid, building sector and cities.

Session I
Storage & Micro Grids

Session II
Smart Buildings & Cities

1st October 2013
Parc des Expositions
Paris Nord Villepinte, Paris, France

For more information, please visit
www.smartbuild.eu
www.photovoltaic-conference.com/parallel-events

Organized Jointly by
WIP / EU PVSEC and EU Photovoltaic Technology Platform

Foreword

Eurozone recession ends with 0.3% growth in 2nd quarter.

This encouraging headline on the France24 website is a ray of positive news among all the horror emerging from the Middle East. The recession has of course reduced levels of economic activity and carbon emissions across Europe, making our article by Commissioner Oettinger particularly timely. Acknowledging progress towards the 20.20.20 climate objectives, he nevertheless sounds a note of caution about the 2009 Renewable Energy Directive. He suggests that renewable technologies represent the most cost effective way to decarbonise the energy sector, and that a diverse mix of low carbon energy sources across the EU will deliver the cheapest electricity for consumers. At issue is the need for large investment in energy infrastructure across Europe, which he believes will create jobs and boost the economy. 'Green growth', he says, doesn't mean growth of green technologies, but is 'growth of the whole economy stimulated by green projects'.

In our country focus on Sweden, Minister for Information Technology and Energy Anna-Karin Hatt emphasises the importance of strong public support for the country's climate, energy and environmental policies. These, she says, are designed to help make Sweden carbon neutral by 2050. She discusses the driving factors, which include the carbon tax and green-certificate schemes and argues that both renewable energy and energy efficiency will have to increase significantly by 2030. Meanwhile, the Swedish Energy Agency reminds us of the tradition of energy research that stretches back to the first oil shock of the 1970s, and which has put the country within touching distance of generating 50% of its energy from renewable sources. This places the efforts of some countries towards their 20-20-20 targets into perspective.

Vincent Berrutto provides another insight into Europe's Energy Efficiency Challenge. Energy efficiency is, he says, a 'no regrets' option that increases competitiveness, creates jobs and often improves living conditions while responding to concerns about the affordability of energy and security of supply. Malcolm Harbour offers a further insight when writing about the significance of public sector buying power. He assesses the case for the most economically advantageous tender (MEAT) to be used when assessing opportunities for SMEs when it comes to public procurement.

Dietmar Zembrot, President, LightingEurope comments upon the success of the policy of phasing out inefficient lighting products. However, he adds that it would be an injustice only to look from an energy efficiency perspective. Meanwhile, Siegfried Luger, Founder and CEO of Luger Research - Institute for Innovation & Technology explains the importance of Trends of Engineering System Evolutions (TESE) for predicting future product generations and for extracting the winning technology approaches for lighting strategies.

A review by Reinhold Buttgereit, Secretary General, European Photovoltaic Industry Association (EPIA) of the growth of photovoltaics concludes that it is no longer a niche technology, but on its way to becoming mainstream. This is why the article by Arnulf Jaeger-Waldau is so important. Dr. Jaeger-Waldau reviews the factors that influence proper consideration of the price of electricity to address an absolutely fundamental question: How competitive is Photovoltaic Electricity? Among the considerable economic evidence is his observation that electricity production from residential photovoltaic solar systems has shown that it can be cheaper in a growing number of countries, depending on the actual electricity price and the local solar radiation level.

Now that really is positive news.

…and there is a lot more for you to read inside.

Michael Edmund
Editor

The publishers of European Energy Innovation would like to offer their sincere thanks to all individuals and organisations who have contributed editorial images photos and illustrations to the magazine. Whilst every effort has been made to ensure accuracy of the content, the publishers of European Energy Innovation accept no responsibility for errors or omissions.

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Renewable energy in the EU: to 2020 and beyond

By Günther H. Oettinger, European Commissioner for Energy

In 2009 the Member States of the European Union set themselves the goal of having 20% of their energy come from renewable sources by 2020. More than three years on, we are still committed to achieving this goal. Our latest Report on Renewables shows that while progress has been made until 2010, there are reasons for concern about future progress: the transposition of the 2009 Renewable Energy Directive has been slower than wished, also due to the current economic crisis in Europe.

Since the indicative trajectory to meet the final target grows steeper over time, in reality more efforts by most of the Member States' are needed in the forthcoming years. Current policies alone will be insufficient to trigger the required renewable energy deployment in a majority of Member States. Hence, additional efforts will be needed for Member States to stay on track in the forthcoming years.

In addition to investing in renewable generation, we must invest in grids to have a functioning market. Firstly, we need smart grids capable of handling multiple variable inputs, balancing power and delivering consistent supply to consumers. Secondly, we need support schemes for renewables that do not create harmful distortions between states. All countries within the EU will be building their renewables capacity and we must ensure that state support in one country does not make it harder and less competitive to build renewables elsewhere. Furthermore, renewables must one day be able to compete openly against other energy sources. As a nascent technology it is right that they receive public support but we cannot create a system that is overly reliant on public funds as this is unsustainable. National support schemes must also find equilibrium and settle.

Key to our success is creating an environment that provides certainty for investors. Most of the funding for transforming our energy system will come from private sources and governments must show signs that investors will see good returns if they chose European energy projects. For the time beyond 2020, without a suitable framework renewable energy growth will slump. This why we have to set a framework for 2030. In March this year, we have published a Green Paper which will be discussed with stakeholders and Member States before coming forward with a concrete proposal. One of the key questions is whether we should have a binding target for renewable energy as we have for 2020 or opt for a technology neutral target for CO_2 only.

You may ask 'why renewables?' The answer to this is simple. In spite of our current economic situation all our studies, including the EU 2050 Energy Roadmap, show that the most cost effective way to decarbonise the energy sector to meet our commitments to help stop climate change show that a diverse mix of low carbon energy sources across the EU will

deliver the cheapest electricity for consumers. This will require large investment in energy infrastructure across Europe and our analysis shows that starting earlier, rather than later will be the most cost effective approach. Indeed, large scale infrastructure investment will pay dividends to European economy by creating jobs in building and operating our new systems which will, in turn, boost the economy. That is why it is important to remember that 'green growth' doesn't mean growth of green technologies, but is growth of the whole economy stimulated by green projects.

Efficient use of residual heat in Combined Heat & Power systems

By: Jeroen van Ruitenbeek and Johan van der Kamp

Generating electricity, a (fossil) fuel – gas, coal, or oil – is converted into heat and subsequently is being used to generate high pressure, high temperature steam. Then, in a steam turbine connected to a generator, a significant part of the energy in this steam is converted into electrical energy to be supplied to the power grid. In large modern power stations, approximately 40% of the energy in fossil fuel is converted into electrical energy, the remainder being discharged in (cooling) water as waste heat, and/or into the air. That waste energy does nothing other than heat the planet.

COMBINED HEAT AND POWER

It is physically and technically almost impossible to convert a higher percentage than the above mentioned 40% of the energy from fossil fuel into electrical energy. It is, however, possible to make efficient use of the waste heat – for example, for district heating. However, this solution also has negative consequences, because it usually means that an even smaller proportion of the energy in the fuel is converted into electrical energy. In most cases, just one third (33%) of the potential energy in fossil fuel than is converted into electrical energy. But in these applications, a larger proportion of the remaining two-thirds of the waste heat can be used for heating greenhouses, buildings, or processes. This waste heat can also be stored underground as a seasonal energy supply. Processes making efficient use of part of the waste heat, are called CHP (Combined Heat & Power).

Figure 1: A-frame at existing plant

LOCATION OF THE CHP

Most electricity is still generated in large power stations with an efficiency of 40%. Where the powerstation is built is determined by the supply and/or availability of fuels because the electricity can easily be transported over long distances. In CHP plants, however, the waste heat cannot be transported over long distances. These power stations must therefore be built close to the waste heat users. For that same reason, CHP plants are often smaller, as there is often a limited local capacity to use large amounts of waste heat. Waste incineration plants are much smaller, for example, than the larger power stations. But these waste incineration plants are very suitable for CHP. The electricity supplied by these waste incineration plants is supplied to the power grid and the waste heat is used nearby.

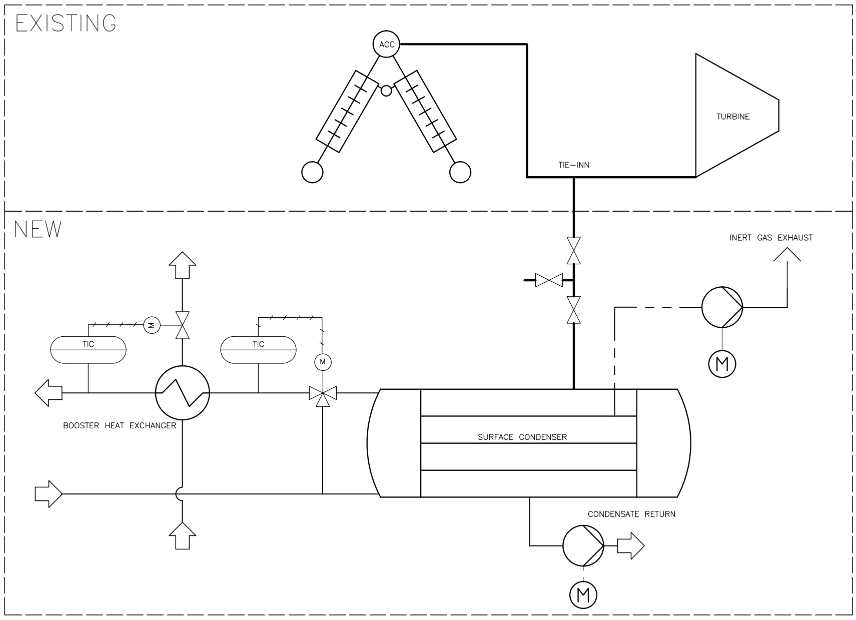


Figure 2: P&ID of existing plant with additional options for higher energy efficiency.

THE ELECTRICAL EFFICIENCY

The electrical efficiency of a power station is mainly determined by two criteria that influence the efficiency of the turbine:

- The higher the pressure and temperature of the steam before the turbine, the higher the efficiency of the turbine, but also:
- The lower the pressure and temperature of the steam after the turbine, the higher the efficiency of the turbine.

Condensers are used to achieve the lowest possible pressure and temperature after the turbine. Because the steam boiler and the steam turbine in the first case (high pressure, high temperature steam) are relatively very expensive for smaller systems, its operators of smaller systems opt to work with lower pressures and temperatures. Also, since very low pressure after the turbine can only be achieved when the condenser is very large and very expensive, the operators of small systems often opt for a higher pressure after the turbine. Together, this means that the electrical efficiency of a CHP plant is usually significantly lower than that of a large (expensive) power station.

FACTORS THAT INFLUENCE THE DESIGN

Because in most locations it is no longer allowed to use surface water to condense steam, after it has passed through a turbine, nowadays steam is almost always condensed using air-cooled condensers. The lower the pressure in this condenser, the higher the electrical efficiency of the system. But also the more cooling air is needed to achieve a lower pressure, the larger the condenser needs to be (and the more expensive it will be).

The steam pressure in air-cooled condensers is usually between 0.2 and 0.06 bar absolute at a temperature of between 36˚C and 60˚C. Some of the heat that is still present in the condensed steam can be used for other purposes. For many waste incineration plants also have a water purification installation, in which bacteria play an essential role. These bacteria survive at temperatures between 30˚C and 40˚C and break down certain substances in the water. If the temperature of the water becomes too high or too low, the bacteria die. It is important, therefore, to keep the water exactly at the right temperature. The waste heat in the cooling air of the air-cooled condenser is very often exactly right for these types of applications.

However in many cases the processes would employ the waste heat require a higher temperature than the temperature at which the steam comes out of the condenser. This problem can easily be solved by choosing to set the pressure after the turbine a little higher. Although the electrical yield of the entire system then would decreases slightly, steam becomes available at a higher temperature, making a lot of waste heat available for other purposes. This may in fact be a profitable choice for the total system.

MORE EFFICIENT USE OF RESIDUAL HEAT IN EXISTING CHP SYSTEMS

One of our clients, Attero, had an A-frame condenser that was operating at a pressure of 0.07 bar with a corresponding steam temperature of 39˚C. When the temperature of the outside air was higher than 15˚C, the pressure in the condenser increased, which resulted in lower efficiency of the turbine, causing less electricity to be produced. Bronswerk developed and delivered an alternative to this system, which taps off some of the steam between the turbine and the condenser. This steam is used to heat water. As a result,

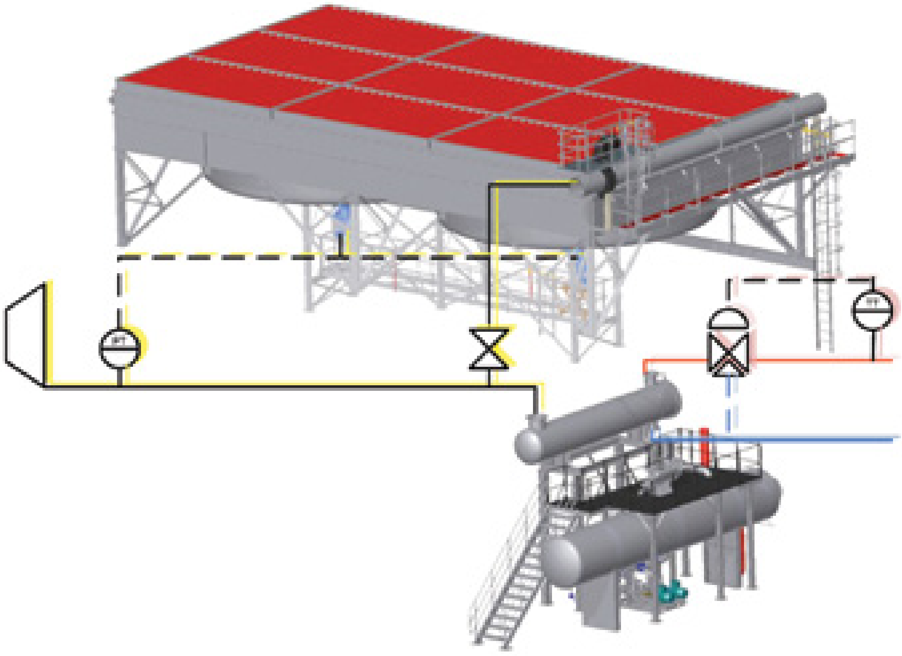


Figure 3: The Rive Droite Environment plant.

less steam is supplied to the condenser, so less cooling air is required and the ventilators can run more slowly; this means that less driving power is required for the ventilators.

Because the condenser is supplied with less steam, up to an outside air temperature of 19°C the pressure in the condenser can remains low, so that the maximum amount of electricity can be generated for many more hours per year. In the past, this water was heated by a separate boiler running on biogas. This boiler can now be taken out of service and the biogas can be sold. All in all, the economic efficiency of the entire system has greatly improved.

By proposing and implementing this type of conversion as a total project, Bronswerk's know-how and skill were shown to great advantage and the client only needed a single supplier. The entire project consisted of:

- Tying into the existing steam pipe such that it caused minimal pressure loss
- Designing and manufacturing a new water-cooled condenser
- Supplying the pipe section from the main steam pipe to the condenser
- Supplying the vacuum unit to extract air in the steam
- Supplying condensate pumps
- And supplying a special booster heat exchanger for proper control of the temperature.

This is a good example of how low-temperature waste heat can be used efficiently.

Other possible applications for the efficient use of low-temperature waste heat include:

- Greenhouses
- Swimming pools
- Fish farms
- Drying food or grass or grain
- Seasonal soil heat.

MORE EFFICIENT USE OF RESIDUAL HEAT IN NEW CHP PLANTS

For district heating, heat is required at temperatures of up to around 100°C. The criteria described above show that this use of CHP will lead to much lower electrical efficiency. Another disadvantage of district heating is that the heat requirement varies enormously in summer and winter and during the day and at night. Needless to say, no advantage is gained from generating electricity with a low efficiency, while on top of that, only a small part of the waste heat can be used efficiently. In most systems, this disadvantage is overcome by creating an extra steam tap in the steam turbine. This is used to take steam from the turbine where the pressure is still high. Although this is a good technical solution, it does make the turbine design very complicated.

For this reason, our client Rive Droite Environment (Veolia Environment, Bordeaux, France) decided not to opt for this concept. Instead, they chose to operate the turbine with a low outlet pressure in the summer allowing the maximum amount of electricity to be supplied. In the summer, there is no need for district heating. In the winter, the outlet pressure of the turbine is increased, leading to the generation of less electricity, with greater amount of heat.

When the plant is in winter mode, most of the steam is supplied to a shell and tube heat exchanger for the district heating. This heat exchanger now operates as a condenser (surface condenser). However, heat consumption is not constant in winter, so an air-cooled condenser is used to control the system pressure in a simple manner. This solution was supplied complete with a vacuum system, condensate collector and return pipes.

Making nuclear energy in Europe even safer

Philip Lowe, Director General for Energy, European Commission, DG ENER (pictured)

Time has moved on and the shock of the Fukushima nuclear power plant accident in spring 2011 has already faded in terms of media priorities. Whilst no longer headline news, Fukushima, nevertheless, will have a lasting impact around the world. It shook public trust in the safety of nuclear energy production to its very roots and directly led to the stress testing of nuclear power plants here in Europe.

Between 2011 und 2012 the European Stress Tests assessed the responses of nuclear power plants to severe external events and made recommendations for improving their design in order to reduce, even further, the chances of a nuclear accident occurring in Europe. These Stress Tests extended beyond the borders of the EU and involved also the Ukraine, Switzerland and for parts of the exercise Turkey, Armenia and Belarus. This follows a longstanding tradition of international collaboration under the International Atomic Energy Agency (IAEA).

By the end of 2012, both Member States and participating non-EU members had to draw up national action plans to implement the Stress Test recommendations. These were peer-reviewed during an international workshop in Brussels in order to ensure a consistent implementation of these recommendations throughout Europe. While the Stress Test exercise showed the benefits of international coordination and cooperation, the implementation of the Stress Test recommendations remains a national responsibility. The Commission is monitoring this implementation process in close cooperation with national regulators and intends to issue a report in June 2014. The European Nuclear Safety Regulators' Group (ENSREG) will come out with a follow-up peer review in 2015.

I am convinced that the future of nuclear energy will depend to a large extent on public acceptance and trust in the safety of nuclear operations. This requires a modern and transparent way of deciding on nuclear safety provisions. As a consequence, following a wide public consultation, last June the Commission adopted a proposal for a directive reviewing the existing European framework for the safety of nuclear installations, the 2009 Nuclear Safety Directive.

The Commission's proposal complements and strengthens the provisions of the 2009 directive. It further increases transparency on nuclear safety matters and enhances the role and effective independence of the national regulatory authorities. It introduces ambitious safety objectives which are shared at the EU level, and a European system of peer reviews of nuclear installations, successfully practiced in the Stress Tests.

Whilst on-site emergency management in the event of a severe accident was one of the topics covered by the stress tests, off-site emergency management was not included since it does not fall under the responsibility of nuclear safety regulators, but rather Member States' authorities. It is being dealt with in a dialogue between the Commission and ENSREG. In January 2013, the Commission launched a study on existing arrangements in the EU's Member States and in neighbouring countries. By the end of this year, we intend to identify possible improvements and communicate them to the Council and the Parliament.

Nuclear insurance and liability is another important element for a modern nuclear safety framework. In the EU, different international conventions apply and some EU Member States are not party to any convention at all. Victim compensation levels for example still vary widely across the EU and are in general insufficient.

Furthermore, claims management is not addressed by the Member States in the case of a cross-border accident. This issue also impacts on the internal market. The Commission therefore set up an informal expert group on this matter which presented its recommendations several months ago. The overall aim is to propose a legislative initiative on nuclear third party liability insurance in early 2014.

If we want to make nuclear energy in Europe even safer – and the focus areas are now pretty well identified – we all need to work together in the years to come. Let us all assume our respective responsibilities, from operators and regulators to the European institutions.

How competitive is Photovoltaic Electricity

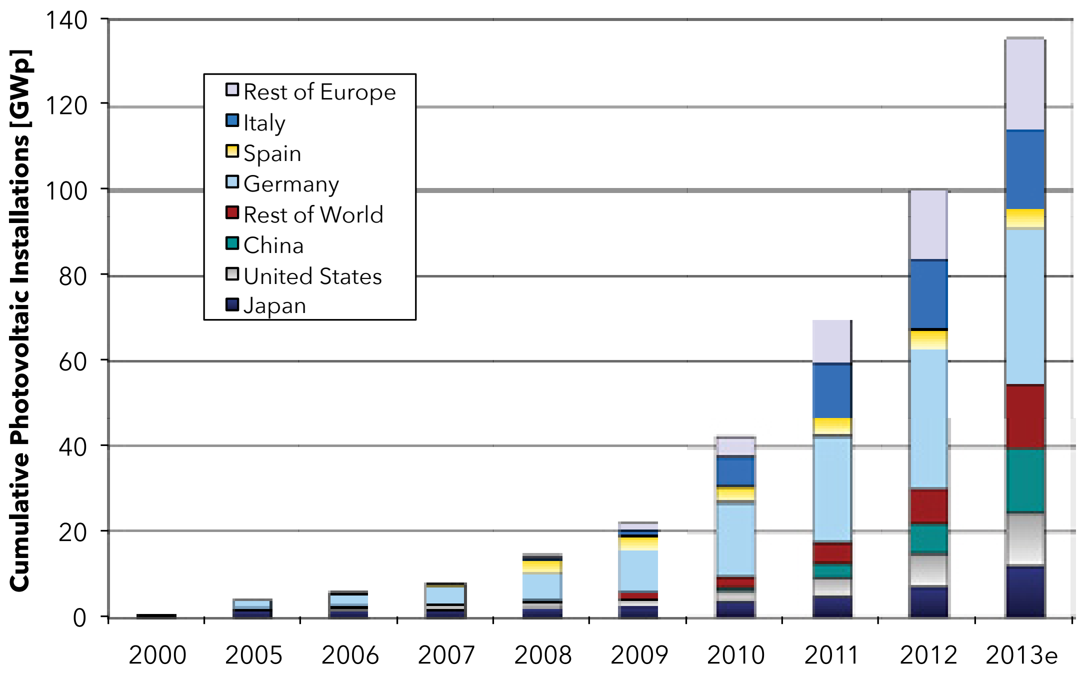
Solar energy is the most abundant energy resource on earth today, providing about 10,000 times more energy per year than we actually use. There is a whole family of solar technologies which can deliver heat, cooling, electricity, lighting, and fuels for a variety of applications. One of these technologies is photovoltaics which converts solar energy directly into electricity using semiconductors which exhibit the photovoltaic effect and are called solar cells.

The importance of renewable energy and amongst it solar photovoltaic electricity for mitigating Climate Change was highlighted by a special report of the Intergovernmental Panel for Climate Change (IPCC)[1] and recently by the IEA *Medium-Term Renewable Energy Market Report*[2], which forecasts a more than threefold increase of cumulative PV installations in 2018 compared with 2012.

After the world-wide photovoltaic market more than doubled in 2010, the market grew again by almost 30% in 2011 and another 11% in 2012, despite difficult economic conditions. The 2010 market volume of 20.9 GW includes those systems in Italy, which were reported under the second "*conto energia*" and installed, but connected only in 2011. There is an uncertainty about the actual installation figures in China. The Chinese National Energy Administraion published a cumulative installed capacity of 7 GW at the end of 2012, whereas most other market reports cite figures between 8 and 8.5 GW[3]. The stronger than expected market in Germany and the strong increase of installations in Asia and the

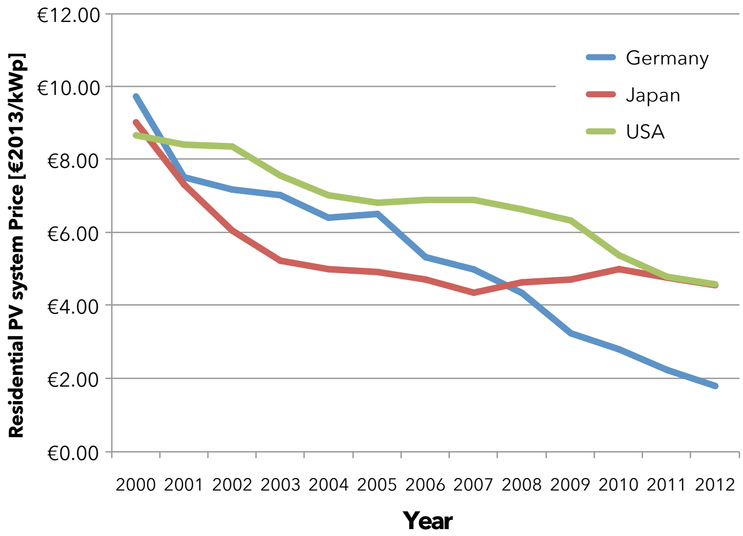
Figure 1: Cumulative Photovoltaic Installations from 2000 to 2013

(data source: EPIA[4], Eurobserver[5] and JRC analysis)



1 Intergovernmental Panel on Climate Change (IPCC), Special Report on Renewable Energy Sources and Climate Change Mitigation, 2011; http://srren.ipcc-wg3.de/report
2 International Energy Agency, Medium-Term Renewable Energy Market Report 2012 - Market Trends and Projections to 2018, 182 pages, ISBN 978-92-64-19118-1 (2013)
3 National Energy Administration, China, 8 January 2013, http://www.nea.gov.cn/2013-01/08/c_132089068.htm
4 European Photovoltaic Industry Association, Global Market Outlook for Photovoltaics until 2017, 2013
5 Photovoltaic Energy Barometer, Systèmes Solaires, le journal du photovoltaique no 9 – 2013, April 2013, ISSN 0295-5873

Figure 2: Residential PV system price development over the last decade.
Data sources: IEA PVPS, BSW, DoE Sun-Shot Initiative, Eurostat, OECD key economic data



USA resulted in a new installed capacity of about 30 GW in 2012 and for 2013, an increase to about 35 GW is expected (Fig. 1). This represents mostly the grid connected photovoltaic market. To what extent the off-grid and consumer product markets are included is not clear, but it is believed that a substantial part of these markets are not accounted for as it is very difficult to track them.

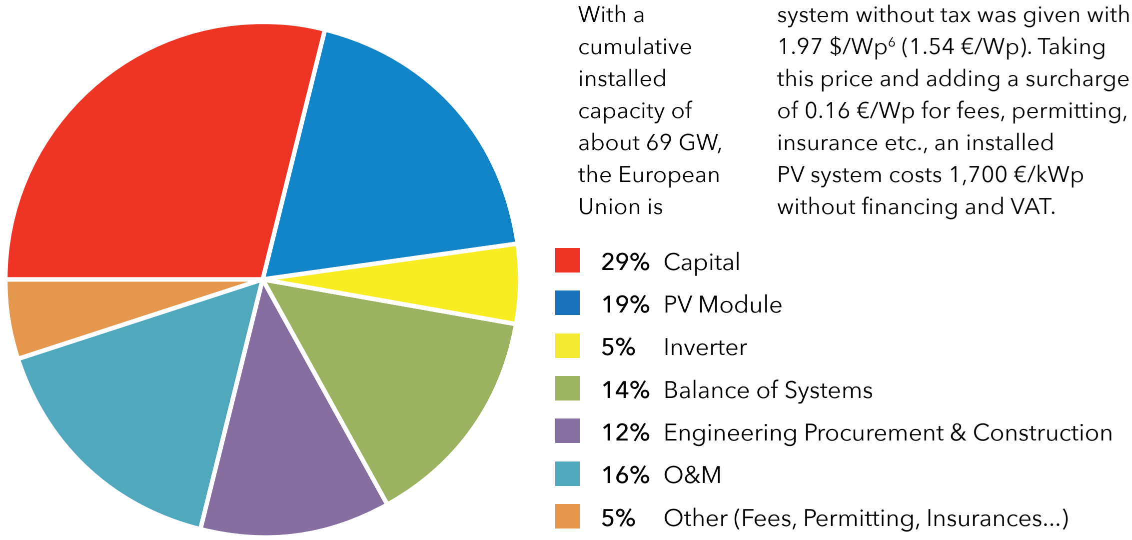
With a cumulative installed capacity of about 69 GW, the European Union is leading in PV installations with a little less than 70% of the total world-wide 100 GW of solar photovoltaic electricity generation capacity at the end of 2012.

Over the last decade prices for residential grid-connected PV systems have decreased significantly as shown in Figure 2. The increase of PV system prices in Japan between 2007 and 2010 on is due to the change in exchange rates because in local currency the system prices decreased further.

Electricity production from residential photovoltaic solar systems has shown that it can be cheaper as residential electricity prices in a growing number of countries, depending on the actual electricity price and the local solar radiation level.

In June 2013 the world-wide average price of a residential system without tax was given with 1.97 $/Wp[6] (1.54 €/Wp). Taking this price and adding a surcharge of 0.16 €/Wp for fees, permitting, insurance etc., an installed PV system costs 1,700 €/kWp without financing and VAT.

Figure 3: LCOE shares of PV generated electricity for residential systems with a system price of 1,700 €/kWh (excluding VAT), 1.5% Operation, Maintenance and Repair (O&M) cost, an annual generation of 1,000 kWh/kWp/y installed, Return on Investment of 5% and a financial lifetimes of 20 years.



6 PVinsight, 29 June 2013, http://pvinsights.com/SolarSystem/SolarSystemPrice.php

	Price [€/kWp]	LCOE Product [€ct/kWh]	LCOE Capital [€ct/kWh]			LCOE O&M 1.5% [€ct/kWh]	LCOE Total [€ct/kWh]		
Return on Investment	-	0%	3%	5%	10%	-	3%	5%	10%
Annual electricity generation of 1,000 kWh/kWp	1,700	8.5	3.3	4.4	9.7	2.5	13.5	15.4	20.7
Annual electricity generation of 1,300 kWh/kWp	1,700	6.5	2.1	3.5	7.5	2.0	10.6	12.0	16.0

Table 1: LCOE of PV generated electricity for residential systems with a system price of 1,700 €/kWh (excluding VAT, because the differences in various countries are too large), 1.5% Operation, Maintenance and Repair (O&M) cost, and financing payback of 20 years.

It is interesting to note that already at 5% Return on Investment (ROI) the financing costs are the largest single cost factor (Fig. 3). Together with fees and permitting costs they contribute to one third of the electricity generation costs from a residential PV system during the first 20 years.

Depending on the actual radiation level, the 1.5% Operation, Maintenance and repair costs (O&M) are the second or third largest cost factor. The O&M costs cover the foreseeable repairs and exchange costs of components like the inverter, as well as the annual degradation of the solar modules as specified by the manufacturers. LCOE for different ROI rates are shown in Table 1 for the financing period of 20 years. Adding a conservative safety margin of 1.5 €ct/kWh on top of the 2.0 to 2.5 €ct/kWh results in an electricity price of 3.5 to 4.0 €ct/kWh after the 20 years of financial payback time.

The average European residential electricity price given by EUROSTAT[7] for the 2nd Semester 2012 was 0.197 €/kWh and higher than PV generated electricity for the lower ROI financing options, which are more realistic for private consumers. Denmark, Cyprus and ex. Equo Estonia and Germany had the highest prices with 0.297 €/kWh, 0.291 €/kWh and 0.268 €/kWh respectively. It has to be mentioned, that the LCOE in Cyprus are more than 20% lower due to the higher solar radiation.

Without any support, the profitability of a solar PV system primarily depends on the self-consumption by the owner, as less energy has to be purchased from the utility. In the case of a PV system size that generates enough electricity over a year as the customer uses, the actual consumption during the time of generation is in general just around 30% if no demand shifting or local storage is applied. Therefore, 70% of the generated electricity has to be sold to the grid. The question is at which price: contract, wholesale or day ahead price. Table 2 shows at what price the surplus electricity has to be sold to break even with a ROI of 3%.

The average annual electricity consumption of European households is about 3,500 kWh and would require a PV system of 3.5 kWp.

The first option to improve the profitability would be to increase the self-consumption by demand shifting and using electrical appliances like the washing machine or dishwasher during the day when the sun shines. Another option is to use the difference between the necessary selling rice of PV electricity and household retail price could also be used to invest in local storage options, being they residential or community owned. However, at the moment this is still a relative expensive options with prices for electricity from storage at 0.18 to 0.21 €/kWh, which has to be added to the PV LCOE.

7 EUROSTAT, Electricity prices for domestic consumers, from 2007 onwards - bi-annual data [nrg_pc_204]; Last update: 26-06-2013

Table 2: Necessary selling price of PV electricity to break even with a system price of 1,700 €/kWh (excluding VAT), 1.5% Operation, Maintenance and Repair (O&M) cost, ROI of 3% and financing payback of 20 years.

	Without PV system	With PV system
Purchase from utility (kWh)	3,500	2,450
Own PV electricity use (kWh)	-	1050
PV electricity generation costs at 1,000 kWh/kWp (€	-	472.5
PV electricity generation costs at 1,300 kWh/kWp (€)	-	371.0
Retail electricity price European average (€/kWh)	0.197	0.197
Electricity bill European average (€)	689.50	482.65
Necessary selling price of PV electricity to break even at 1,000 kWh/kWp (€/kWh)	-	0.11
Necessary selling price of PV electricity to break even at 1,300 kWh/kWp (€/kWh)	-	0.067
Retail electricity price Denmark (€/kWh)	0.297	0.297
Electricity bill Denmark (€)	1,039.50	727.65
Necessary selling price of PV electricity to break even at 1,000 kWh/kWp (€/kWh)	-	0.066
Retail electricity price Cyprus (€/kWh)	0.291	0.291
Electricity bill Cyprus (€)	1,018.50	712.95
Necessary selling price of PV electricity to break even at 1,300 kWh/kWp (€/kWh)	-	0.027
Retail electricity price Estonia, Germany (€/kWh)	0.268	0.268
Electricity bill Estonia, Germany (€)	938.00	656.6
Necessary selling price of PV electricity to break even at 1,000 kWh/kWp (€/kWh)	-	0.08

According to various consultancy reports, the electricity storage market is expected to grow 10-fold over the next five years and exceed € 2 billion by 2017. This market development together with a further retail price increase and a PV system price reduction could lower the LCOE of a PV system including storage below the average European electricity retail prices and make PV electricity the lowest cost option for more than 230 million Europeans within the next five years.

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Multi-Approach for high efficiency integrated and intelligent Concentrating PV (CPV)

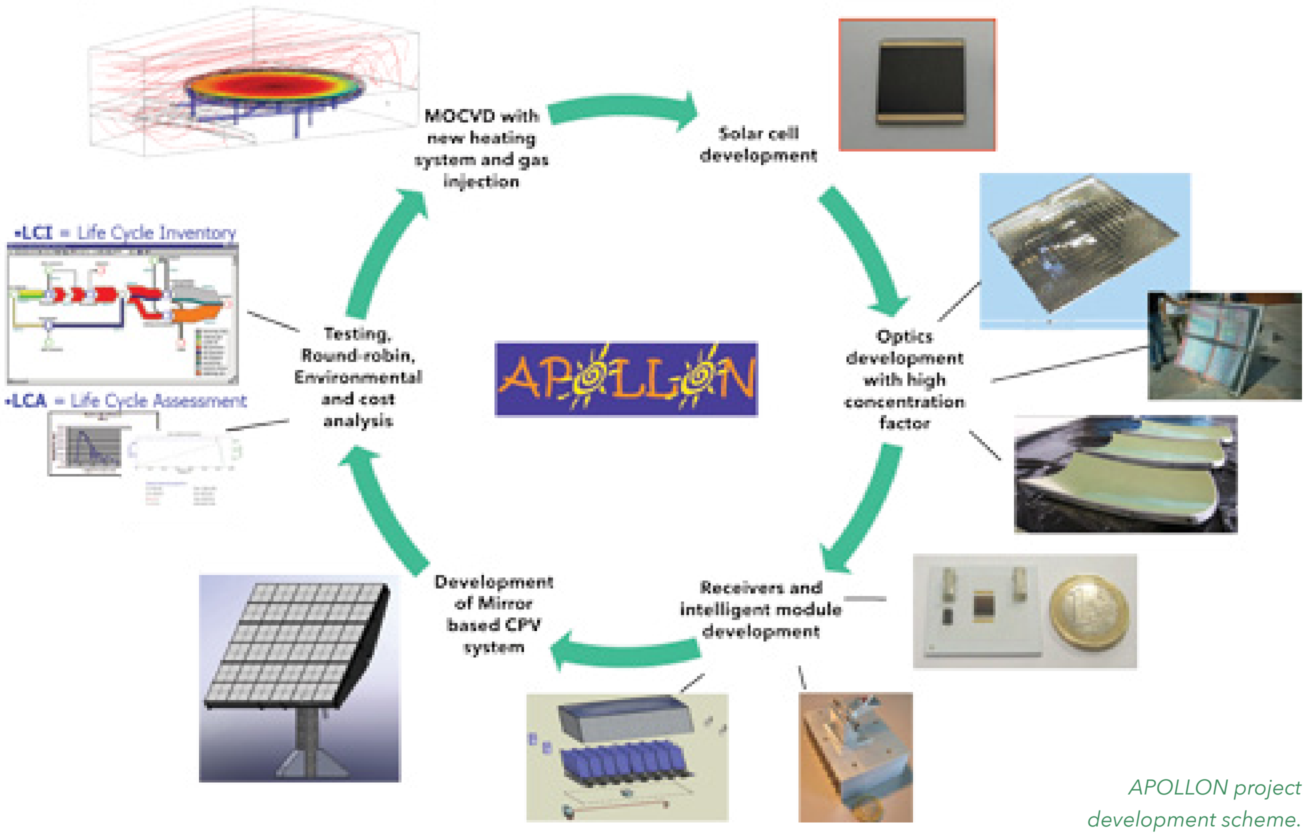
NEW MODULE CONCEPTS AND PERSPECTIVES FOR THE CONCENTRATING PHOTOVOLTAIC TECHNOLOGY AS RESULTS OF THE FP7 LARGE INTEGRATED PROJECT APOLLON

The APOLLON project carried out in the European Seventh Framework Program has reached its culmination of 5 years work from 2008 to 2013.

This Project is bringing together the results concerning all the development chain of the Concentrating Photovoltaic Technology, from the improvement of the Metal-Organic-Chemical-Vapor Deposition (MOCVD) technique, which is used for the growth of semiconductor materials composing the photovoltaic device, to the final construction of a prototype concentrating photovoltaic system.

With respect to the previous European Projects, one innovative character of APOLLON was the possibility to compare the two main concentrating photovoltaic technologies under development of the Photovoltaic Community, namely, Point Focus (PF), based on **refractive optics**, and PF or Dense Array (DA), based on **reflective optics**, throughout a full integrated approach able to face all the critical technology issues related to each component of the CPV system.

In order to achieve the higher potential for a future commercial exploitation of the CPV technology, the APOLLON Consortium has been formed by aggregating 17 Partners (coming from 8 European countries), joining the two "wings" of technological innovation, the research centers and the industry, fixing the final objective to develop an innovative, high concentration CPV system with a target cost of **2 Euro/W**. The ultimate product developed in APOLLON has been a concentrating mirror-based photovoltaic system, composed of **new tracking control based on "intelligent" modules**, 30 %



APOLLON project development scheme.

efficient (850 W/m² and 25°C), with **patent pending new optics** working at **high concentration** factor (around 850 X) and adopting high efficiency InGaP/InGaAs/Ge multi-junction (MJ) solar cells. The new "intelligent" concentration modules have been developed with **integrated patent pending sun pointing sensors** which allow tracking the sun with high precision (angular resolution of 0.012 °) and integrated DC/DC devices with Maximum Power Point algorithm which are able to maximize the production of the electric power generated by each CPV module.

The APOLLON Consortium has also investigated a new technological route **enabling to expand the combination of semiconductor materials to be used in the solar device**, in particular demonstrating the possibility to deposit with a new "MOCVD" growth chamber both elements of group IV and elements of groups III and V of the periodic table. in perspective, by joining III-V and Ge alloys, for example, developing InGaP/InGaAs/SiGeSn (0.9-1 eV) /Ge MJ junction solar cells, the concentrating photovoltaic technology is expected to show further progress surpassing efficiency value of 45%.

In order to show the reliability status of the CPV technology , the Consortium conducted reliability tests on solar cell receivers and pre-qualification on CPV modules.

Furthermore the APOLLON partners worked for contributing to the **actual standard on CPV, developing new methodology on module current mismatch analysis and for the determination of outdoor solar cell temperature**. It is finally important to highlight the contribution of this project on the **measurement campaign of Solar Direct Radiation (DNI)** in joint collaboration with the European **FP7** project on Research Infrastrures SOPHIA which allowed increasing the accuracy of these measurements, as well as to enrich the European data-base.

These and other results of the APOLLON project, along with the possible development scenarios of the Concentrating Photovoltaic Technology, will be presented during the **APOLLON Workshop** which will be held **in Paris on the 3rd of October, as parallel event of the 28th European Photovoltaic Conference**.

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under the Grant Agreement n°213514.

Partner	Country	Role
RSE	Italy	Coordinator. Multi-junction solar cell development by adopting a new Metal Organic Chemical Vapor Deposition growth chamber; Mirror design, cell and module characterization. Development of Point Sensitive Sensors (PSS) for intelligent module
AIXTRON	Germany	Development of a new MOCVD growth chamber
CNRS	France	Fundamental research activities on epitaxial germanium and SiGe alloy on Si by MOCVD
ENE	Belgium	III-V solar cell industrial partner
CRP	Italy	Development of Chip on Board (COB) solar receivers. Reliability and mechanical testing
SE SR TIIE	Ukraine.	Development of Chip on Flex (COF) receivers. Life time testing
JRC	(European Commission)	Measurement, Testing devices/modules. Pre-qualification testing of the CPV components
ENEA	Italy	Si solar cell optimization, selection of Anti reflection coatings, design of prismatic/hybrid lenses. Outdoor Round Robin characterization
UCY	Cyprus	Out door high insulation CPV module testing. Dissemination
CPower	Italy	Mirror Based Spectrum Splitting System (MBS³) development
Solar*Tec Int.	Germany	Point Focus (PF) system development
ECN	The Netherlands.	Environmental and Economic Assessments of CPV technologies
Enel Ingegneria e Innovazione S.p.A.	Italy	Monitoring off-grid and grid connected PF and MBS³ CPV system
FUNDACIÓN TECNALIA Research & Innovation	Spain	Developing tracking electronic control, Maximum Power Point Tracking devices, software and control logic for PSS
NaREC	United Kingdom	Si cell industrial partner
UNIFE	Italy	Design of MBS³ concentrator
ASSE	Italy	Mirror based system development

RSE Ricerca Sistema Energetico AIXTRON CRP ECN ENE ENEA Enel EUROPEAN COMMISSION Joint Research Centre NaREC Photovoltaic Technology University of Cyprus university of ferrara tecnalia Inspiring Business ASSE

Investing in a solar future

By Reinhold Buttgereit, Secretary General, European Photovoltaic Industry Association (EPIA)

Solar power has come a long way in a relatively short time. Now, at a crucial time in its evolution, it faces political challenges that will determine how effectively it continues its progress toward being a mainstream source of electricity.

In 2012, even during a time of economic crisis and regulatory uncertainty, the global market for photovoltaics (PV) – the technology behind solar electricity -– continued to grow. In fact last year, PV achieved a significant milestone as the world's cumulative capacity surpassed 100 GW. This capacity can produce as much annual electrical energy as 16 coal power plants or nuclear reactors of 1 GW. Each year these PV installations save more than 53 million tons of CO_2.

Few could have predicted even five years ago that today, PV technology would be meeting nearly 3% of Europe's electricity demand – and would be on a path to providing 15% or even 25% of Europe's electricity needs by 2030.

There will always be naysayers, and the old-school fossil fuel interests will continue to argue that renewables cannot contribute significantly to meeting our energy needs. But the numbers do not lie. In 2012, even in the face of growing adversity, more than 30 GW of new solar PV capacity was connected to the electricity grid. In Europe it was the number-one newly installed source of electricity, ahead of gas and wind.

Polls continue to show that people want solar power, and see its potential for improving our energy system. In the debate

over how best to achieve the world's climate-change goals, we should not underestimate this potential, and policymakers should ensure that the progress made in recent years can continue. As a clean, safe and infinitely renewable source of electricity, PV has the power to help achieve these goals. We all know the benefits of solar electricity, and the market's appetite for it will continue to grow as the technology becomes more efficient – and cost-effective compared to other sources of electricity.

PV is no longer a niche product. It is an increasingly important source of electricity generation, on its way to becoming mainstream. This means we have to start thinking differently about it.

For Europe's electricity system, the coming decades will bring a whole new world. Achieving Europe's ambitious climate goals will require an almost complete decarbonisation of the energy sector by 2050. This will have important implications for the continent's power system. The rise of variable renewable energy sources, including PV, requires a new perspective on managing the electricity grid. However, in many ways, PV is already providing solutions – meeting a growing share of electricity demand at increasingly competitive cost without creating a strain on the European power system.

EPIA's recent report: "Connecting the Sun: Solar photovoltaics on the road to large-scale grid integration", is all about taking the next step in the PV industry's evolution. Yes, this will require some changes from grid operators, from policymakers and from the PV industry itself. But the challenges are not insurmountable. Solutions to enable a high penetration of PV are achievable and, in many cases, already exist.

Europe's electricity demand is increasing. In the context of Europe's decarbonisation goals, this power will have to come from more variable sources. As European policymakers consider their options for investing in new and more efficient grid infrastructure, they should take into account the benefits that PV is already producing and, more importantly, plan for the greater benefits it is capable of producing in the future.

Now is the time to take the steps that will allow us to take full advantage of PV's enormous potential. With so many stakeholders involved – the PV industry, grid operators, utilities, policymakers and, let's not forget, electricity customers – the discussion in the coming years will not always be easy.

By making the right choices now, PV can deliver on its promise as a major contributor to meeting Europe's energy, environmental and economic goals for the coming decades.

For more information on "Connecting the Sun", visit www.connectingthesun.eu

ABOUT THE AUTHOR
Reinhold Buttgereit became Secretary General of EPIA in May 2011. Previously, Mr Buttgereit worked in Public Affairs and Lobbying for Vattenfall Europe for 12 years. He has also worked as an expert in environmental impact assessment, mediation and project management at the technical consultancy firm Prognos as well as at the Berlin utility Bewag.

Mr Buttgereit earned his PhD in Landscape Architecture from Technical University of Berlin.

Solar Revolution:
More opportunities for own consumption

A revolution in using photovoltaics has started in Germany and other European countries, which is going to have an enormous impact on the decentralization of energy supply and on the modifications of renewable energy.

The Plug & Save solar systems, which are produced by ALGATEC Solar AG from Brandenburg, Germany, and invented by the British-German company Sun Invention, extend the range of utilization of solar energy: Plug & Save is unique and the first worldwide easy-to-use solar modules with integrated micro inverter, controller and energy storage.

Therefore Plug & Save can be utilized by home owners, tenants and landlords if they have a balcony, a façade, a garage, a garden or a roof exposed to the sun. The produced solar energy is directly fed into the household grid through a cable and a socket and contributes to the private standby-consumption.

The configuration of the solar systems plays a crucial role as modules with energy storages and modules without energy storage can be combined. The standby-consumption of households can be programmed for day or night with intelligent controllers and thus achieving an own consumption rate of 30 percent.

Also the European Union has now noticed the potential of the Plug & Save solar system. At present, The European Parliament is debating on a resolution of the Committee of Industry, Research and Energy for electricity and heat generation in small and micro scales. Therein, the Board is committed to small-scale photovoltaic and is demanding that the Commission allows electricity generation in future European energy legislation especially in the context of the climate and energy package of the EU for 2030.

Sun Invention is already the global leader in the technology as well as in the development of easy-to-use solar modules. Since August the company has combined the innovative decentralized energy generation technology of Plug & Save with their own exclusive eco power tariff and eco gas tariff, S-I-E 100. For the first time supplier and customer have common interests – namely the decentralized production of a reasonable part of the required energy or to make customers almost self-sufficient using stationary energy storage systems.

The EU Committee has also requested that the European Commission develops guidelines to simplify the grid connection of small photovoltaic systems in the member states. European harmonization of these rules and regulations should essentially be striven for; to let the solar revolution 2.0 go ahead.

Further information:
www.suninvention.com
www.suninvention-energy.com

Photovoltaics R&D: Pursuing new frontiers in performance measurements

By Nigel G. Taylor, PhD, European Commission's Joint Research Centre

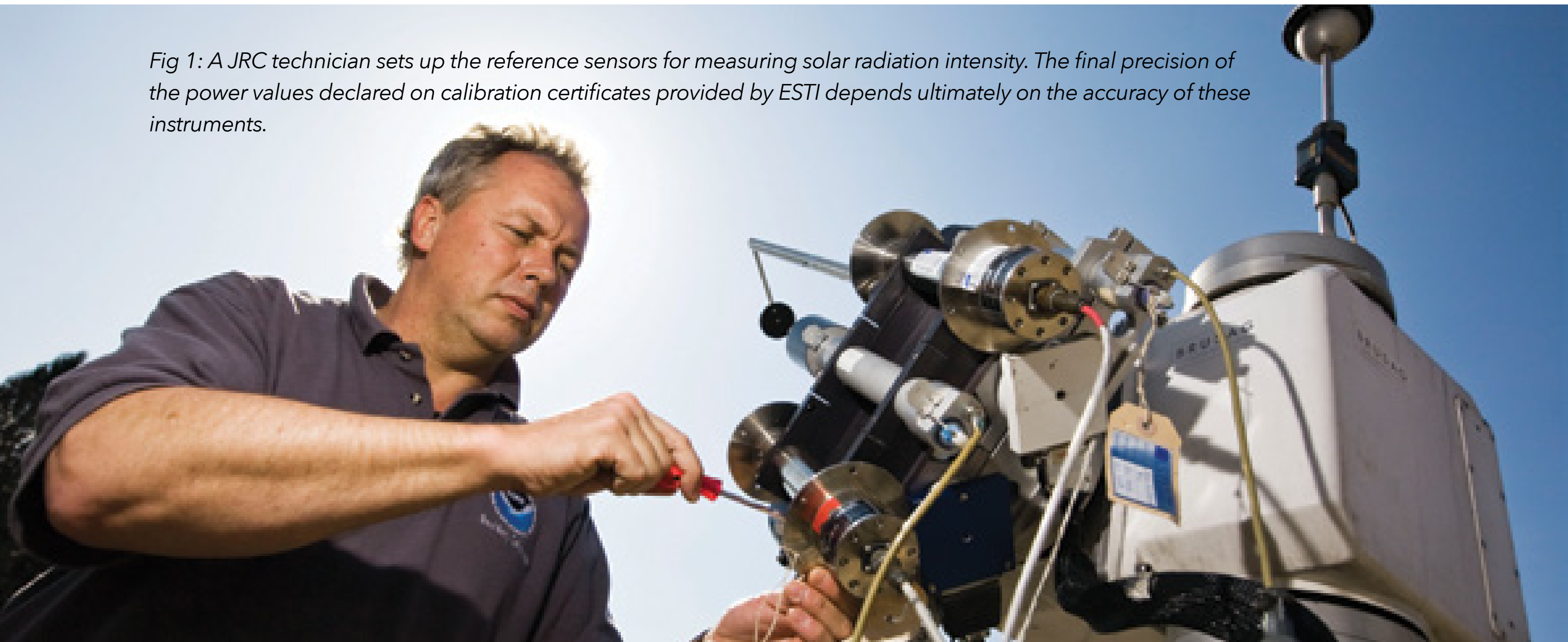
Clean, safe, secure and affordable energy is one of the big challenges facing Europe today. Increasing global demand, together with the need to tackle climate change, requires a major shift towards a low-carbon economy. The Joint Research Centre (JRC), the European Commission's in-house science service, provides support to energy policy over a broad range of issues. One of these is photovoltaics, a field of strategic importance for competitive renewable energies on account of the available resource and the technology's potential for increased efficiency and extended economic lifetime.

The PV industry grew an average of 35% per year over the last 10 years, while its manufacturing costs went down four-fold. In Europe, approximately 69 GW of installations provide (2012) already about 2.4% of Europe's electricity needs – enough electricity to power 4.5 million homes. The potential to increase this share significantly over the coming decade relies on continuing technology development and innovation.

Within this context, the JRC has upgraded its European Solar Test Installation (ESTI) which now offers a unique range of precision measurement capabilities to research into factors influencing the cost-effectiveness of photovoltaic installations. This reference role is based on best-in-class measurement uncertainty levels, which have been improved by 20% since 1997 (from 2.6% to 2.0%) - with the production of modules now at over 10 GW per annum and rising, this represents a potential gain of approximately €200 m/year for end-users (Fig. 1).

The modernised laboratories in Ispra, Italy, provide power calibration for high performance silicon, thin film, as well as concentrated PV or organic PV. These will in turn contribute to the promotion of innovation in PV technologies in the EU. The innovation pathway goes straight into PV manufacturing equipment industry. Therefore, advanced devices for PV conversion need to develop modules made from organic-, plastic-, and nano-structures. These materials allow for the development of new, high throughput manufacturing equipment, suitable for very high capacity manufacturing plants. One of the new facilities – the Apollo large-area steady-state simulator – opens the door to new measurements on advanced products as it provides full sunlight conditions over a 2 m x 2 m test area for up to 8 hours, and is the first of its kind installed in Europe (Fig. 2). The lab works directly with industry and R&D organisations to

Fig 1: A JRC technician sets up the reference sensors for measuring solar radiation intensity. The final precision of the power values declared on calibration certificates provided by ESTI depends ultimately on the accuracy of these instruments.



establish adequate performance measurement procedures for new products. This step is often critical to establishing the "bankability" i.e. investor confidence, in particular for start-ups, which need to provide a trustworthy, competent and unbiased reference for potential success of a new and innovative technology.

Improved methods for determination of long-term performance (more than 20 years) continue to be a priority. ESTI pioneered tests on the reliability of early PV products in the 80s, when the European Commission financed the first pilot phase of terrestrial PV systems, and helped to provide the basis for international standards, which supported a market worth €20-€25 billion in Europe last year. Emphasis is increasingly on quantifying long-term performance so as to calculate the cost of the electricity generated once the plant investment costs are recovered.

To continue the growth of photovoltaics, different technology paths have to be pursued. Europe continues to be a global leader in PV research. On the one hand, efforts need to be increased on advanced solar cells – notably on low-cost organic or plastic materials – together with manufacturing technologies for large-scale production. In addition to capitalising on global partnerships, there is also large scope for innovation regarding buildings that incorporate PV devices specifically designed as roof material.

On the other hand, the cost of the PV device itself now accounts for less than 50% in a system, so the other elements have to be also addressed. The increasing share of PV electricity in the grid is driving the development of new models for distribution of photovoltaic electricity and of integrating storage technologies. These will rely on regulatory procedures to ensure a fair and smart access to the electricity grid and market. The JRC's broad range of competences, covering building energy efficiency, solar resource assessment, electricity storage technologies and smart grid models, put it in a strong position to provide effective support to all these developments as an integral part of the 2050 vision for a low-carbon economy.

Fig 2: ESTI's new large-area steady state simulator opens a range of possibilities for studying the electrical performance of new module technologies with long response times.

metaPV

A new path for smart grid development: more PV, more control, lower costs

The European MetaPV project is demonstrating techniques to manage grids with high penetration of photovoltaics, in new, intelligent and inexpensive ways, using smart inverters.

The potential costs and impact of increased renewable energy penetration on current grid infrastructure are globally debated. Unfortunately, there is still very little reliable data from the field to weigh in on the discussions. The MetaPV project is addressing this issue and has recently proven that it is possible to significantly reduce the costs of photovoltaic (PV) power integration. MetaPV has demonstrated that in real-world conditions, regulating the grid by using the power of new inverter technology can delay the need for grid reinforcements and be a cost-efficient solution to support the grid. First results have shown that grid hosting capacity for PV can be increased by half with costs reduced by a factor of 10.

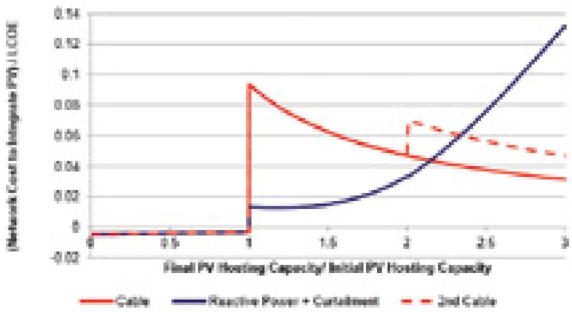
This is a step forward in enabling the deployment of more PV, keeping Europe on track to reach its renewable energy objectives. The innovative products and services demonstrated in MetaPV are also reinforcing the competitive edge of European PV system technology.

Very high levels of distributed PV generation in some regions can lead to high voltage situations. There are many options to address these issues and make grids more resilient. However, very few of them have yet been demonstrated in the real world and at sufficient scale to deliver replicable and practical techniques to be used by utilities. MetaPV has succeeded in bringing together European partners and citizens on a viable testing site to deliver real world demonstration results. The MetaPV team is focusing on how to control reactive power from smart inverters and extra storage, in order to increase the grid hosting capacity. The sense and viability of reactive power control from inverters has been proven in real conditions, using new SMA technology. MetaPV is now focusing on fine-tuning the parameters of this control in combination with other regulation mechanisms. The project will then deliver practical techniques to be used by distribution system operators.

MetaPV is a first step towards a reliable solution for PV integration. By proving that more PV, with advanced control systems, can be a source of more stability, the project is delivering major breakthroughs for the PV manufacturing industry

MetaPV is funded by the European Commission in the 7th Framework Programme (GA 239511). The project is

coordinated by renewable energy consultancy 3E, in cooperation with grid operator Infrax, research partners AIT and the University of Ljubljana, inverter manufacturer SMA Solar Technology AG, and investment partner LRM. More information and results can be found on www.metapv.eu.



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Solar PV Technologies and the Sustainability Challenge

by Professor Vladko Panayotov, MEP, (ALDE, Bulgaria)

Solar PV technologies have tremendously grown in the past decade despite financial difficulties and have the potential to become a major source of sustainable energy in the future if growth continues at such significant rates. Technical and economic challenges however still present obstacles to achieving grid parity for solar PV technologies in some countries. A sustained growth of solar PV in the future will depend both upon the design and implementation of adequate R&D policies supporting the development of advanced technologies and upon tackling the problem of supply scarcity for some critical raw materials, which are necessary for the development of European industries.

Studies demonstrate that there will be a higher risk of bottlenecks due to metals' availability for some renewable energy technologies if these technologies are deployed at a significantly larger scale in the future. Some critical metals which were identified by the European Commission such as neodymium, indium, tellurium, gallium, or dysprosium for example, are largely deployed in solar PV technologies and essential for their build-up and functioning. Thus, the availability of supplies of these metals for the EU would be instrumental in enabling these technologies to exist and continue to improve in the future. If solar PV continues to grow at the same rate that it did in the past couple of years, demand for these metals would also grow significantly and this on its turn might lead to shortages in critical raw materials due to the limited availability of these metals at the global level.

Europe should pay attention to the potential of increasing risks of bottlenecks in the deployment of solar PV in the future and should look at the overall value-chain for solar PV technologies in order to minimize these risks for the future. In this context, it would be equally important to devote enough attention and resources in the directions of both explorations for alternative materials, substitution of certain metals, recycling of already used PV panels, and to promoting research and innovation along the whole value chain for PV. All of these actions will help reduce the potential risk of bottlenecks to the large-scale deployment of solar PV in the future. Europe can further benefit from stronger cooperation with its international partners in order to ensure for itself enough supply of strategic metals for its industries.

Import dependence of the EU on some critical raw materials can become a major challenge for Europe in the future as the expected increase in the use of some critical metals for the deployment of solar energy technologies might be bigger than the resources that Europe has or has already secured through existing commercial agreements. However this would be an equally great opportunity for the development of more advanced solar technologies like organic cells, more resource-efficient types of technologies, better storage capacities etc. Investing in R&D thus would be critical in making it possible for solar PV to both take a more prominent place in the energy market and to help the EU achieve its long-term goals of energy efficiency, reduction of carbon emissions and sustainable growth.

Solar PV technologies' role for building a sustainable future of the EU has grown enormously and will continue to grow both at a European and global level, but the sustainability itself of solar PV technologies in the long run will depend highly upon the long-term availability of raw materials for the advancement and improvement of these technologies. European policies should thus strongly encourage the development of both alternative and emerging technologies in order to limit the risks of bottlenecks connected to metals' availability in the future. Research and innovation in the field of advanced materials can help increase efficiency of solar PV and conversion rates; it can bring down demand for energy as well as energy prices and costs of production.

Last but not least, Europe should encourage practices for recycling of solar panels and

Professor Vladko Panayotov, MEP

recovering more efficiently the precious metals that are already circulating within the market in order to mitigate the risks related to high import dependence for some of these critical raw materials. Sustainability of these technologies should translate into an environmentally safe way of disposing of old panels, which means that effective recycling is the best way to prevent both pollution of the environment and the loss of precious metals and materials and simultaneously to encourage resource efficiency at all levels.

Investing strategically into research, development and innovation actions for solar energy technologies will be crucial in tackling this sustainability challenge both for solar PV and for Europe's long-term energy goals. Thus continuous and well-targeted R&D efforts at all different levels of the value-chain will be crucial for ensuring the longer-term availability of strategic metals for solar energy technologies and for supporting their commercialization and advancement.

The sustainability challenge is a mid- to long-term challenge and opportunity and it requires a holistic approach in order for Europe to successfully mitigate the risk of bottlenecks due to scarcity of critical raw materials for strategic energy technologies such as solar PV. This challenge requires quick responses and targeted actions along the entire value chain from research and development to production, commercialization and successful grid integration. The "sustainability goal" presents both a challenge and an opportunity for Europe to exit the crisis. Whether "sustainability" will mean a "challenge" to achieving EU's long term low-carbon future or whether it will bring further opportunities for advancement and leadership of the EU at the global level, this will depend entirely on the approach and actions Europe takes now towards achieving this goal.

Real scale thermal assessment of advanced insulation materials

Collaborative research success story

By Ignacio del Val, physicist of Acciona Infraestructuras Research Center

Regarding building science, studies about new insulation materials tested at the laboratory scale must be carefully considered when drawing conclusions about their real energy efficiency. Even though this kind of tests are necessary during the first development stages, they cannot be taken as sufficient evidence since they are conducted under very optimistic conditions and are generally not taking into account thermodynamics of complex systems, where the single constructive element is interacting with the environment and its surroundings.

By November 2010, European research centres working on energy efficiency in buildings did not count on a specific demonstration site to carry out comprehensive tests in the medium and the large scale for newly developed insulation materials of their research. Thus, the interaction of the single prototypes with the complete building structure needed to be investigated using a theoretical approach, which remains imprecise.

By this date, the European consortium NANO E2B CLUSTER composed of six research projects funded under the working topic of "New nanotechnology-based high performance insulation systems for energy efficiency" (including 11 large enterprises, 16 small and medium enterprises, 17 research and technological organizations and 5 universities with a total budget of 24.2 MM €) decided to join economical and technical efforts to solve this shortcoming, installing a testing facility to compare effectiveness of different building materials and HVAC systems on a real scale.

This facility, the so-called DEMOPARK, was finally agreed to be located in Madrid (Spain), where temperature spectrum is wide enough over the year (120°F interval from minimum to maximum values). With a total area of 1200 m^2, DEMOPARK covers all possible needs of such a facility. Each testing room counts on its own monitoring system and allows coping with any particular sensor distribution fitting with specific demonstration needs. The real hearts of the monitoring system are the data logger devices, programmed to ask the sensor net for physical parameters periodically. Once data from each sensor is scanned by the data logger, it is transmitted to the Data Acquisition Centre using a local area network. There, data is filtered, stored and statistically treated under specific quality controls. The whole process can be double-checked using a special protocol that allows to take over the system and to analyze data on real time from any location worldwide.

Testing rooms are built ad-hoc following researchers guidelines, which define design and geometry inputs depending on the nature of the project and building material developed. To produce reliable results, the scaled down buildings have to count on the same amount of mass per square meter than the ones of real size. With this rule in mind, almost any design is possible, making the DEMOPARK a good scenario to pre-test avant-garde materials designs.

Just before a new building is placed, a computer simulation

is carried out to minimize shadowing effects from adjacent constructions, thus maximizing solar irradiance over the structure during the whole year.

Construction process ends up when infrared scanning is used to find possible undesired anomalies. Normally, when one building is erected, researchers design another identical one to serve as a reference for comparison. This twin structure is not designed with the new materials to be characterized, but with the commercial ones to beat. The tandem coexists during the whole testing procedure, being the real core of the comparison strategy.

Regarding physical characterization, thermal tests are varied depending on each specific project. Commonly, it is focused on the study of the temperature profiles and the heat fluxes throughout facades, walls, roofs and other constructive elements as windows and doors in order to create a comprehensive map of the building thermodynamic behaviour. Thereafter a statistical analysis over these variables is conducted; the results give rise to in-situ measurements of crucial physical parameters such as thermal resistivity and thermal conductivity, thermal inertia diagrams and averaged internal temperature and humidity profiles. Tests are complemented with HVACs systems working in summer or winter regimes, looking for differences in the energy consumption and CO_2 emissions.

To back up the results, the DEMOPARK counts on its own weather station, with an independent pyranometer to measure global irradiance on site over the year.

Nowadays, DEMOPARK facilities are operated by the following consortia, whose members have already tested their building insulation solutions with success: COOLCOVERINGS (coatings reflecting the infrared part of the solar spectrum), NANOPCM (Phase Change Materials integrated in lightweight insulation panels) and NANOINSULATE (lightweight vacuum panels with ultra-low thermal conductivity).

DEMOPARK is foreseen to be continuously occupied by several simultaneous research activities. In the near future, additional European projects as AEROCOINS, HIPIN and NANOFOAM are expected to test their insulation elements on the site.

Apart from its technical assets, the DEMOPARK is an example of European cooperation in Research and Development issues, and symbolizes the firm compromise of its members to reach the 20-20-20 Objectives using 100% European cutting-edge technologies as a quality hallmark.

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Europe's Energy Efficiency Challenge: The Need for Market Uptake Measures

Vincent Berrutto, European Commission, Executive Agency for Competitiveness and Innovation, Energy Efficiency Unit

Energy efficiency is a 'no regrets' option for transforming the EU's energy system. In addition to its environmental benefits, it increases the competitiveness of businesses, creates jobs and often results in better living conditions. Furthermore energy efficiency responds to concerns of households about the affordability of energy and, by reducing the need for fossil fuels, it also reduces energy imports thus increasing EU's security of supply.

Still the adoption of energy efficient technologies remains low compared to their potential benefits. High cost-effective savings potential remain in all end-use sectors. A study from the Fraunhofer Institute for Systems and Innovation Research found that in 2050 the overall final energy use could be reduced by 57% compared to the baseline projection.

To increase the market penetration of energy innovations, stronger efforts are required in terms of facilitating energy policy implementation, building capacity among market actors, and mobilising finance for large-scale investments. Such efforts are often more effective when carried out jointly between countries as has been demonstrated in the Intelligent Energy Europe programme (IEE).

Since 2007 this 730 million EU funding programme has co-financed projects with the aim to offer a helping hand to private and public stakeholders willing to increase the uptake of sustainable energy solutions.

To facilitate policy implementation, the IEE programme has supported EU-wide 'Concerted Actions' whereby national bodies in charge of implementing EU legislation – e.g. the new Energy Efficiency Directive from 2012 – collaborate together to share experiences and solutions. IEE has also been supporting the definition and implementation of sustainable energy and transport policies at local and regional level; e.g. in the on-going project Cascade, front-running cities like Malmö and Stockholm in Sweden are transferring their long-standing experience to several learning cities.

To build capacity among energy stakeholders, the IEE programme is supporting the new EU Build Up Skills initiative which aims at raising energy skills in the construction sector. In an unprecedented manner, no less than 30 countries have joined in and developed national roadmaps for the continuing education and training of their craftsmen and other on-site workers. Complementary actions have also been launched in IEE to engage and empower final users. In the project PremiumLight for instance citizens have been guided in the purchase and operation of energy efficient lighting, including LED.

To mobilise funding, IEE is offering project development assistance to public authorities to help them access funding for major energy efficiency investments such as the renovation of large building stocks or the installation of innovative street lighting. IEE is also fostering the use of energy performance contracts whereby public bodies short of capital can rely on energy service companies to pay for the energy efficiency improvements in exchange for part of the savings. In the project Transparense for instance, partners raise trust in the market by creating European and national codes of conduct for energy services companies and their clients.

These are only a few examples of market uptake activities initiated with support from the IEE programme. Since 2007, nearly 350 multinational projects in 32 countries have received funding.

An independent evaluation carried out in 2011 found that these projects have been relevant and useful as they respond to the evolving needs, problems and barriers related to sustainable energy issues that Europe is facing.

From 2014, continuation of these activities is foreseen under the new Horizon 2020 programme for research and innovation. Energy research and market uptake activities will be addressed in a more integrated manner notably under the so-called Societal Challenge on Secure, Clean and Efficient Energy which will contribute to achieve the energy policy targets set by Member States for 2020, as well as the longer-term objective of reducing greenhouse emissions by more than 80% by 2050.

The NEWLED project

The NEWLED project ("Nanostructured Efficient White LEDs based on short-period superlattices and quantum dots") aims at the development of highly efficient white light-emitting diodes (LEDs) with roughly twice the efficiency compared to current LED light bulbs. Widespread adoption of such high efficiency LEDs would allow for significant reduction of global energy consumption by approximately 10% and of CO2 emission by up to 3bn tones.

The project, which brings together 7 academic and 7 industrial partners from all over Europe and Russia, and which is led by University of Dundee, UK, is targeting white LEDs with overall efficiency of 50-60%, with luminous efficacy of 200 lm/W as well as a high colour rendering index (CRI) higher than 90.

These challenging goals are tackled by examining the entire LED fabrication process chain, from the growth of the LED structures, device processing, packaging, light and heat management and colour mixing. New knowledge on the control of semiconductor properties and on the physics of growth and device operation, down to atomistic level, will be produced and used to guide process development and optimization. The examination of all processing stages will also allow to avoid compromising the achievements of the overall process and to ensure significant system and operating cost reduction.

The high efficiencies are planned to be achieved by eliminating the power losses due to phosphor conversion in blue GaN LED pumped devices and by overcoming the "green-gap", enhancing the efficiency of both green InGaN/GaN and of yellow InGaAlP/AlGaAs LEDs. Quantum dot based and bandgap-engineered superlattice designs will be used for this purpose. High CRI will be reached by enhanced colour mixing approaches. Advanced packaging will allow for efficient heat dissipation and improved light management.

The NEWLED project is funded with €11.8 million by the EU's FP7 Seventh Framework Programme and will run until end of October 2016. The participants are, besides project leader University of Dundee: Università Degli Studi Di Roma "Tor Vergata", Italy; Technische Universität Berlin, VI Systems and Osram Opto Semiconductors GmbH, Germany; Top-Gan, Poland; CNRS, France; M-Squared Lasers Ltd, Compound Semiconductor Technologies Global Ltd and Lux-TSI Ltd, UK; Vilnius University, Lithuania; IOFFE Physico-Technical Institute of the Russian Academy of Sciences, Russia; and the Optoelectronics Research Centre of Tampere, Finland.

Fig1: Highly efficient white light emission can be achieved by combination of high efficiency red, green and blue LEDs.

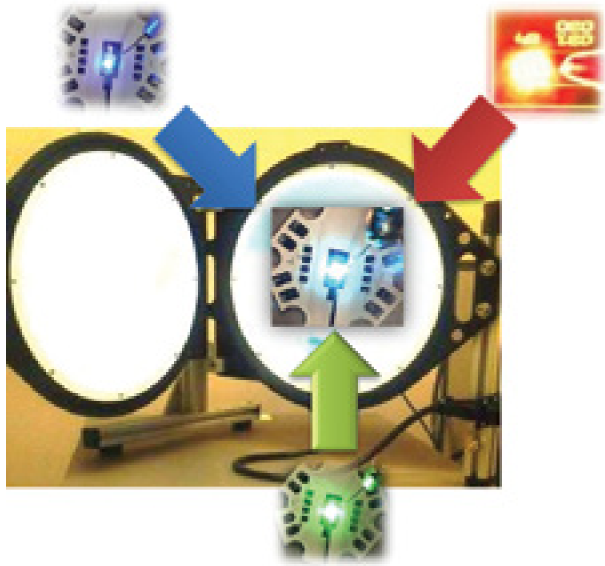
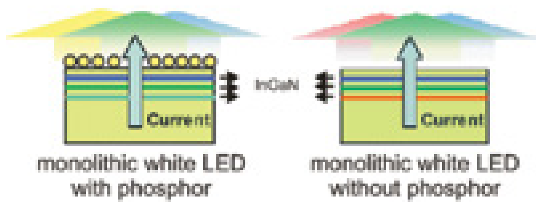


Fig2: Phosphor based white light emission relies on partial down-conversion from blue to yellow light by a Phosphor (left panel, yellow circles), accompanied by energy loss. Phosphor-free approach (right panel) eliminates this loss.



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LEDs: Artificial made Natural

"We burn daylight" - William Shakespeare

By Mike Edmund

Summer or winter; twilight or noonday sun: artist, scientist or office worker, the quality of light has always affected our moods. Ritter Joseph von Fraunhofer, discoverer of the eponymous dark lines in the solar spectrum, unlocked much of its science. In Arles, Vincent van Gogh was greatly influenced by its natural qualities; while research in America in the 1920s investigated the impact of varying light levels in the work environment. In the study, researchers varied the lighting in the area in which a group of women worked, measured their productivity and compared it with that of a control group whose lighting was left unchanged. As the lighting level was increased, so productivity increased. Interestingly, productivity also increased when the light level was reduced. Rather inconveniently, however, the productivity of the control group responded in the same way as that of the experimental group, an observation that eventually led the researchers to conclude that lighting had no particular effect upon productivity. Rather, it appeared to not have been affected by the changes in the light level, but by the fact that it had changed; and, of course, by the fact that the workers knew they were being monitored. This phenomenon is known as the Hawthorne Effect, after the factory in which the study took place.

More recently, and prompted by observations by the American Society of Interior Designers (ASID) that two thirds of employees "complain about the light in their offices"; and by a Silicon Valley study that found 79% of VDT users wanted "better lighting", a team from Cornell University led by Professor Alan Hedge compared a parabolic downlighting system with a lensed indirect uplighting system on the 'visual comfort, satisfaction, health or productivity of computer workers'. The Cornell research went to great lengths to avoid confounding of the results by the Hawthorne effect. It found that when parabolic lighting was used, work-related health complaints (specifically, tired eyes and focusing difficulties) were more common, and work function (workspace glare, screen glare and office light levels) was substantially worse. Office workers commonly made adjustments to the parabolic lighting (usually in the form of makeshift paper shades) but not to the lensed lighting.

Hawthorne or not, workplace lighting conditions do seem to matter after all, which provided the illumination for a collaboration between researchers at the Fraunhofer Institute for Industrial Engineering IAO; and LEiDs GmbH. In a novel approach, they have used the unique properties of LEDs to simulate natural lighting. It is made up of 50cm by 50cm tiles, each incorporating 288 LEDs mounted on a board that is attached to the ceiling. A combination of red, blue, green and white LEDs can reproduce the full light spectrum, while a diffuser film ensures homogenous illumination by ensuring that individual LEDs are not perceived as separate points of light. Another key element in this illusion is how light changes as clouds move across the sky. LEDs allow this dynamic situation to be simulated in a way that is not directly obvious to the naked eye, so people are not distracted from their work. Light levels still fluctuate enough, according to Fraunhofer, to promote concentration and heighten alertness; and preliminary results indicate that users find this dynamic lighting extremely pleasant to work in. Ten volunteers carried out their daily work over the course of four days. Throughout the first day, the level of illumination was constant. On the second day, it fluctuated gently, and on the third more rapidly. On the fourth day, participants could choose which type of lighting they wanted: 80 percent opted for the fast, dynamic lighting cycle. In short, the science behind modern LED lighting can convey the impression of being outdoors, when indoors.

In 1872, Claude Monet depicted the port of Le Havre in a painting he called "Impression, soleil levant". In his attempt to mock the work as little more than an unfinished sketch, critic Louis Leroy unwittingly gave this new movement the name Impressionism, now widely associated with the interpretation of light. In later life, Monet suffered from cataracts, which may have been responsible for the reddish tone of some of his paintings. In 1923, these were removed and he subsequently repainted some of his works with bluer water lilies than before. Perhaps even Monet had cause to see his first impressions in a different light. ●

LED
Simply a new dressing gown?

Innovation in the lighting industry has always been driven by the development of new light sources. So it might be interesting to look back in history to gain some insights about the technology adaptation.

When Mr. Edison developed the first incandescent bulb, it took years if not decades to change the luminaire design; the first luminaires to house an incandescent lamp looked exactly the same like the old gas-mantle lanterns.

Later, with the development of the fluorescent tube, the luminaire designs had to change; the tube was the first longitudinal lamp which needed another form factor. In the later phase of the fluorescent lamp other shapes were developed: the compact fluorescent lamp, the energy saving lamp with integrated ballast and round versions in different diameters.

So the new light source LED now meets a variety of existing luminaire archetypes in different shapes – and guess what happens: LEDs are – once again – integrated in old design luminaires.

Even retrofit LED lamps are offered – both for incandescent and fluorescent lamps, in round and tubular shapes.

This does not come as a surprise – the lighting industry is used to treat the lamp as a consumable wear part which has a much shorter lifetime than the luminaire itself. The lamp always had to be easily replaceable; lamp replacement is part of the lifecycle maintenance of each and every lighting installation.

In the old days this even made sense from an economic point of view: The expensive luminaire stayed in place, the cheap light source was replaced.

BUT NOW THINGS ARE CHANGING:

Imagine a typical residential luminaire, maybe with a lamp shade made out of tissue paper, to house a simple Edison socket originally designed for an incandescent bulb. In a “modern” installation this lamp might be dimmed by means of a simple dimmer on the wall. The production / material costs of the luminaire are significantly below an Euro, it already stayed in place for a couple of years.

Now the incandescent lamp brakes, the sale of incandescent bulbs is banned, and the people integrate an LED retrofit bulb into this old luminaire. New high-tech for umpteen Euros in old low-tech for a few cents. Suddenly the wall dimmer does no longer work because the electrical load is much to small and the customer gets angry about the huge investment he was forced to take which in the end does not work properly. He will try to get his old incandescent lamp again. Lighting is not always a very rational business.

Unfortunately lighting is not fashionable, is not trendy, is not in. Otherwise you would expect something to happen like Denis Diderot described it in his 1769 essay “Regrets on parting with my old dressing gown“:

Starting with the first LED retrofit bulb, the user starts to exchange everything: All other light sources, the old wall switches and dimmers, the old luminaires. And he will end up with a new, modern lighting system, with wireless control, nicely designed luminaires which not only gives his home a new and fresh look but also saves a lot of electrical energy: Enhanced comfort with less energy consumption.

But this will not happen, lighting is not a fashionable B2C business.

But it would be necessary to take full advantage out of the energy saving potential of the LED:

THE LED IS A COMPLETELY DIFFERENT LIGHT SOURCE FROM THE ONES WE ARE USED TO:

It generates heat – but not in form of infrared radiation which is distributed like the visible light into the room but which is to be transferred by heat transfer and dissipated by heat sinks.

The LED is a low voltage DC semiconductor element which is run on a high voltage AC supply.

The LED has a much lower power consumption than the old lighting technologies already installed; cables, dimmers, other electrical components are overdimensioned and will no longer work properly.

The LED is a long lasting light source. It's 50.000 hours nominal lifetime will only be reached after decades in normal residential usage.

The LED is a digital light source: If necessary, it can be switched off and on in milliseconds and can easily be dimmed on the right equipment.

The LED is a revolution to lighting – not an evolution.

Klaus Vamberszky

To make full advantage out of its potential it is necessary to redefine the whole lighting system.

LED lighting for energy efficiency therefore does not mean to replace the old light source by a new one – no. It means to start from scratch, develop new systems with new components.

Then – and only then – the full potential in terms of energy efficiency can be tapped.

In opposition to Denis Diderots view this is not a question of taste, of style – it is a question of technology and energy saving potential.

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Public Procurement lighting up Innovation Opportunities

Malcolm Harbour CBE MEP

Far better opportunities for businesses developing new technologies to benefit from the public sectors' enormous buying power are needed. Public procurement accounts for 19 percent of EU GDP, yet this spend is still not readily available, in particular for small and medium sized enterprises (SMEs) with high growth potential.

There is a real need for governments, the wider public sector, and Universities, to work up research and innovation programmes targeted at developing new solutions to the problems caused by growing demand, frozen budgets and shrinking energy resources.

Successful businesses, for their part, must also drive the delivery of innovative proposals for quality, efficient and modern public facilities and services. Public bodies tend to be risk averse and do not have the culture found in our most innovative enterprises. But innovation and efficiency are now desperately needed attributes for spending taxpayer's money better.

Up to now, good practice in public procurement is being stifled by complex and expensive regulations but recently agreed changes to the EU rules will cut red tape, promote efficient solutions, and help reduce environmental impacts. They will be translated into national regulations over the next two years.

The European Parliament Committee on the Internal Market and Consumer Protection, which is responsible for EU law on public procurement, had been advocating reforms since 2009 to make the procurement process more effective, more focused on innovative service delivery and the smarter procurement of goods. The committee has finally achieved this very outcome following protracted negotiations with Member States in Council. Political agreement was reached at the end of June 2013, with confirmation votes by the Council and the Parliament in the Autumn,

The new framework improves opportunities for entrepreneurs and should help to deliver more choice and better quality for citizens. Sweeping simplifications, more flexibility in applying the rules and new tools to boost innovation and new growth opportunities have been agreed. Especially welcome is a new tool to foster the creation of Innovation Partnerships which will encourage public buyers to set ambitious outcomes and work with suppliers to develop and implement new solutions.

Public bodies will now have to look at whole lifecycle costs in public procurement and consider factors other than lowest price in award criteria. Taking the example of electric lighting, the immediate savings from choosing, at the point of purchase, cheaper but more energy intensive lighting solutions, are dwarfed by the significant savings derived from the reduced energy consumption of LED lights. This is compounded by the far higher durability of LED lights, which brings down replacement and recycling costs overall.

On a lifetime cost basis, the case for new technology is clear and will clearly prove to be the most economically advantageous tender (MEAT). The same can be said for promoting photovoltaic installations to offset the costs of lighting and other electrical hardware used in public buildings. Although these costs may be recouped over a longer timeframe, with even the shortest lived public buildings lasting for at least 30 years, the 'MEAT' solution would prevail. Instruments such as the EU voluntary ECO management and audit scheme (EMAS) can help sharpen procurement cost calculations when it comes to facilities management.

The public sector has long been waiting for a change in culture to fully embrace the practice of presenting initial requirements to business, and include them in devising innovative and optimum final specifications, and this is now on course to come into play through the roll out of innovation partnership procurements.

It is imperative that public bodies now entrust innovative enterprise to come up with the answers rather than attempting to micro-manage and specify every detail in isolation, particularly now that they have a clear European legal framework to rely on.

New opportunities for suppliers with great technology must now be opening up to be able to deploy them in public applications. SMEs must now be encouraged to tender for even more public contracts, and public bodies now have a requirement to consider the way in which they might divide contracts up into lots with the advantage of widening the pool of innovative SME suppliers and specialist companies offering more efficient solutions.

This legislative reform, accompanied by new European and national schemes to support innovation in public markets, will open a new era in EU public procurement. The new rules clearly support good procurement, and should no longer be a constraint on good practice. Public markets must now open the doors to new technologies and not shelter behind outdated administrative practices.

Malcolm Harbour is a member of the ECR Grouping within the European Parliament and Chairman of the Internal Market and Consumer Protection Committee.

Lighting the way: The European lighting industry at the forefront of innovation and sustainability

By Dietmar Zembrot, President, LightingEurope (pictured)

More than 100 years after the invention of electric light, the lighting industry in Europe is undergoing unprecedented change. The shift to LED technology not only provides a highly energy efficient lighting technology, but it also enhances the possibilities lighting offers to consumers, designers and the environment.

The European lighting industry has always been at the forefront of innovation. Still today Europe is the leading region when it comes to technological development and scientific research related to light in its different applications. For example, the lighting industry is also driving renovations in the European building sector and requiring a highly skilled labor force for this growth.

LightingEurope represents 17 national lighting associations and currently 14 lighting companies. The sector is driven by high innovation potential, accounts for an estimated €20 billion turnover, and represents over 100,000 jobs in Europe. The lighting industry in Europe is and always has been a sector that is SME driven when it comes to the production of luminaires and of high value products. This SME culture within the industry is the most crucial precondition to provide the market with highly decorative, innovative, and sustainable products.

A FIRM CONTRIBUTOR TO ACHIEVE ENERGY EFFICIENCY IN EUROPE

Lighting accounts for approximately 14% of the electrical energy used in Europe and 19% globally. Significant improvements on the energy performance of lighting have been achieved already, as light sources are now fully regulated by the European Ecodesign legislation, setting minimum performance requirements for all product groups.

The European policy concept of phasing out inefficient lighting products has proven to be successful. In 2011 the European lighting industry sold for the first time more energy efficient products than less efficient products – this is a clear success of European legislation in the field of Ecodesign and a role model for other sectors that a shift towards more energy efficient products is possible.

Next to such legislative measures, it is necessary to increase initiatives that aim at stimulating the market for energy efficient products, systems, and services. As reported in the 2011 McKinsey & Company report, Lighting the Way: Perspectives on the global lighting market, the investment

LIGHTINGEUROPE
THE VOICE OF THE LIGHTING INDUSTRY

in energy efficiency is much more effective and efficient than an investment in renewable energies. The European lighting industry is convinced that predominately Green Public Procurement as well as adequate financial incentives for building renovation has a key role in concretely implementing energy efficiency in Europe.

THINKING BEYOND – NEW APPROACHES TOWARDS LIGHT

It would be an injustice to overlook the highly innovative approach lighting can offer society if it is only viewed from an energy efficiency perspective. Given the socio-economic challenges Europe is already facing, and will increasingly face in the future, it is critical to foster a policy of phasing in new and innovative products, systems, and services to the European lighting market.

Europe is facing a challenge regarding its future demographic development as becomes an ageing society. The impact of this development is noticeable today and requires courageous, tangible and implementable policy measures. Albeit possibly not visible on first sight, the European lighting industry has the potential and expertise to accompany political initiatives that are to be taken to cope with these challenges and translate them into opportunities.

Recent research has proven that the non-visual spectrum of artificial light has a positive impact on human health and well-being and can influence the human circadian rhythm. For example, initial data shows positive improvements for elderly persons with dementia who receive customized light solutions in their nursing homes. With an ageing society in our future, the potential impact of this cannot be underestimated. More research in this area is needed to fully understand this subject and to build a thorough scientific basis in order to enable the European industry to enhance its role as technical leader in a global environment in this field.

FROM PRODUCTS TO SYSTEMS – SMART LIGHTING FOR OUR SOCIETY

As pointed out above, the new LED technology will change not only the perception towards light but it is fundamentally changing the lighting industry. Mere production of lighting products will not enhance the competitiveness of the industry. The European lighting industry is taking up this challenge and provides the market with integrated systems and services. Intelligent lighting systems will not only reduce energy consumption by another 40% but will also allow for the integration of lighting in smart buildings. Intelligent systems also require an experienced labor force which can contribute to European job growth.

Besides legislative measures that set minimum performance criteria for lighting systems it is important to foster additional research related to intelligent lighting systems. This will ensure that the European lighting industry maintains its leading role during the next phase of the switch to LED lighting: the digitalization of light.

Moreover, it is necessary to foster market information and market surveillance in order to enable customers to make an informed purchasing choice and to accelerate the take-up of high quality products, systems, and services in the European market.

The lighting industry in Europe is at the forefront of innovation and is looking forward to continuing the successful co-operation with all stakeholders to maintain Europe as a light house when it comes to energy efficient and high quality lighting in all applications.

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Interchangeable LED light sources enhance the adoption of LED lighting technology

Tim Whitaker, Zhaga Consortium

For most people, replacing a light-bulb is a straightforward task that usually involves waiting until the lamp stops working. It is then replaced with a new one that fits into the socket, and (hopefully) produces the same lighting effect. As new lighting technologies such as LEDs have entered the market, it has been necessary in Europe to introduce labels that explain to consumers the performance of the product. This allows the buyer to purchase an LED lamp that is broadly similar to the older incandescent lamp they want to replace (but can no longer buy in many cases, due to European energy-efficiency regulations).

In the scenario just described, the older lamp and the new LED lamp are interchangeable in the sense that they both fit into the available socket. They may have roughly the same performance, but they are not exactly equivalent. And the old lamp is easily replaceable with the new one, since the socket provided is inherently easy to use.

All these terms – interchangeable, equivalent, replaceable – are important when considering other types of LED light sources. LED retrofit lamps fit into existing sockets and look like existing lamps, but the lamp-socket combination is not the best design to take advantage of the main benefits of LEDs, such as long lifetime and high energy-efficiency.

OPTIMIZED LED LIGHT-SOURCE DESIGN

Although they are efficient, LEDs still produce waste heat. If the heat is not removed, the LEDs themselves get hot, with disastrous results; the light output drops, and the lifetime can be severely affected. Removing the heat through a light-bulb base and socket is not easy. Many LED lamps have unusual designs that include fins and other features to keep the LEDs cool.

The optimum approach is a design that ensures efficient removal of heat. This involves mounting the LEDs onto a structure that conducts heat away, using passive or active heat-sinking where appropriate. Some LED luminaire (lighting fixture) manufacturers mount LEDs directly into their fixture, while an increasingly common approach is to use building blocks that are commonly termed LED modules or LED light engines.

Definitions vary, but usually an LED module is a unit containing one or more LEDs together with a board and other components. An LED light engine includes both the LED module(s) and the LED driver, or electronic control gear, which provides the required current.

INTERCHANGEABLE LED LIGHT SOURCES

Rather than designing a fixture around a custom-built LED light engine, it can be beneficial to the luminaire maker to use a building-block product that is interchangeable with other products from different suppliers. Let's explore what interchangeable means. Two LED light engines are said to be interchangeable if one can be used instead of the other without any change in the design of the luminaire.

To achieve interchangeability, the luminaire must "know" what to expect from an LED light engine. As with lamps, this includes the mechanical dimensions and method of fixation (which could involve a socket of some kind, or screws at fixed positions). But with LED light engines, many other factors also need to be considered, such as the amount of heat generated by the LED light engine as well as the maximum operating temperature; the location and size of the light-emitting surface, in relation to the luminaire's reflector; the distribution, uniformity, and other photometric properties of the light emitted by the LED light engine; and the electrical characteristics.

SETTING STANDARDS

For component suppliers to offer interchangeable LED light sources, there has to be some form of standardization in the industry. The Zhaga Consortium, a group of companies from throughout the international lighting community, is focused on this issue. Zhaga is developing specifications that define various interfaces – mechanical, thermal, photometric, electrical and control – between an LED light engine and an LED luminaire.

It's important to note that "interchangeable" doesn't mean "equivalent". Zhaga doesn't define performance characteristics, leaving companies to use innovative technology inside the LED module, and innovative design for the luminaire. Also, "interchangeable" doesn't mean "replaceable" – some Zhaga-compatible modules have sockets and are easily replaceable by the user, some have to be returned to the factory to be exchanged, and some luminaire designs do not allow replacement at all.

Standardized, interchangeable products should promote the adoption of LED lighting technology, giving luminaire makers a choice of suppliers. R&D costs can be reduced because the luminaire maker does not have to redesign the luminaire each time a different LED module is used. For the end customer, Zhaga-based products bring reduced risk and peace of mind with the knowledge that compatible components will be available in the future, if luminaires need to be repaired or upgraded. ●

Author
Tim Whitaker is Marketing Communications Director for the Zhaga Consortium (www.zhagastandard.org).

Philips Lighting has supplied LED fixtures to the Rijksmuseum in Amsterdam, the Netherlands. The use of Zhaga-compliant modules was important, as it ensures the customer is not reliant on a single supplier of components if future upgrades or replacements are necessary.

Solid-State Lighting Considerations

Siegfried Luger, Founder and CEO of Luger Resarch - Institute for Innovation & Technology, summarizes some important results in the lighting area out of research studies and explains the importance of and method for technology forecasts. Trends of Engineering System Evolutions (TESE) are suitable for predicting future product generations and for extracting the winning technology approaches for lighting strategies.

The demand for energy efficiency across all sectors of our society is growing. Overall, lighting accounts for approximately 19% of the worldwide electricity consumption which can be reduced with the use of LED and OLED light sources. It isn't only the general lighting market that is being fundamentally changed by Solid State Lighting technologies; it's the whole lighting industry. Predictions for the next five to seven years are that we'll see more LED/ OLED performance increases along with continuous price declines. For example, state-of-the-art white LEDs have already reached 30-50% efficiency, have luminous efficacies of 100-150 lumen/Watt (lm/W) and a color rendering index (CRI) of 80. Target values for warm white LEDs in the next 10 years are: 50-60% efficiency, more than 200 lm/W efficacy and a CRI of over 90. State-of-the-art OLED products are around 50 lm/W today. While their efficacy is expected to always stay below that of LEDs, the added value of OLED technology will come from its size, flexibility and opportunities for new applications. But a lack of information and awareness about the availability and performance of energy efficient lighting can hinder the implementation of energy efficient lighting programs around the world.

The EU green paper stated that in 2010, total market revenues of general lighting worldwide were around 52 billion Euros of which close to 30% was spent in Europe. By 2020, the world market is projected to reach 88 billion Euros with Europe's share decreasing to less than 25%. Current market penetration of SSL in Europe is very low: the LED market share (in value) reached 6.2% in 2010. Several studies predict that SSL will account for more than 70% of Europe's general lighting market by 2020. Europe's lighting industry has a clear role to play in the transition to SSL. It is large and world-class, and is ready to build upon its strengths in conventional lighting in order to capitalise on this emerging technology. However, European SSL market uptake is slow and SSL related research, innovation and cooperation activities are fragmented. In contrast, in other regions of the world, especially Asia and the USA, the lighting industry is moving ahead quickly, with the help of significant government support. Regulations to support more efficient forms of lighting has increased and became a global theme with the rapid move to LEDs. In post Fukushima Japan we have the most impressive example with 50% of down lights sold in 2012 being LED based. Japan and China are leading the transition to LED lighting.

First studies on the full life-cycle impacts of LED lighting compared to other lighting technologies have already been carried out. The full life-cycle impacts need to be further monitored as LED technology evolves. In the future, SSL applications may be widely deployed beyond the mere replacement of existing lighting systems. In the long run, this could reduce the expected energy savings, known as the rebound effect. Experts from Sandia National Laboratories published a study in the "Journal of Physics D: Applied Physics" that energy consumption will increase even with the use of energy efficient LED and OLED technology due to the fact that the better the artificial lighting is, the more it's used in general. Mr. Tsao, head of the research project, stated, that the annual costs for lighting stayed constant at 0.72 percent of the GDP over years. Artificial lighting and prosperity are closely connected and more light would make sense because today's brightness levels for indoor applications just reach about 1/10 of that of a cloudy day. Not to forget the demands for lighting in developing and emerging countries. Researchers expect that light consumption will increase by the factor of 10 within the next 20 years, doubling energy consumption. Their simulation model included the global economic output, the energy prices and the efficiencies

of lamps. The study showed that the overall required energy for lighting will only decline if the electricity prices are tripled. However, LED technology may help to overcome the loss in human productivity based on more and better lighting.

Another research study, founded by the Austrian government investigated the energy efficiency of shop lighting. The researchers from e7, items Innovation and Technology Management and Luger Research found out that a 1:1 replacement of conventional lamps with LED lamps is far too little. The great potentials of LED lighting systems (up to 50%) can only be achieved when the lighting systems are adapted to the needs of the respective applications and in combination with the use of intelligent control modes with dimmable lighting systems. Two shop applications from a petrol company and a textile chain store were investigated under real planning conditions.

Nevertheless, the challenges of phasing out old, traditional lighting technologies and ramping up new technologies are huge. The upstream market (LED light sources, etc.) has been characterized by overcapacity and falling operating margins in 2011/2012 with a cyclical recovery in 2013 underway. Many upstream players, both traditional and newcomers, made moves into downstream (luminaries, etc.) with an aim to escape the eventual commoditization and standardization of a large part of the upstream market. Philips started this move and built the most comprehensive downstream offering in the industry. However, it is still unclear to what degree a downstream expansion strategy will be successful or needed for upstream players. The LED industry is rather fragmented. It is usually divided into five segments: materials, equipment, finished lamps and components, luminaires and systems, and finally lighting services and solutions. In the medium and long run, the latter is expected to become important as consumers could be provided with lighting services instead of lamps and fixtures.

We also see another new important situation on the lighting market. The "merging" lighting with the fast and innovative semiconductor industry requires new processes, structures, partners, alliances and a new understanding of the lighting sector itself. Restructuring the lighting business to enable potentials for new, environmentally friendly lighting is required to make a substantial contribution to the world's energy situation. Deployment of smart lighting is of interest to building owners, governments, utilities, and many other stakeholders as it can help to further reduce energy consumption. Controls can allow perceived light quality to match lighting codes precisely and allow LEDs to be powered at lower current levels, extending their lifespan, as dimming an LED makes it run cooler, which in turn makes it more efficient and reduces depreciation.

New and enhanced technologies are still the major innovation drivers in semiconductor lighting. Technologies are being increasingly merged on a sub-system level while diverse industries are intensifying their collaborations. But the key question remains: "What will the winning approaches be in the years to come"?

The "Trends of Engineering System Evolutions" (TESE), which are derived from the studies of Mr. Genrich Altshuller, the founder of TRIZ, are common valid trends for engineering systems and therefore also applicable to LED & OLED lighting technologies (see Figure 1). Engineering Systems are evolving by adding useful functions, reducing or eliminating harmful functions and by reducing costs. This increased idealism is obtained through the "Transition to the Supersystem" (e.g. Multi-chip arrays, remote phosphors, central control and supply units, etc., "Increasing Degree of Trimming" (e.g. Driverless systems, single-stage converters, zero-binning, etc.), "Optimization of Flows" (e.g. Heat-spreader, analogue dimming techniques, etc.), "Increasing the Degree of Completeness (e.g. Digitalization of control units, etc.), "Elimination of Human Involvement" (e.g. Self-adjusting systems, self-calibrating systems, etc.), "Increasing Coordination" (e.g. Form factors, white colored PCBs, nano- and microstructured chip surfaces, etc.), "Increasing Controllability" (e.g. externally controlled / updatable systems, self-systems, etc.), "Increasing Dynamization" (e.g. OLEDs or LEDs with flexible substrates, resonant mode control, wireless control, etc.). There are still fundamental developments on all system levels and in every single trend recognisable, knowing that LED lighting systems are still in an early development phase, stage 2 of the life-time S-curve.

The TESEs, representing the technology trends, derived intellectual properties, R&D networks and market/business potentials altogether create the building blocks for new lighting strategies. Years ago, Siemens started the "Picture of the Future" approach to forecast new product generations. The basic idea is to combine and align future market opportunities with technology trends for the future, creating a new picture of the world. One part of this approach is the extrapolation of technology trends known as TESEs. The better we can forecast the technology developments, the better we can imagine new and future products.

THE EU REPORT "ACCELERATING DEPLOYMENT SSL REPORT" HIGHLIGHTS THE FOLLOWING, ONGOING R&D EFFORTS:

- Developing LEDs and OLEDs with higher efficacy, and higher lumen output at different colour temperatures.

- Development of cost-effective lamps which can replace incandescent and CFL lamps. There are some LED lamps replacing the 60 W incandescent bulbs available from €10 - €20, but products delivering the same quantity of light, such as the Philips Ambient LED, are available on the European market at around €40-€60.

- Better cooling with passive methods and improved low-cost heat sinks. Novel methods include an ioniser, where a mesh of wires near the LED chip creates an electric field with a small electric charge. The ions create a breeze, which in turn eliminates heat. Another approach uses a tiny device that creates a vortex of wind near the chip to dissipate heat.

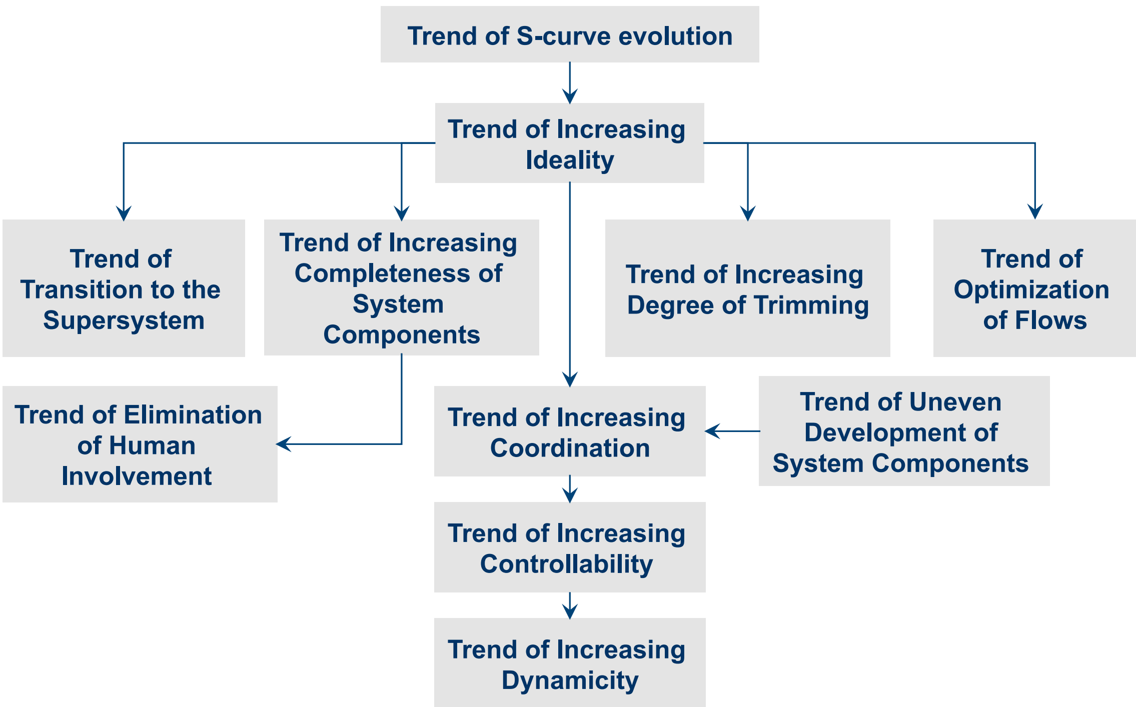
- Quantum Dot LEDs: In recent experiments, LEDs emitting blue light were coated with quantum dots. These dots glow in response to the blue light of the LED, resulting in a warm yellow light similar to that of incandescent lamps. Quantum dots have unique properties which enable them to create almost any colour on the visible spectrum. This increases the possibilities of

LED use in display screens, as well as lighting.

- Development of high efficiency and long-life LED drivers.
- Development of integrated controls, which can have embedded sensors for intelligent control.
- Development of lamps without DC converters for better efficiency, as well as to decrease costs and weight.

One event which focuses precisely on LED and OLED lighting technologies is the annual, international LED professional Symposium +Expo in Bregenz, Austria (see www.LpS2013.com), which takes place in the Festspielhaus Bregenz on September 24th to 26th. A distinguished advisory board selects the "Winning Technologies" from the technology field every year and the highlights are presented in Bregenz. Based on lectures, workshops, tech-panels and an exhibition, visitors are able to understand the key influence factors for strategic decisions which have to be made for the coming year.

The dynamism in the field of LED and OLED lighting is huge and it's not an easy task to get a clear picture even of the near future due the complexity on all system levels. The bottom-up approach in forecasting the future developments is a valid process and it delivers fact-based results for business strategies. LED and OLED lighting is and will be the winning technology in the end, but precise predictions of available technologies are an important factor for giving the right answers - strategies for lighting.



Smart Lighting: Energy Efficient Streetlights with Comfort

By Eveliina Juntunen and Marko Jurvansuu, VTT Technical Research Centre of Finland

The first wave of energy savings in lighting is accomplished by switching traditional light sources to more efficient ones such as LEDs. Still the second wave of smart lighting is needed to reach the energy saving targets while maintaining comfortable light for the user. As public lighting accounts for 60% of typical community electricity cost, improving energy efficiency in this area contributes substantially to the European Union aim to decrease energy used for generic lighting 20% by 2020.

Smart control with light level and presence sensing has already proven to be very effective in office lighting with energy savings of 40 – 65 % demonstrated. By introducing smart light concepts, the streetlight segment could also benefit from similar levels of energy savings. In street lighting however, the "intelligence" level is still low resulting also in low energy efficiency. Current streetlights are usually turned on/off automatically either at certain time of a day or when the ambient light level reaches certain threshold. And when the streetlight is on, it is close to the full power, even when less light level would be sufficient. In addition, the streetlights are controlled in groups containing kilometers of streetlights neglecting the needs that may arise from different traffic or weather conditions that vary from one area to another.

Smart street lighting is based on adjustable luminaires, dense sensor network and of course, smart control that orchestrates the system based on the sensor information. One example of smart streetlight system that consumes significantly less energy than current lighting, while improving the lighting characteristics was developed by VTT. The LED based street light adapts to the ambient conditions with the help of sensors and wireless control, allowing them to be dimmed on the basis of natural light, environmental conditions (for example light reflected from snow) and the number of pedestrians. All these functions are realized with commercially available components. For the user comfort, several

characteristics important to pedestrians, such as the amount of light and the shape of the light beam, were considered in the luminaire design. With lighting levels adjusted according to the number of pedestrians or to natural lighting conditions, energy savings of 40 – 60 % was observed. In addition, pilot installation on a pedestrian road revealed that on average the users experienced the developed streetlight to be more comfortable when compared with current commercial luminaires.

"Smart Lighting is about intelligent lighting systems and design with a strong focus on safety & security, health & wellness, lighting becoming emphatic and intuitive, controlling & managing energy efficiency and the ambient environment." says Carlos Lee, Director General at EPIC – European Photonics Industry Consortium.

The focus needs to be on future and strategic business developments in intelligent solid state lighting, enabled by and in addition to the emergence of HB-LED and OLED technology. Of great importance is the impact of networked ICT solutions and systems on the further enhancement of efficiency and management of smart lighting systems and solutions. The enabling technologies photonics & electronics will benefit the further development of smart lighting applications in the future. From a business perspective there is an opportunity to move from a product-based approach (which has been the usual business model in traditional lighting) to a service-based approach, where the offer is centered not so much on the product but on quality, safety and experience. ●

Carlos Lee, Director General, EPIC

New energies in road transport at the heart of Horizon 2020

Frederic Sgarbi, Directorate-General for Research, Head of Automotive Innovative Systems, European Commission

The European Green Cars Initiative (EGCI) is a research and innovation measure, which was included in the European Economy Recovery Plan adopted in November 2008.

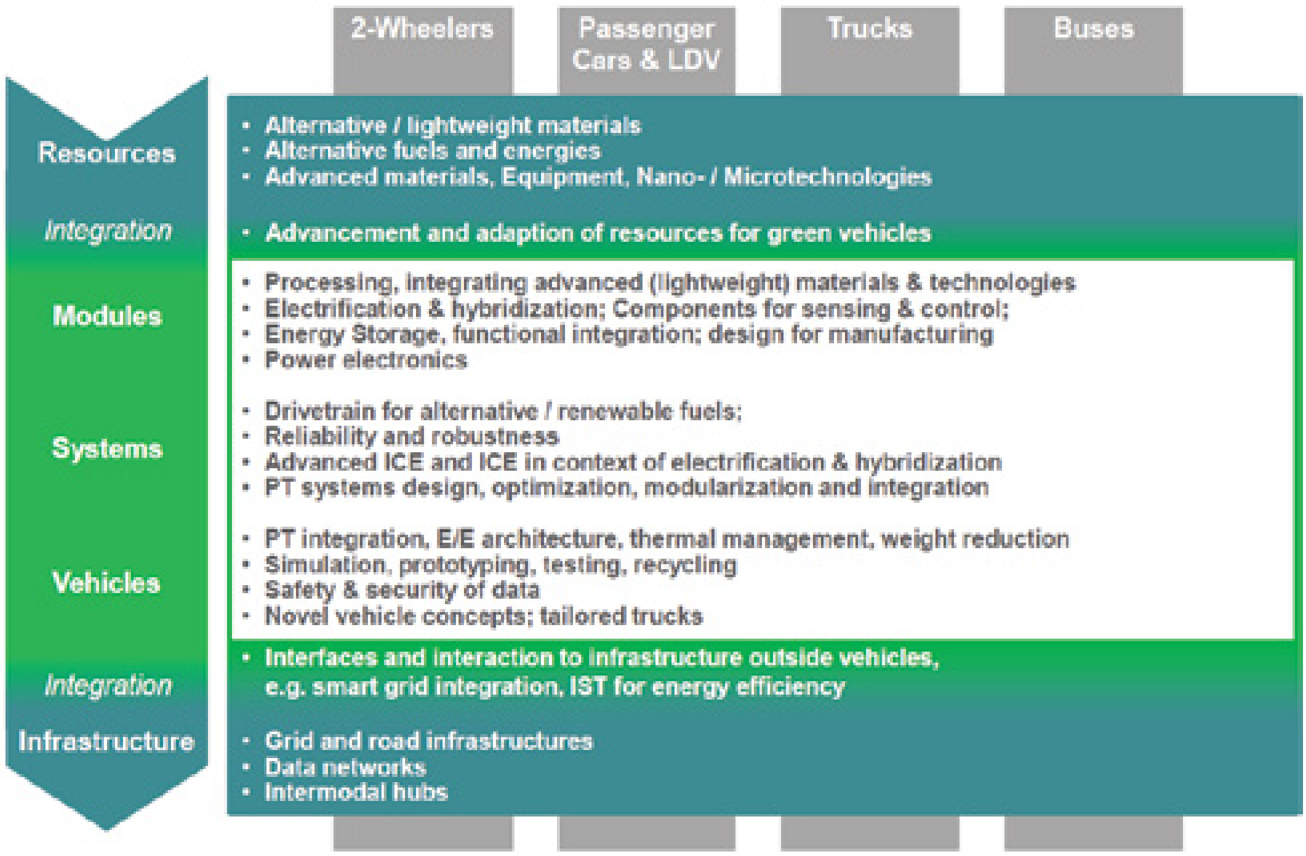
Along with two additional research and innovation measures, the EGCI is a so-called Public Private Partnership (PPP) with a total budget amounting to €1 billion to develop new technologies for the greening of road transportation. It includes all kinds of vehicles: two wheelers, passenger cars, bearers, vans and trucks for long distance haulage.

The main target retained for the EGCI has been to contribute to improving the energy efficiency of road transport operation with a double effect on decreasing CO_2 emissions and therefore mitigating global warming on the one hand and securing energy availability through rationalisation and diversification of energy sources.

Although three major research pillars were identified, 1) long distance road haulage represents 50% CO_2 emissions in road transport, 2) electrification of road and surface transport and 3) logistics and co-modality, electrification represents more than 50% of research efforts within the PPP.

The EGCI has set up a steering committee called the "EGCI ad-hoc Industrial Advisory Group" to define and prioritise technological research topics that are included in the 7th Framework Programme annual calls. This group is composed of representatives of major European industries (Volkswagen, Renault, Volvo, Siemens, Bosch, Valeo, etc.). Industries have developed several road-maps for research and innovation, in particular a multi-annual road map and a long-term strategy for road and urban transport electrification.

The electrification roadmap foresees mass production of



Examples of technology content of the PPP EGVI electric cars in 2018-20. For passenger cars two technology paths are considered which can be expected to develop at comparable pace: Plug-In Hybrid Cars and Full Electric Cars.

Last call for proposals financing projects within the EGCI has been concluded at the beginning of 2013 and all successful projects have already been initiated. The overall contribution of the initiative to electro-mobility can be figured out: in total 91 projects on electro-mobility were financed representing a total European financial support of €350 million. The main research areas supported were: Integration of the electric components within the vehicle (25 projects), Integration in the transport system, particularly new business models (15 projects), drive train technologies including both electric engines and down sized internal combustion engines (13 projects), grid integration (9 projects) ad electric energy storage systems (25 projects).

The concerned road transport industries together with the Commission Services have been reflecting on a successor of the EGCI for Horizon 2020. Industries have developed a concept paper and views from stakeholders were gathered through a stakeholders' consultation that ended in September 2012. There is consensus among stakeholders that the new PPP should be called the "European Green Vehicles Initiative" in order to broaden its scope to all types of road transport vehicles (passenger cars, trucks, vans, buses, two-wheelers and light urban vehicles). The main objective will still be energy efficiency but the emphasis on electro-mobility has been extended to all forms of alternative energies, be them renewable and fossil hydrocarbon energies such as natural gas.

The figure illustrates the technologies addressed within the initiative. The scope of the EGVI includes all layers from the use of generic technologies and external resources until the interface with the infrastructures.

By external resources it is meant the results from generic technological research such as new materials, alternative energies and micro-nanotechnologies. These developments are not within the scope of the EGVI, however their adaptation for their use in road transport will be included. The same applies to transport infrastructures, such as pavements and refuelling/recharging infrastructure: only their interfaces with the road vehicles are within the scope.

PROJECT EXAMPLES:
SMARTOP: SELF POWERED VEHICLE ROOF FOR ON-BOARD COMFORT AND ENERGY SAVING

The main objective of the project is the development of a smart roof equipped with energy harvesting/storage
sub-systems to drive autonomously integrated comfort auxiliaries such as innovative thermoelectric distributed microclimate control, compact LEDs ambient lighting and electro-chromic solar radiation control glazing.

System and sub-components specifications and a comprehensive design of overall architecture and subsystems have been provided taking into account the target vehicle design and its constrains. SMARTOP roof frame and components have been designed and tools to integrate and fix the roof on the IVECO Daily have been identified.

Subsystems such as solar roof, battery packs, power management packs and climatic units have been designed to match geometrical constrains and subsystem specifications and components fabrication and integration procedures have been identified.

HIWI: MATERIALS AND DRIVES FOR HIGH & WIDE EFFICIENCY ELECTRIC POWERTRAINS

At present, motors for FEV (Fully Electric Vehicle) and HEV (Hybrid Electric Vehicle) applications develop their highest efficiency of around 93~95% within a speed range of typically 1/4 to 1/3 of the maximum rotating speed, and at an ideal torque, whereas in real usage - in the majority of driving cycles - the motor operates at a wider range of speeds and at partial load (low torque) resulting in much lower efficiency. HI-WI will address the mismatch between the region of HIGH efficiency and the WIDE region of frequent operation with advances in the design and manufacture of motors. HI-WI will couple its novel design approach to breakthroughs in materials and manufacturing, winning size, weight, and cost savings. The three-year HI-WI project will deliver prototyping and demonstration of innovative motors; new approaches to the holistic design of motors nano-scale materials advances to create magnets with reduced rare-earth content; micro/nano-scale manufacturing advances to create permanent magnets and integrated assemblies.

Charging 2.0

Intelligent load management is the future. This form of e-vehicle recharging not only allows the simultaneous supply of power to a complete vehicle fleet using favourably priced electricity, but also permits the charging of every single plug-in electric vehicle (PEV) according to an individual strategy. KEBA provides the load management system KeContact, a system solution consisting of charging stations (also known as wallboxes) and a central control unit.

Over 90 per cent of all charging procedures will in future be completed at home or at work. Therefore the creation of a full coverage e-charging station network like that for petrol is no longer the key issue. Of greater importance is the intelligent control of electricity sourcing during battery recharging. KEBA's KeContact enables the extremely comprehensive, finely tuned control of the charging process and thus efficient load management.

FULLY CHARGED IN AN HOUR

In this connection, the charging procedure should proceed quickly, be uncomplicated and comparatively cheap. This is all realized using KEBA load management. It permits rapid charging and is able to supply e-vehicles with up to 22 kWh within an hour. Consequently, even vehicles of the youngest generation can be charged fully at ten times the speed available when using a standard domestic socket.

DIFFERENT CHARGING STRATEGIES

A variety of charging strategies can be established using KeContact, which allow a PEV to be charged in an hour or over night. Moreover, several PEVs, or indeed an entire vehicle fleet, can be supplied with energy. The time for charging can also be established individually, for example during low consumption periods, or whenever there is a surplus supply of green power.

All modern e-car models, which are charged in line with ISO 15118, are able to employ the entire performance and service range of the KeContact load management system. For such cars, the control unit can provide an even more differentiated charging strategy through its linkage of the data of the vehicle, the owner or fleet management and the data of the power supplier, which is aimed at securing the most efficient and inexpensive charging procedure.

EFFICIENT LOAD MANAGEMENT

In order to avoid overloads, which as a rule constitute the most expensive electricity, KeContact limits the charge performance or shifts the charging point to a lower cost window. In coordination with the energy provider, the system automatically reduces performance peaks and smoothes electricity intake, which above all saves costs relating to volatile energy sources.

Accelerating e-Mobility!

Lambert van Nistelrooij MEP

Europe wants to move towards 20% reduction from 1990 in greenhouse gas emissions in 2020. This has to be achieved through a package of measures including in transportation. Nowadays, Member States face challenges of growth in user and energy demand and high dependency on fossil fuel sources for transport, contributing to an upward emissions trend. Electricity or e-mobility provides for an important viable solution. In the European Parliament, I support the solutions that the sector is offering. At the AutomotiveCampusNL in Helmond (the Netherlands), solutions for electric driving and fleet driving were showed. In the nearby future, I will bring colleague MEPs to this Dutch campus to convince them of the new techniques that are developed.

But still, the rate at which electric mobility develops and is taken up as a transport mode depends in part on our ability to engage and learn from initiatives and on the extent of cooperation between various stakeholders. Inefficiencies of weak coordination and dispersed, ad hoc activity mean potential has not been fulfilled. This applies within North-West Europe (NWE), individual States and also at a global level.

ENEVATE

It is in recognition of this situation, that the ENEVATE consortium was formed. ENEVATE is an Interreg IVB project with the aim to facilitate an accelerated introduction of electric mobility in Northwest Europe (NWE) through structured transnational cooperation between public authorities and business representatives. The project wants to boost innovation and competitiveness of the rapidly developing electric vehicle sector in NWE and at the same time to contribute to the urgent environmental challenge of reducing CO2 emissions. ENEVATE targets electric road vehicles, energy infrastructure, integrated mobility concepts, and demonstrates the potentials through pilot actions and enables other actors. The ENEVATE partners from 5 European countries create an exciting network with organizations from different backgrounds and different structures, working hard on the introduction of e-mobility in Europe. After nearly 3 ½ years, they are facing the most important milestone: The results of ENEVATE will be presented to decision makers, experts, policy makers from the European automotive and energy industry at the ENEVATE Final Conference on 25th and 26th September 2013 in Brussels. In this article, I will describe some key activities of ENEVATE.

1. ELECTRIC VEHICLE TECHNOLOGY

Project Partner Autocluster.NRW (Germany), together with several other partners, took a close look at today's battery electric vehicles (BEV), analysed supply chains and found out what competences and capacities might be needed

for mass production of BEV in Europe. For the BEV, ENEVATE expects most Original Equipment Manufacturer to produce engine management, integration of batteries and electric systems, thermal and battery management. Suppliers will develop and produce transmission, battery cells, power electronics, high voltage wiring and comfort, safety and infotainment components.

2. CHARGING INFRASTRUCTURE

Project Partner Future Transport Systems (United Kingdom) has been leading the development of a practical tool kit designed to help organizations and project managers develop and implement EV charging infrastructure projects and subsequently lead on to sustainable operating schemes. The tool kit includes a practical workbook. Key issues are how to plan for a realistic EV charging infrastructure, how to deliver a project, what technical issues need to be considered, how can interoperability be fostered and how to plan for sustainable operation.

3. MARKET DRIVERS AND E-MOBILITY CONCEPTS

The lead partner for this activity is Cardiff University (Wales). The objectives of this part of the ENEVATE project were to identify: impacts of the introduction of electric vehicles on user and market behavior; potential for new e-mobility concepts, and; market drivers that will influence the acceptance of the different electric vehicles mobility concepts and the conditions needed for realizing their acceptance. The results were positive for electric vehicles as respondents enjoyed their pilot experience and would be willing to consider the cars in the future, but only if two vital obstacles were overcome: cost and range.

4. ANALYSES OF EXISTING EV PILOTS IN NORTHWEST EUROPE

The overall objective, led by AutomotiveNL, is to support an accelerated implementation and development of sustainable e-mobility in North West Europe by mapping and take lesson from the wealth of existing EV pilots in NWE. During the last number of years, regional and national authorities have spent tens of millions of Euros on implementing e-mobility by means of pilot initiatives. These pilots took on many forms and included a range of different vehicle types from bikes to buses. In order to prevent stakeholders in the e-mobility industry from duplicating results and trying to solve the same problems in isolation, AutomotiveNL chose to study four pilots from different regions within North West Europe.

5. ROAD MAP AND POLICY RECOMMENDATIONS

One of the major outputs of the ENEVATE project will be the e-mobility road map and policy recommendations. A road map and policy recommendations based on the results of the work packages of ENEVATE is about to be elaborated, which highlight necessary steps for the implementation of e-mobility in the partner regions and define realistic aims for 2020. Based on these fields of application, the road map and policy recommendations highlight the potential of e-mobility in the partner regions with the result, that e-mobility will rise, not in a revolutionary way, but slowly and steady. So that we can state that the introduction of e-mobility is not a revolution but an evolution.

JOIN!

Please join the ENEVATE Final Congress welcome reception that I will host on 25 September in the European Parliament. An excellent opportunity for networking in an environment which underlines the need for joint and synchronized action by public policy makers throughout the EU, the automotive industry and the energy sector.

ESTRELIA: Good progress on development goals

Ewald Wachmann

The project ESTRELIA aims to provide building elements with enhanced reliability and safety at lowered costs for smart energy storage for FEVs.

AFTER THE SECOND PROJECT YEAR SEVERAL SUCCESSFUL RESULTS ARE ALREADY AVAILABLE:

The first samples from ams' Battery Management BMS IC are available and have been used to build-up the demonstrators of a Li-Ion cell based Energy pack and an Ultra-capacitor based Power pack.

These ICs from ams will for the first time provide full monitoring functions together with flexible passive or active cell balancing in one single integrated circuit perfectly suited for the high accuracy demanding monitoring of Li-Ion batteries and ultracapacitors.

THE BMS IC PROVIDES THE FOLLOWING KEY FEATURES:

- Simultaneous cell voltage capture for balancing and safe operating area (SOA) monitoring.
- Autonomous balancing and SOA monitoring strongly reduces data communication and data processing, and thereby improves EMC robustness.
- All shuttle switches integrated to enable 100 mA of active or passive balancing current.
- For active balancing true energy re-distribution, if energy is taken from entire pack; Optional energy source from PV or 12V board net.
- Absolute cell voltage read out through EMC robust 3 wire daisy chain communication. Chained direct action pins for fast SOA diagnosis.

A new ultracapacitor power pack is developed by Corning and evaluated by Valeo and Austrian Battery Research Lab. High-energy density ultracapacitor samples delivered by Corning have now been assembled by Valeo, including integrating the BMS ICs from ams. These ultracapacitor samples demonstrate an average capacitance greater then 2800F, this compares to commercial cells in the same form factor of 2000F hence confirming the > 40% improvement in energy density. Initial cell level testing has demonstrated good reliability performance for both steady state (maximum temperature and voltage) and current cycling operation across the full temperature range.

The development of the very important safety sensors for EV's is also progressing well on schedule.

ESTRELIA has shown successful progress with development of new spark detection sensors based on silicon MEMS approaches. In order to perform spark detection, CEA-LETI focused on a new architecture of ultra-sonic acoustic sensors using Silicon piezo-resistive nanogauges as detection principle as it exhibits high sensitivity with low voltage and high adaptability.

The new spark detector concept will enable general safety functions by spark detection from hazardous events in and around a FEV battery.

The gas sensor developed by AppliedSensors has been integrated into E4V's battery pack demonstrator and monitors changes of combustible gases in battery cycling experiments. In all experiments the gas sensor has shown a stable baseline and high sensitivity for alarm threshold levels.

Temperature variations result in gas sensor signal fluctuation from outgassing of polymers. Fraunhofer IISB measured high gas sensor signals from outgassing of a pouch cell in an overcharging experiment when the cell did not blow the safety relief valve. It is assumed that small amounts of combustible gases were emitted at the cell's electrode feed through when cell temperature reached 80°C.

Supported by the simulation from Fraunhofer IISB the development of the galvanic isolated driver ICs at ams is progressing enabling communication between BMS ICs on different voltage potentials. Newly developed high voltage testers from Active Technologies enable the verification of the reliability for this galvanic isolation technology.

ESTRELIA
Safe Batteries with power

Active Technologies has successfully developed a first prototype of its high voltage tester for evaluating galvanic isolation function of BMS communication ICs to proof test isolation protections in the environment of several hundred volts as present in FEVs.

Finally, the completely new concept for the development of low cost power antifuses by Fraunhofer IISB together with the new energy management hardware (BMS IC) and software enables dynamic reconfigurable topologies in the energy storage unit, thus providing limp-home functionality to the FEV despite single cell failures.

A detailed concept using self-triggered power antifuses to bypass faulty battery cells has been developed strongly supported by device simulation. Experimental results show that this is a first step to provide a cost effective solution to bypass single cell failure for the future.

E4V has started to assemble the energy pack including battery and BMS ICs and safety sensors both by its local engineers in Bordeaux and Le Mans (France). Strongly experienced, mainly due to its president background and experts support, the company offers its partnership in the development of a large range of dedicated energy storage solutions.

As a first e-mobility demonstrator ams has integrated its IC solutions for battery monitoring and battery management in an electrical go-kart (e-kart) with first exciting driving test results.

For more information please refer to the ESTRELIA webpage **http://www.estrelia.eu**.

Energy Storage with lowered cost and improved Safety and Reliability for electrical vehicles

ESTRELIA aims to provide building blocks with enhanced reliability and safety at lowered costs for smart energy storage for FEVs.

The project will develop battery management system BMS ICs for an integrated flexible BMS to enable simultaneous cell measurement and active cell balancing for ultra capacitors and Li-Ion battery cells.

An advanced development goal is a new cost effective power antifuse for dynamical configuration of energy storage units, e.g. to bypass failing cells in battery packs. The project covers also the development of new high voltage (several kV) capable test and characterization equipment to test and verify newly developed galvanic isolated ICs to enable BMS communication within the high voltage levels of FEV energy storage solutions.

To enhance the overall safety of energy storage solutions the project covers also new safety sensors: it will provide a new gas sensor with high sensitivity and fast response and investigates a new MEMS based spark detection sensor to improve safety monitoring.

New ultra capacitor power cells targeting for 50% higher energy density will be investigated and verified as power pack extension for energy storage systems.

In overall ESTRELIA targets with these highly integrated IC developments to reduce the electronic component costs for integrated Li-Ion battery management by 1/3rd

Started: May 2011, Duration: 36 months

Funding Program: FP7

Coordinator

AMS AG	AUSTRIA

Key Partners

VALEO EQUIPEMENTS ELECTRIQUES MOTEUR SAS	FRANCE
COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	FRANCE
ACTIVE TECHNOLOGIES SRL	ITALIA
E4V SAS	FRANCE
ABR BATTERY RESEARCH LABORATORY GMBH	AUSTRIA
CORNING SAS	FRANCE
FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V,	GERMANY
APPLIEDSENSOR GMBH	GERMANY

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Save the Date for the ESTRELIA/SUPERLIB joint conference 2014:

"Smart concepts for Battery Management & Sustainable Energy Storage"
Date: 09th – 10th April 2014
Location: ams AG, Unterpremstätten (Graz), Austria

Don't miss the opportunity to get the insight view to latest developments on Battery Management Systems based on the experience of 2 leading companies – AVL and ams! Check out the details on the following websites: **www.estrelia.eu**, **www.superlib.eu**

Consumer acceptance of EV's; its more than just economics and uniformity

While much research, development and investment is rightly focused on the need to reduce the cost of production, ownership and value per km for electric vehicles it is important to remember that obtaining customer acceptance does not begin and end with the bottom line alone. Issues such as audible warnings for EV's are provoking much debate as legislative moves take place in the EU, US and Japan to ensure EV's remain detectable in the absence of the internal combustion engine while ensuring the generated sound will not add to the environmental noise.

Going a level deeper acceptance becomes more about preference; customers expect electric versions of their preferred vehicle brand or model to give a similar driving sensation, combining performance, feel (vibrations, road tenure) and sound. It is perhaps this point which is most important for electric vehicles to gain acceptance across the widest consumer profile possible, as after early EV adopters the rest of the socio-demographic groups will require progressively more convincing of the non-economic merits. The complexity of the novel vehicle designs combined with the subjective nature of the problem makes this a huge challenge. It is in these aspects where LMS is focuses its research on and development.

At LMS, our most recent project entitled 'DEsign, MOdelling and TESTing tools for Electrical Vehicles Powertrain Drives', funded under the European Commission Marie Curie Industry and Academia Partnerships and Pathways (IAPP) scheme, aims to close the gaps in the development phase of electrical drives for light passenger vehicle applications by taking all important attributes into account in the modeling and testing process from early development to detailed component design.

The project is coordinated by Universitatea Tehnica din Cluj-Napoca, Romania and together with LMS is executed with 'top of the class' partners from academia, Université Libre de Bruxelles, Belgium and industry, ICPE, Romania. Each brings their expertise in the field of electrical machines, power electronics and electric drives to develop the necessary methodologies and technologies concerning electrical powertrain development and testing. An extensive researcher secondment program between the partners will ensure the dissemination of methods and results benefits all parties.

The project deliverables will bring new insight and methods to predict, evaluate & optimize the vibro-acoustic impact of the powertrain integration of the electrical machine and its related power electronics at component and vehicle level, by taking advantage of the knowledge, know-how and available MiL and HiL modelling, simulation and testing tools.

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E-mobility: providing a seamless charging experience

Aura Caramizaru, Policy Advisor, EURELECTRIC

In addition to an electric car's battery range and costs, one of the major barriers in the field of e-mobility is the lack of easy access to charging infrastructure. In a recently published paper, EURELECTRIC – the association representing the European electricity industry – aims to address this barrier by setting out how a cost-efficient and customer-friendly market model for e-mobility could be structured across Europe.

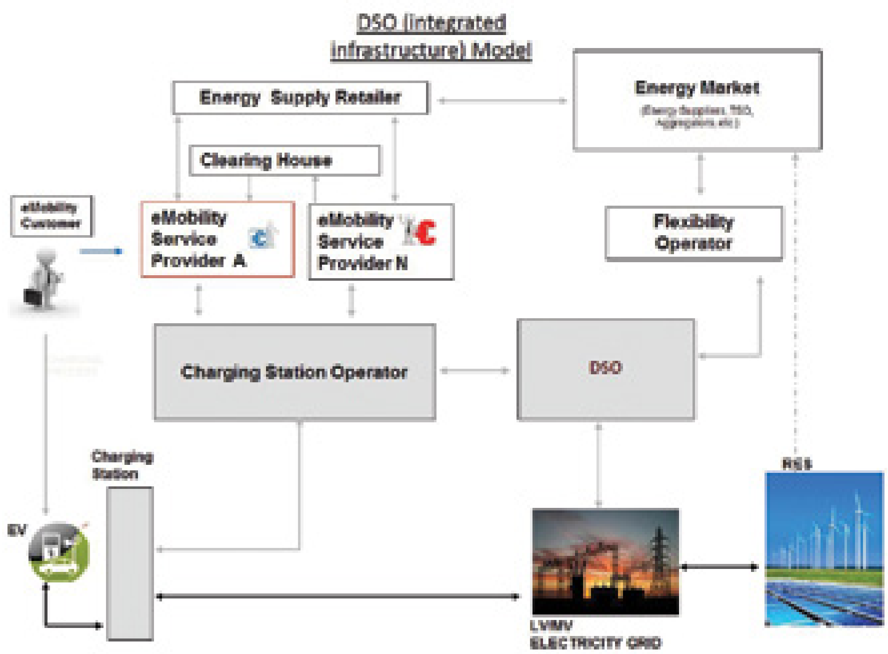
The central aim of the paper "Deploying publicly accessible charging infrastructure for electric vehicles: how to organise the market?", available at **www.eurelectric.org**, is to ensure that users of electric vehicles can simply and easily access charging infrastructure anywhere in Europe. This can be done via a "roaming" process between different charging station operators, similar to the way we use our mobile phones today. Roaming in this context means nothing more than using a charging service outside the coverage area of one's e-mobility service provider – the party that sells services to e-mobility customers.

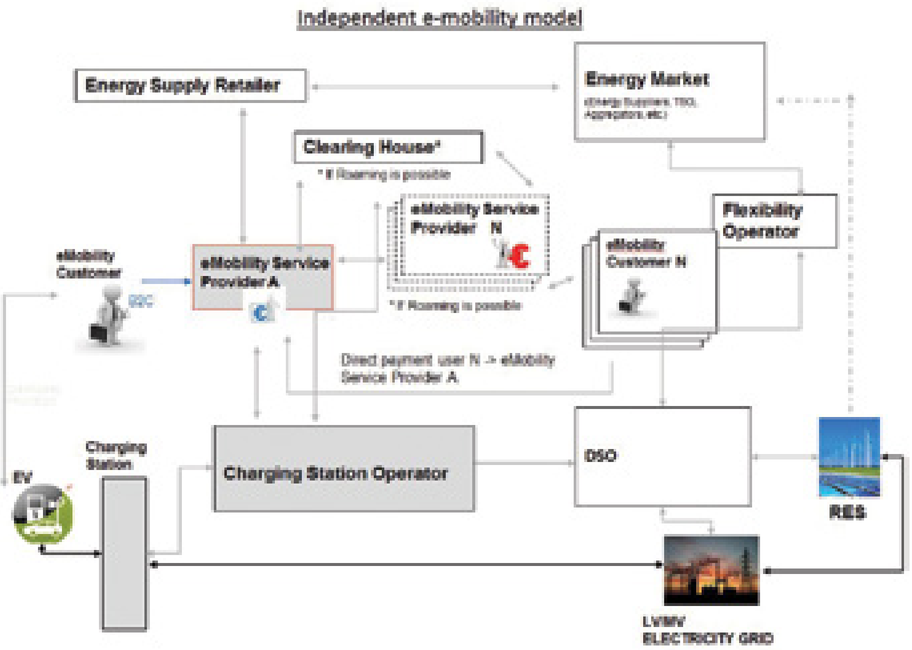
The paper defines two roaming scenarios: roaming of charging services and roaming of both electricity and charging services. In both scenarios, electric vehicle customers who have agreed a contract with an e-mobility service provider for charging services are able to charge their car at any public charging station via a business-to-business agreement between the e-mobility service provider and the charging station operator in question.

The difference between the scenarios stems from the way in which the supplier of electricity is selected. Either suppliers are fixed at the charging station, as chosen by the charging station operator, or they are linked to the electric vehicle in question through a business-to-customer contract with the e-mobility service provider.

Roaming will allow the drivers of electric vehicles to access the charging stations of other suppliers in addition to those operated by their own e-mobility service providers, without having to enter into contractual relations with a multitude of service providers.

In practice, the two roaming scenarios are usually not discussed or implemented in their pure form. Hybrid types may exist depending on the specific national market conditions or regulatory framework. Taking into account on-going national initiatives regarding the e-mobility market structure in Europe, the paper analyses two possible market models linked to the two types of roaming identified above: an independent e-mobility model and an integrated infrastructure model.





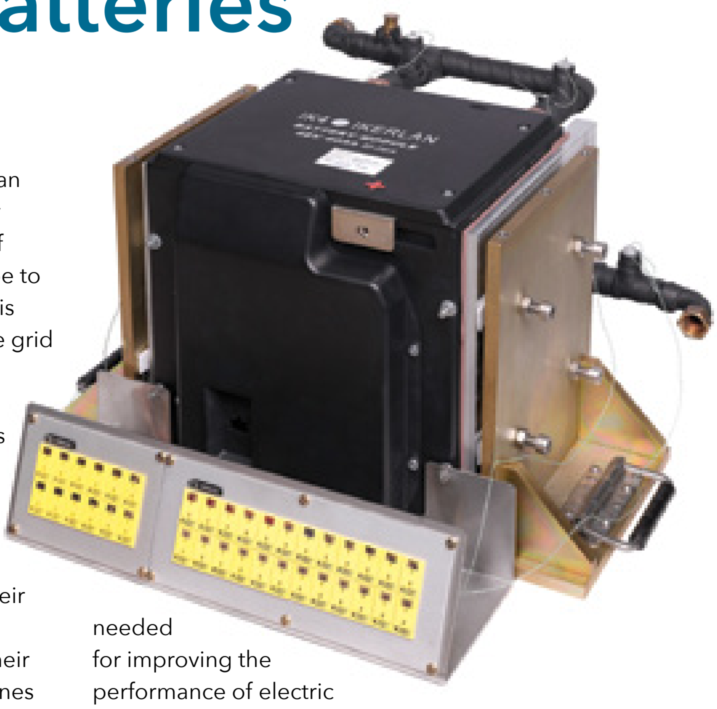
In the independent e-mobility market model, the building, owning and running of the charging station is a competitive activity that can be carried out by any market participant. Thus, more than one party might install charging stations in a town or even on a single street. In addition, the e-mobility service provider sells a "bundled service" that might include electricity – similar to the "roaming of charging service" scenario. In this model, the e-mobility customers are asked to bear the costs of the infrastructure investment.

In the integrated infrastructure model, by contrast, the public charging infrastructure is integrated into the assets of the distribution system operator (DSO). Thus, the costs for rolling out charging infrastructure are spread between all electricity grid users. Building on the "roaming of charging service and electricity" scenario, this model establishes a multi-vendor platform that allows for competitive offers between multiple service providers. An ICT back-end system allows charging station operators to "link" customers to an e-mobility service provider with whom they have a contract that includes electricity.

Both market models aim to provide e-mobility customers with the same confidence in infrastructure access that they might have with conventional vehicles. The European electricity industry does not favour one market model over the other. However, the paper makes clear that policymakers urgently need to take a decision, to ensure that e-mobility can truly get off the ground.

EURELECTRIC therefore welcomes the European Commission's continued focus on the electrification of transport, not least its "clean power for transport" strategy, published earlier this year. Breaking the vicious circle of a lack of charging infrastructure and a corresponding slow uptake of electric cars in Europe will be one of the biggest challenges in ensuring that a mass market for e-mobility finally gets off the ground.

A second life for electric-vehicle batteries



Electric-car batteries are retired at the latest after five years in use. At that moment they still retain about 80% of their charge/discharge capacity yet they are no longer useful for this demanding application. Which is why they are scrapped and hardly any of their materials are recycled.

Batteries 2020, a research project started on the 1st of September, aims to pioneer strategies that will give used Li^+ batteries a second lease of life in stationary applications before they are scrapped. To achieve its ambitious goals, a consortium has been set up led by the Basque research centre IK4-IKERLAN. It further consists of Umicore, Leclanché, FIAT and Abengoa - companies leading their respective fields - and the universities of Aachen (through its ISEA and IME institutes), Aalborg and Brussels. Eurobat, the European association of battery manufacturers, collaborates in the dissemination of the project. The project has an eight million euro budget and is co-funded by the European Union's 7th Framework Programme.

Accumulators made from spent electric-car batteries developed in this project will be used to store energy produced from renewable sources in both industrial and domestic facilities. Electricity produced by wind turbines or solar panels is not normally stored but fed directly into the grid, which leads to weather-dependent production peaks potentially causing instabilities in the distribution network. As a result, it is presently not possible to produce more than 20 to 30% of the total energy from renewables. One way of increasing this share would be to store excess energy where it is produced and feed it into the grid when needed.

Apart from seeking strategies for re-using them, the *Batteries 2020* project sets out to substantially improve the batteries of electric cars: the aim is to increase their capacity-per-unit-volume by 30% to 40% and to double their useful life compared to the ones currently on the market, as well as improving their reliability. This project is expected to result in a pre-commercial product by 2016.

Batteries 2020 is part of the EU's 'Green Cars' initiative which seeks to generate the knowledge needed for improving the performance of electric cars. The aim of the European institutions is to set up a research and production network that will not only release the Continent from its technological dependence in this area, but will put it at the forefront of this market.

For more information, please visit www.batteries2020.eu

Enexis takes the lead in a standard for smart charging

ELECTRIC TRANSPORTATION HOLDS A BIG PROMISE FOR THE FUTURE, BUT ALSO POSES A SERIOUS CHALLENGE FOR THE ELECTRICITY GRID. IF IN ONE STREET 10 ELECTRIC VEHICLES START CHARGING AT ABOUT THE SAME TIME, THIS IS VERY LIKELY TO OVERLOAD THE BREAKER RESULTING IN THE WHOLE STREET BEING WITHOUT ANY ELECTRICITY. THE SOLUTION TO THIS PROBLEM IS RELATIVELY SIMPLE: DO NOT CHARGE ALL VEHICLES AT THE SAME TIME. SINCE THE AVERAGE ELECTRIC VEHICLE CHARGES FOR ONLY AN HOUR AND IS PARKED FOR ABOUT 23 HOURS A DAY, THERE IS A LOT OF FLEXIBILITY IN THE TIME AND SPEED OF CHARGING. ONE MIGHT USE THIS FLEXIBILITY TO ADAPT THE CHARGING PROCESS TO E.G. THE LOCAL AVAILABLE CAPACITY, THE PRICE OF ENERGY, THE AVAILABILITY OF LOCAL RENEWABLE ENERGY AND OF COURSE THE DEMANDS OF THE DRIVER. THIS IS WHAT IS CALLED SMART CHARGING.

ENEXIS AND SMART CHARGING

Enexis is a Dutch distribution service operator (DSO) that manages the gas and electricity grid for about 2.7 million customers in The Netherlands. Enexis has been working on different aspects of smart charging for the past five years, resulting in several tests, pilots and demonstration projects. In the beginning of 2013 Enexis started working on the Open Smart Charging Protocol (OSCP).

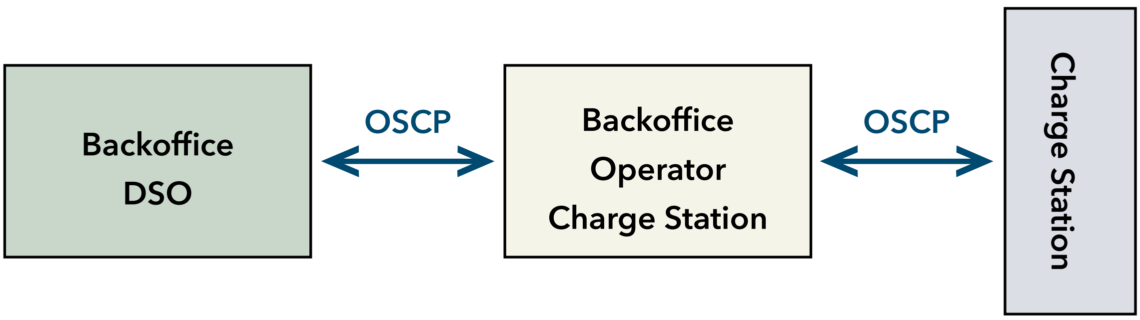
THE OPEN SMART CHARGING PROTOCOL

There exists a well-established protocol that defines how to communicate with charge point. This protocol is called the Open Charge Point Protocol and is already being used in many countries throughout the world. The protocol that Enexis has developed is an extension on the OCPP and defines what information should be exchanged between the operator of the charge point and the DSO and what messages should be used to do this (Figure 1).

Using the protocol, the operator of the charge station can be provided with all information he needs to prevent overloading the local electricity cable or transformer station. Being able to do this means that in many cases it will be no longer necessary to increase the network capacity when electric vehicles are charging in private areas. This could save the electric vehicle owner a lot of money.

SPREADING THE WORD

At the moment this protocol is used by multiple parties in The Netherlands, but other parties, also outside The Netherlands, are welcome to use the protocol as well, it's freely available. See www.smartcharging.org for more information.



Norway takes the lead on emobility – universal solutions to serve all cars on the market

The Norwegians think and act different and they are the world leading country of electric cars. During the last 25 years the *polluter pays* principle have been implemented as a general policy for taxation making e-cars cheaper than ICE cars. Zero pollution – zero tax. Together with smart user incentives and access to the buslane – ecars have become popular. The market is now rapidly growing with 6% of all new cars sold in august 2013 electric. 14000 EVs are registered now and around 17000 will be the number by the end of 2013. We do expect that the market share will increase to 10% within november when the ecars from Volkswagen and BMW (eUP and i3) comes to the market.

WORLDS FIRST UNIVERSAL CHARGING STATION OPENED IN LILLEHAMMER

The worlds first universal charging station was opened in Lillehammer in September 2013 by the Ministry of Transport and Communication and their tool for emobility – Transnova. Transnova is a governmental agency working on environmental friendly transport in general with emobility as first priority. Zero emission solutions from renewable energy sources are the preferred long term solution, but the scope of Transnova is also to improve a wide range of transport technologies, including biogas, hydrogen and smarter logistic solutions.

The universal charging station in Lillehammer are able to charge 10 cars at the same time. While the cars are charging – the drivers and passengers can eat quality food from the Marche restaurant nearby.

MULTISTANDARD FOR MULTIPLE BRANDS AND TECHNOLOGIES

The Norwegian policy are based on brand- and technology neutrality stated in one sentence:

Stig Hansen from Ishavskraft with the CHAdeMO plug, Erlend Solem from Transnova with the CCS plug and Rune Haaland from the Electric Vehicle Union with the type 2 connector – all plugs from the same fast charger delivered by Efacec (Portugal)

"We shall provide all cars on the market with fast charging".

Multistandard fast charging is the way for Norway.

- We are shooting at a moving target, and our policy will allways be to investigate and support future technologies that can improve e-mobility based on renewable energy sources. Inductive charging is an example of future possibilities, Mr. Erlend Solem stated after the opening on Lillehammer. Normal charging is the Norwegian word for AC slow charging, and future normality for Norway will be the European type 2 connector which is safer and support higher effect than excisting household connectors.

Two Tesla S charging from the 120 kw DC superschargers on Lillehammer.

- The Norwegian State will support further development of technologies and logistic solutions that can reduce air pollution from transpor. Our mission is not only to electrify cars. We are supporting mobility solutions that also include shipping. In 2015 the first electric ferry will start transporting cars and passengers from one side of the Sognefjord to the other. One fast charger on each side of the Sognefjord will supply the ferry with renewable power. The effect from these chargers are 1000 kw according to Mr. Solem. We will cofinance further development of a national fast charging network – both in corridors and on urban locations. Transnova will cooperate with private and public owned utilities and operators of fast chargers, according to the Transnova-boss, Erlend Solem.

CHADEMO – FIRST MOVER TO THE MARKET

In September 2010 there was only one technology available for fast charging – CHAdeMO – developed by the first movers on the market – the Japanese manufactures together with Tokyo Electricity Company (Tepco). The worlds best selling electric vehicle, Nissan Leaf, are using the CHAdeMO technology for fast charging. More than 100 000 EVs are CHAdeMO compatible.

CCS AND AC QUICK

A small group of CHAdeMO members (DBT, Efacec, EV Tech and Delta Electronics) started to develop the next generation universal fast chargers based on their existing CHAdeMO devices. The mission was to implement CCS and AC Quick to serve other cars that will come to the market within 2013.

90% of the excisting CHAdeMO fast chargers can be used also for CCS. Version 2 of a universal fast charging might be including the Tesla technology and connector.

- The Norwegian Government are preparing a new program for infrastructure from 2014 and we have established two reference groups of stakeholders to help developing a universal strategy that can continuing the Norwegian ambition of 50 000 EVs in Norway within 2018 being able to achieve the 85g/km goal for 2020, says the leader of Transnova, Erlend Solem.

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Sweden: Five Key Facts

Size:	407, 340 square km [1]
Population:	9, 596, 436 [1]
Total Primary Energy Supply (Mtoe):	51.28 [2]
Total CO_2 Production:	53.2 Mt [3]
Proportion of Electricity from Renewables:	58.72% [4]

[1] Statistics Sweden
[2] International Energy Agency (2012)
[3] US EIA (2011)
[4] Eurostat (2011)

Corrigendum
In our last issue, we inadvertently stated that the proportion of Germany's electricity that is generated from renewable sources is 8.2%. The correct figure, according to Eurostat, is 20.35%. We are grateful to an alert reader from Forschungszentrum Jülich and very happy to set the record straight.

Lagom är Bäst

By Mike Edmund

At every door-way, ere one enters, one should spy round, one should pry round for uncertain is the witting that there be no foeman sitting, within, before one on the floor

Hávamál, The Words of Odin the High One [Sæmund's Edda]

These words (translated, of course) form the first stanza of the Hávamál, Old Norse poetry that was no doubt being told and retold amid the sparks around the campfires more than a thousand years ago. The caution they seem to suggest might contradict today's popular Viking image of horned helmets and bloodthirsty adventure; of longboats, plunder and Valhalla. But it does have an echo in the much more modern writings of Aksel Sandemose. His 1933 novel *En flygtning krydser sit spor** contains a set of rules, the 'Jantelagen'‡ that appear designed to suppress the desire of any individual to make himself stand out from the crowd. So what does it mean to be Swedish today?

Politically, the Kingdom has been governed over recent years by successive coalitions dominated by the *Sveriges Socialdemokratiska arbetarparti*§, whose fundamental philosophy is based upon equality of opportunity. Vattenfall, one of the largest energy producers in Europe, may illustrate their philosophy: the company generates 178.9 TWh of electricity and sales of SEK 167.3 billion/€19 Billion [*Data: Vattenfall*] and is entirely owned by the Swedish State. Meanwhile, the title of this article is an idiom that may be translated as "the middle way is best".

Whether any of these examples on its own is truly representative of modern Sweden, together they might describe something of the unique amalgam of Lutheranism, trade unionism and self-reliance that many suggest best describes its national character.

Intriguingly, Sweden seems happy to set itself apart with its approach to renewable energy. In 2006, Stockholm announced the ambitious goal of a completely oil-free economy, anticipating the EU 20-20-20 targets by some four years and putting the country at the forefront of the climate/energy debate. "Our dependency on oil should be broken by 2020," said Mona Sahlin, then Minister of sustainable development, adding memorably: "No house should need oil for heating, and no driver should need to turn solely to gasoline." Today, 49% of all the energy consumed in Sweden, and no less than 59% of the electricity it generates, is derived from renewable sources. [*Data: Eurostat*].

According to the Swedish Institute, although Sweden's consumption of electricity is relatively high, its CO_2

emissions are relatively low because emission-free hydropower and nuclear together provide almost 85% of the country's electricity. According to the Swedish Hydropower Association, 65 TWh of electricity annually is generated by a total of 2057 hydropower plants, with a combined rated capacity of 16 GW. However, Sweden's approach towards the atom might show a little contradiction: for decades, the Swedish Institute says, policy had been to phase nuclear out of the energy mix. But that direction was reversed by the *Sveriges Riksdag* in 2010 with a decision that paves the way for new reactors to be built. There are currently ten of these online, producing some 40% of the country's electricity [Data: World Nuclear Association]. Meanwhile, the World Bank states that over two-thirds (68.7%) of Sweden's 410,340 square km land area is forested, while peat covers a further 15 %. It is therefore no surprise that biofuels represents almost 20 % of Sweden's total supply of energy. [*Data: Swedish Institute*].

It will also be no surprise to anyone making a basic calculation that other sources of renewable energy are almost insignificant in Sweden. Notable examples include the city of Lund, which extracts geothermal energy to meet about one third of its district heating requirements, while Stockholm-Arlanda Airport uses an underground aquifer in what is effectively the world's largest energy storage unit. During Summer, cold water pumped out of the aquifer to be fed into the airport's district cooling network and cool half a million square meters of terminal space. The warmed water, and the heat it now contains, is pumped underground to be stored until winter.

But that sense of Scandinavian contradiction returns again: Wind Energy. Currently, the world's largest offshore wind farm is the UK's London Array, rated at 1GW. Yet this year, a positive opinion was given on the proposed Blekinge Offshore Wind Farm, rated at 2.5GW. Not for the first time, and for good reasons again, Sweden will stand out in the renewable energy/climate debate.

The very words "Land of the Midnight Sun" hold mystery and contradiction for those from less polar latitudes. But whether the Jantelagen are the source of Swedish national character or the result of it, it nevertheless seems clear that the country as whole is prepared to stand out when it comes to renewable energy. Modern Vikings? Perhaps not. Worthy successors to their intrepid forebears? Certainly.

No doubt Odin himself would approve.

* 'A Fugitive Crosses His Tracks'
§ The Swedish Social Democratic Party
‡ 'The Law of Jante'

Sweden's road to a sustainable energy future

Anna-Karin Hatt, Minister for Information Technology and Energy, Sweden

Sweden has long enjoyed strong public support for its climate, energy and environmental policies. When the issue of climate change was raised by the Intergovernmental Panel on Climate Change, there was a general consensus among our political parties that this challenge must be addressed and that Sweden should take an active role in tackling this challenge.

Since Sweden's historic climate and energy package, presented in 2009, our energy policy has been based on three vital pillars: creating an energy system that is ecologically sustainable, ensuring greater competitiveness, and increasing the security of supply. These three pillars are designed to help us reach our ambitious goal of making Sweden carbon neutral by 2050.

Today it is clear that Sweden has already come a long way and that we are still making substantial progress. Since 1970, we have managed to cut our use of fossil fuels from over 80 per cent of our total energy consumption to currently less than 35 per cent. Today almost half of Sweden's energy comes from renewable sources. We have managed to combine high and sustainable economic growth with a significant decrease in greenhouse gas emissions.

One of the driving factors behind this development has been, and is, our carbon tax, which was introduced already in 1991. By internalising the external costs of

fossil fuel use, we have been able to drive innovation in the energy sector. Combined with good conditions for renewable energy sources, we have been able to phase out the use of fossil fuel from almost our entire heating sector and most of our industrial sector.

To support renewable electricity, ten years ago Sweden introduced the market-based system of green-certificate schemes. This market-driven, technology neutral instrument has truly supported a really cost-effective expansion of renewable electricity. Both the carbon tax and green certificates will continue to remain important key elements in the future, too.

In addition to this, Sweden, as a small export-oriented country, puts strong emphasis on open markets and close interaction with our neighbouring countries. This holds true for our reduction of greenhouse gas emissions and the development of renewable energy. One illustration of this was the world's first cross-border support scheme for renewables, introduced in 2012, when Sweden and Norway established a common green certificate market.

Although we have a strong track record, many challenges remain to be tackled in Sweden, in both the short and the long term.

We surely have to take even stronger action to realise the full potential of energy efficiency. Implementing the EU Energy Efficiency Directive represents a good opportunity for us to do this. Over the years, Sweden has implemented several successful programmes, not least regarding efficiency measures in industry. We are now seeking ways to strengthen and broaden these programmes, in particular to support active demand-side services and new technological solutions.

In this regard, it is essential that the market continues to make investments in sustainable energy and infrastructure. In addition, consumers must have the opportunity to become more active on the market. By providing net metering and smart technological solutions, more and more consumers will have the ability to react to correct price signals.

Correct price signals are also a way of ensuring that effective investments are made, both from a consumer and producer perspective. The EU must avoid introducing measures that distort the functioning of a competitive electricity market. In the worst case scenario, such decisions could lead to the emergence of isolated markets, which must be averted. Instead, all Member States must implement the legislation of the EU's third energy package.

Making transportation sustainable is truly a global challenge. In Sweden, transportation is the remaining sector that is most heavily dependent on fossil fuels. In order to tackle this challenge, we have adopted the ambition of making our vehicle fleet free from fossil fuels by 2030.

THE PATH FORWARD

The EU 2020 targets have been extremely vital to the strong developments achieved in the field of energy in recent years, in our own country and in the EU.

In its Energy Roadmap, the European Commission describes energy efficiency and renewable energy as 'no regret' options if we are to have any chance of limiting global warming to two degrees Celcius. To me, it is perfectly clear that both renewable energy and energy efficiency will have to increase significantly by 2030. To drive this development, the EU really does need new, ambitous commitments, in line with our climate objectives, for both renewable energy and energy efficiency.

Innovation and R&D for a sustainable and prosperous society

The Swedish Energy Agency

Sweden has a long tradition of energy research. After the energy crisis of the 1970s, the National Energy Research Program was implemented. Since then, Sweden has actively been working with replacing oil with domestic fuels, acidification issues and in recent years the climate issue. This has resulted in Sweden now having an energy system with almost 50% of renewable energy.

The National Energy Research Program concentrates on a few thematic areas and has a strong focus on facilitating new technologies to the market. The program includes some 40 programs and 700 projects and focuses on five areas:

- **The Transport sector** - The transport sector is the sector that is most dependent on fossil energy. One fifth of the world's energy is used for transportation. Major efforts are needed to increase the use of renewable fuels and electric vehicles, and initiate system changes to move from fossil fuel dependency to fossil-fuel independent transports

- **The Power System** - Our energy consumption and supply is undergoing rapid changes. The R&D of smart grids is a necessity to handle these changes. Other prioritized R&D areas are solar power, wind power and hydropower.

- **Buildings in the Energy System** – Powerful, long-term energy research and innovation is needed for new and existing buildings, as well as research on behaviour and urban planning.

- **Bioenergy** - A sustainable supply of biomass is critical to meet Sweden's energy and climate policy objectives. Research efforts regarding fuel supply and sustainability are prioritized.

- **Energy-intensive Industry** - The industry has revised its energy use, but continued rationalization is needed. Prioritized R&D areas are energy efficiency, recycling, renewable raw materials, bio refineries, utilization of waste energy, high functional materials and efficient utilization of raw materials.

THE SWEDISH ENERGY AGENCY

The Agency is a government agency that works for a safe, environmentally sound and efficient energy system. Support is given to business ideas and innovations which can lead to new business. The Agency guides Swedish households and businesses to smarter energy consumption. The Swedish government has commissioned the Agency be responsible for, and manage the National Energy Research program. The Agency therefore finances various R&D and demonstration projects with an annual budget of 1.3 billion SEK, focusing on renewable energy sources and energy efficiency. Additionally a number of private companies and organizations co-finance these projects with the same amount. This collaboration with stakeholders is a prerequisite for the results to be implemented and contribute to the energy policy objectives.

The Energy Research and Development Board (EUN), whose members are appointed by the government, is the ultimate decision-making body for the Swedish Energy Agency. The members are representatives from the industry, academy and business associations.

IMPLEMENTING RESULTS IN ORDER TO CHANGE THE ENERGY SYSTEM

"The transition to a sustainable energy system cannot be done overnight. It requires a long-time approach, a good overview in order to make the right choices from a system perspective, and it requires a lot of patience." says

Birgitta Palmberger, head of the Energy Agency's Technology Department.

Results being implemented today typically stem from work that was started ten or twenty years ago. The following are just some few examples:

Swedish buses world leading in energy efficiency

The Agency's commitment to electrification of vehicles through both research and demonstration has helped Volvo AB, who in 2009 delivered its first hybrid buses, with a newly developed electric hybrid powertrain and modern lithium battery technology. By the end of 2011 they had sold over 400 buses.

In London traffic, Volvo's hybrid buses have reduced fuel consumption by 35 percent; those used in Gothenburg traffic by 25 percent. This is the first generation of hybrid and continuous efforts are made to further increase efficiency but also to reduce the cost of this technology.

Strong expansion of the power grid

In the 1990s, the Swedish government granted financial support for a project regarding a power transmission line with, at that time, new and untested DC technology on the island of Gotland. The result is seen today in ABB's successful HVDC technology, High Voltage Direct Current, which is one of many important components in the development of smart grids. The future smart grid is more or less a prerequisite for being able to introduce large scale introduction of electric cars, solar panels and new distributed renewable energy generation.

RESEARCH AND POLICIES IN SYNERGY

Although energy research, development and demonstration (RD&D) activities are necessary for a transition to a sustainable energy system, they are not enough on their own. Synergies with other policy measures and instruments, such as legislation, taxation, standardization, grants and other financial incentives, as well as information to consumers and producers, are essential in order to reach the objectives.

An example of one such instrument is the taxation of carbon dioxide emissions, which is intended to discourage the use of oil for heating purposes. Another example is the electricity certificate system, which supports increased production of electricity from renewable energy sources, such as bioenergy, wind power, and hydro power.

Another important policy measure is that of technology procurement, which stimulates and accelerates the development and introduction of new technologies. Technology procurement of new products, systems or processes is intended to meet purchasers needs better than existing products on the market.

The basis for the adjustment process is effective policy measures and instruments. But sometimes there is also a need for specific stimulus to technologies that are on the brink of breaking through on their own, and where the technology could play a major role in the future of sustainable energy.

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In the news...

A new technology that could turn waste heat from power stations into electricity

Led by Professor Doug MacFarlane and PhD student Theodore Abraham, a small team of Monash University researchers working under the Australian Research Council (ARC) Centre of Excellence for Electromaterials Science (ACES) has developed an ionic liquid-based thermocell. Thermocell technology is based on harnessing the thermal energy from the difference in temperature between two surfaces and converting that energy into electricity. The new technology could be used to generate electricity from low grade steam in coal fired power stations by having the steam pass over the outer surface of a hot electrode while the other electrode is air or water cooled. "The device offers the possibility of a cheap and flexible design suitable for harvesting waste heat in the 100- to 200-degrees Celsius range," Professor MacFarlane said. Abraham added, "The major benefit is that it harnesses energy that is otherwise lost to surroundings."

Wireless electric transport

Two buses currently operating a 15-mile route between the Gumi Train Station and In-dong district,in the city of Gumi, South Korea, mark an important development in emission-free urban electric powered transport.

The buses rely upon shaped magnetic field in resonance (SMFIR) technology developed by the Korea Advanced Institute of Science and Technology. It transfers power wirelessly across an 18cm gap from electric cables buried beneath the road surface. The process, which is rated 85% efficient, can continue even when the vehicle is moving, and overcomes the major limitations on range imposed by battery recharging requirements.

The power strips needed to power the bus only cover 5 to 15 percent of the road surface, so only small sections of road have to be rebuilt. This feature is likely to prove particularly important if the technology is to be deployed in major cities.

Trash into treasure: the first commercial-scale waste to biofuel system

An important milestone in finding a means through which to dispose of trash and create energy, INEOS Bio could potentially be laying the groundwork for an entirely new market and infrastructure. The company has released a statement that they had successfully been able to produce commercial quantities of ethanol from wood waste and non-food vegetative matter, and hope to begin shipments this month of the fossil fuel alternative. Soon, they hope to use municipal garbage as a feedstock to create the alcohol. Their ultimate goal is to produce eight million gallons a year.

The process involves cooking a type of biomass feedstock such as trash or wood trimmings to produce carbon monoxide and hydrogen through a process known as "gasification". Bacteria are added to digest the gas and so produce alcohol, which is distilled and made ready to be used to power vehicles. Central to the technology is a proprietary biocatalyst that is able to unlock the chemical compositions from low-cost, carbon waste materials during bacterial fermentation. Refining only takes a few minutes, and each gallon produced eliminates five pounds of carbon released into the atmosphere.