EUROPEAN LAMP COMPANIES FEDERATION

CELMA

Federation of National Manufacturers Association for Luminaires and Electrotechnical Components for Luminaires in the European Union

The European Lighting Industry's Considerations

Regarding the need for an

EU Green Paper on Solid State Lighting

FINAL

Brussels, 2011, version 2.7

Contents:

Executive summary and conclusions

1. The European Lighting Industry welcomes this EC initiative for mainstreaming the climate policy with their Solid State Lighting (SSL) policy and calls upon the Commission to look at holistic solutions in Energy Efficiency in the current environment and to outline a roadmap for a better integration between manufacturers, installers, customers and other stakeholders along the value chain. The Green Paper on SSL will only be able to fully exploit its potential when interlinked with other interdependent policy areas, namely Climate Change, Environment, Energy, Research and Innovation, Trade and Regional policy.
2. At present the European Union does not have an overall and coherent policy paper on SSL. It is the expectation of the European Lighting Industry that the publication of the EU Green Paper on SSL becomes the framework for an active approach in which the objectives and opportunities, as well as the generic conditions for achieving these objectives, have been laid down as a consistent basis for action for all involved Directorates Generals of the European Commission leading to binding implementation measures for ALL member states
3. An accelerated change-over to SSL will help to achieve the EU Lisbon Agenda 2050, the EU low carbon economy roadmap for a resource efficient Europe.
4. New (ICT) opportunities will result from an integrated systems approach, further reducing energy consumption. Extension of communication and interaction between various (previously independent) control systems will create high level employment and jobs.
5. A specific, new and unexploited area of the application of lighting and LEDs is biological effective lighting. Artificial LED lighting optimized for an application can provide better work and living conditions especially for elderly people. It can also contribute to higher productivity at work places and educational facilities, strongly contributing to management of demographic change in the EU.
6. The characteristics and benefits of the SSL lighting technology will lead to a change in lighting business models. Intelligent and communicative systems will lead to an increase of lighting system providers. Tailor made solutions will become a growth opportunity for many SME's, taking up the possibilities the new LED technology offers for creative lighting design and cost savings.
7. The European lighting industry regards the Green Paper as an appropriate tool to support SMEs in their market access and to increase their overall visibility. The positioning of SSL as a future key enabling European technology vis-à-vis already existing SME networks should be addressed.
8. The total luminaires world market is expected to grow to a level of € 55 Billion by 2020 of which the SSL luminaire share will grow from a modest share in 2012 to (predicted) over 90% in 2020. The European market is estimated to remain 30% of the total world market, also in relation to the share of LED luminaires. We estimate therefore the European SSL luminaire market of 2020 at a level of roughly € 15 Billion.
9. At its peak in 2015, the world market for lamps (all technologies) is expected to be at a level of € 17 Billion of which two-third will be LED-based. The figures for Europe are estimated at a level of 30% of the world market.
10. The expected efficiency of packaged LED's will increase to a level of 220 or 150 lm/W (cool-white and warm-white respectively) by 2020. The cost of packaged LED's is estimated to drop by a factor 10 over the period 2010 to 2020.
11. For OLEDs we expect system efficiencies exceeding 50 lm/W (warm white) and lifetime will be well above 10 000 hours operating lifetime. The shelf-life time will increase to 10 years. Transparent and flexible panels will enter the market with completely new application fields.
12. Leading countries of the world such as USA, China, Korea and Japan, have recognised the potential contribution of SSL in achieving their overall objectives in the areas of energy and environment. This has been laid down in national policy documents and is accompanied by local supportive measures. A similar European approach is not (yet) available.
13. The active SSL approach in other countries has resulted in an ever increasing competition for the European lighting industry. Europe needs to urgently clarify the intended contribution of SSL as 150,000 European lighting jobs are at stake.
14. European OEM's are considered leading in the area of lighting solutions. This segment (level 4 of the value chain) is expected to grow in the period up to 2020. The contribution of levels 2 and 3 (European suppliers of LED and OLED lamps and LED and OLED modules) will show a sharp increase in turnover in the period till 2020. The contribution of levels 0 and 1 (manufacturing of O/LED's in Europe) will remain stable, however with a reduced contribution if compared with the higher levels of the SSL value chain.
15. Development of relevant standards for SSL products is of immense importance. As a guiding principle the European lighting industry calls for standards that facilitate a clear and undisputable comparison of conventional and SSL product solutions to be monitored via active market surveillance.
16. The EU Lighting Industry calls upon the EU to address the issue of effective market surveillance as a key condition for (re)installing customer trust in the SSL products and in this way obtain a tangible contribution of the SSL technology in achieving overall the EU objectives in the area of energy and environment.

Section I: Introduction

1.1 Solid State Lighting: the opportunities

The European Lighting Industry, represented by its associations CELMA and ELC fully welcomes the European Commission's initiative to draft a Green Paper on Solid State Lighting (SSL). This initiative offers the opportunity to build a solid basis for further political and legislative action at the European level to finally establish a level playing field with other regions in the world that have already embarked on a coordinated and stringent SSL policy.

Lighting accounts for 19% of the total amount of consumed electrical energy in the world and 14% as an indicative figure for the EU. SSL is a "breakthrough" lighting technology that can help to drastically reduce the consumption of energy for lighting compared to existing, conventional lighting technologies, whilst improving light quality as well as people's lives and wellbeing. Besides high energy savings, SSL applied in the area of intelligent switching and control enhances energy efficiency, convenience and safety.

In addition, switching to SSL is economically more attractive than other means of GHG emission reduction. According to an analysis by McKinsey[1], the reduction of CO2 emissions in vehicles and via the use of solar energy for electricity generation comes at extra costs of ca. 770 EURO per ton of CO2 abatement. These costs have to be paid by the consumer as part of the purchase price (as for vehicles) or as taxes used for corresponding subsidies (as for solar energy). The situation is totally different in lighting, where CO2 abatement by switching to SSL comes at a profit (rather than costs) of ca. 130 EURO per ton of CO2 due to the improved energy efficiency and extended lifetime of SSL light sources compared to incandescent ones. Switching to SSL is economically more attractive than other means of GHG emission reduction. This is one of the main reasons to further develop SSL in the EU political agenda[2] and even consider a redirection of subsidies from less effective technologies to SSL--in order to maximise the return on these subsidies.

At present, the most important countries/regions in the world have already recognised the contribution of SSL in achieving their overall objectives in the areas of energy and environment. This has been stipulated in national/regional policy and is accompanied by supportive measures in both financing the further development of SSL as well as achieving quicker market penetration (obtaining tangible results in energy saving and emission reduction as soon as possible).

1.2 Solid State Lighting: the technology

The graph below illustrates the expected growth rates for SSL applications. While SSL technology is already widely used in mobile appliances and is increasingly winning ground in larger display applications, it is expected to grow significantly in the general lighting sector in the coming years. This scenario makes the publication of the Green Paper on SSL even more important as it can help shape market conditions and promote innovative lighting solutions in Europe. In this context the comments from the European lighting industry are exclusively directed to the applications for general illumination, as shown in dark blue in the graph below. General illumination includes applications like domestic and tertiary (office, industry, retail and outdoor) lighting. Excluded are automotive lighting and display lighting.

By 2025 a large part off the SSL volume is expected to be used for general illumination

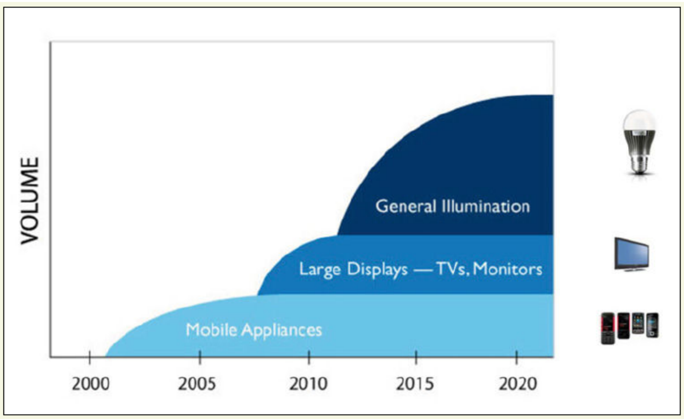


Fig: 1.1

[1] Ref: McKinsey & Company, Strategies in Light Europe, Frankfurt Sep28, 2010

SSL technology is developing fast and already in this early phase of development it can outperform some conventional lighting solutions in various applications. The first fully SSL fitted buildings are slowly starting to emerge in Europe, but we expect this trend to increase in the years to come as efficiency figures for the LED package are expected to further rise to a level of 150 - 200 lm/W (for warm white light with good colour rendering)!

As with every new technological breakthrough, first generations of products sometimes show imperfections, occasionally resulting in customer disappointment. The combined effect of (1) a new technology manufactured in low volume, (2) an initial lack of explicit minimum performance requirements, (3) the absence of effective market surveillance and (4) higher manufacturing cost, have resulted in some manufacturers launching (cheaper) products not living up to market expectations and adding to customer disappointment. To overcome this, structural measures in practically all parts of the value chain are required including additional R&D efforts, further improvement on technology and better information to end-users on the added-value of SSL.

Therefore, to better safeguard the successful implementation of SSL, the European Lighting Industry is strongly calling for all SSL products to fulfil minimum performance requirements as laid down in the EU (Ecodesign) Regulations for which reinforced and effective market surveillance is required.

Moreover, the Lighting Industry is also considering the introduction of an EU quality scheme to further increase and promote customer trust and guidance on SSL products. In close cooperation with the EU, the Lighting Industry would like to investigate various options for such a scheme.

1.3 The European Commission Green Paper

The EU Lighting Industry (represented by CELMA and ELC) considerations for the EC Green Paper addresses a number of key contributions that SSL can make for Europe in the area of energy saving and environment. It also ensures that only quality products enter the European market and negative customer experiences with SSL are minimized. The establishment of SSL quality schemes in Europe connected to market surveillance as well as promotion and awareness activities, need to be at the core of the Green Paper.

The Green Paper also needs to address the competitiveness scenario for the European SSL industry. This includes maintaining manufacturing capacity and green jobs in Europe, further building on unique strengths of the European industry in innovative integrated lighting systems and services, and new ICT opportunities that result from this.

Additionally, the Green Paper should highlight the potential arising from SSL technology to meet socio-economic and societal changes for the next decades. The anticipation of the impact from demographic change on the European societies (including inherent health aspects) and the role that SSL technology can play as a remedy to these changes also needs to be addressed in the Green Paper.

CELMA and ELC will address all the above mentioned issues in the following sections of this document and remain confident that it will constitute valuable input to the Green Paper and a good basis for a profound information exchange for the benefit of all stakeholders involved.

The European Lighting Industry welcomes this EC initiative and calls upon the Commission to look at holistic solutions in energy efficiency and lighting quality in the current environment and to outline a roadmap for a better integration between manufacturers, installers, consumers and other stakeholders along the value chain. The Green Paper on SSL will only be able to fully exploit its potential when interlinked with other interdependent policy areas namely Climate Change, Environment, Energy, Research and Innovation, Trade and Regional policy.

1.4 Nomenclature

Survey of relevant definitions: (in alphabetic order) see also IEC/TS 62504 ed. 2

CELMA	Federation of National Manufacturers Association for Luminaires and Electrotechnical Components for Luminaires in the European Union.
Colour temperature	The colour temperature of a light source is the temperature of an ideal black-body radiator that radiates light of comparable hue to that of the light source.
Control Gear (driver)	Electronic control gear : unit inserted between the supply and one or more LED light sources which serves to transform supply voltage or limit current to the rated values, and may include other control capabilities (dimming).
ELC	European Lamp Companies Federation.
General Lighting	Lighting of indoor and outdoor applications on basis of artificial light sources providing visible (mainly white) light, excluding the use of light sources in machines, equipment, etc.
GHG	Green house gasses.
Lamp	An end-user replaceable unit with a defined cap or base consisting of a source made in order tp produce an optical radiation, usually visible. It is designed to be part of a luminaire, but its performance can be assessed independently. It may include additional components necessary for starting, power supply or stable operation of the unit or for the distribution, filtering or transformation of the optical radiation, in case those components cannot be removed without permanently damaging the unit.
LED	Light Emitting Diode: solid state device embodying a p-n junction, emitting optical radiation when exited by an electrical current.
LED die	Block of semi-conducting material on which a given functional circuit is fabricated
LED Lamp	Light emitting diode (LED) lamp or "end-user replaceable LED module" is a light emitting device in which the light is produced by a solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current. Reference to LED: IEV 845-04-40
LED module	A unit supplied as a light source. In addtrion to one or more LED's it may contain further components e.g. optical, mechanical, electrical and electroninc, but excluding the control gear. Reference: IEC 62031
LED package	An encapsulated LED device encompassing electronic and/or optical means.
LED lamp self ballasted	A unit which can not be dismantled without being permanently damaged, provided with a lamp cap and incorporating a LED lifgt source and any additional elements, necessary for stable operation of the light source. Reference: IEC 62560
Lighting Controls	A device that controls electric lighting and devices.
(LED) Luminaire	An electrical device used to create artificial light and/or illumination, by use of an electric (LED) light source.
MOCVD	Metal-organic chemical vapour deposition (MOCVD) is a chemical vapour deposition method of epitaxial growth of materials for the manufacturing of LED's.
NMP	Nano-materials products.
NGO	Non government organisation
OIDA	Optoelectronics Industry Development Association (OIDA) is a US based not-for-profit association that serves as the nexus for vision, transformation, and growth of the optoelectronics industry.
OLED	Organic Light Emitting Diode.
OLED panel	Organic light emitting diode on substrate with encapsulation
OLED module	OLED panel with first level housing, electric connectors, driver and external (maybe macroscopic) measures for light out-coupling enhancement. Optional connectors to combine modules to a → OLED system
OLED system	OLED module in luminaire system including possible second level housing, dedicated driving schemes.
SME	Small and Medium Enterprises.
SSL	Solid State Lighting (inorganic or organic, LED or OLED)
Wafer fab	A manufacturing /factory composed of many repeated sequential processes to produce complete electrical or photonic circuits including LED's.
WEEE	The Waste Electrical and Electronic Equipment Directive (WEEE Directive) is the European Community directive on electrical and electronic equipment waste.

Table: 1.1

Section II: Current status, barriers and opportunities of SSL in Europe

2.1 Current status of SSL in Europe and the world

2.1.1 Benefits of SSL to EU27

Energy & climate dimension: In the context of the EU 2020 Strategy and the Energy Efficiency Action plan from 2006 and 2011, an accelerated change-over to SSL will help to achieve the EU 20-20-20 Energy Efficiency targets. Lighting is responsible for 14% of all electricity consumption in the EU. If all lighting would be switched to SSL lighting the electricity consumption would be 4% instead of 14% today. Lighting is the most cost effective way to reduce energy consumption and CO_2 emissions. The benefits of SSL in this respect are:

- Long lifetime
- Very high efficacy/ low energy consumption
- Colour variability and control
- Dimmable
- Instant start
- Spectral flexibility
- Also available as directional light source
- Flexibility of designs
- No mercury
-

Only SSL is able to combine all these benefits.

System dimension: New Information & Communication Technology (ICT) opportunities will result from an integrated systems approach with SSL. The use of controls, like presence detection, daylight control etc, will be key to further reduce energy consumption while also affecting the interaction and cooperation of any system in relation to SSL lighting. A next step will be the extension of communication and interaction between various (previously independent) control systems for improving or optimizing light quality, thereby enhancing peoples public and domestic lives, as well as road lighting (safety). Innovation platforms, standardization and new protocols will create high level employment and jobs.

Biological dimension: A specific, new and unexploited area of the application of lighting and SSL is biological effective lighting. Biological effective lighting is based on a recently identified receptor system in the human eye and its corresponding neural pathway to the brain. It influences our hormonal system and sleep/wake cycle, alertness, cognition and in the end our well-being and health. Artificial LED lighting optimized for an application can provide for better work and living conditions especially for elderly people. It can also contribute to higher productivity at work places and educational facilities. With these benefits, LED technology can strongly contribute in the management of demographic change in the EU.

Business dimension: The characteristics and benefits of the SSL lighting technology will lead to a change in business models in lighting. From recurrent revenues of replacement sales towards revenues over life by energy savings, requiring new innovative finance models. Intelligent and communicative systems will lead to lighting system providers. Tailor made solutions will become a growth opportunity for many SME's, taking up the possibilities the new LED technology offers for creative lighting design and cost savings.

Design dimension: The characteristics and specifications of SSL lighting technology is intrinsically different from conventional lighting technology, making it possible for industry and designers to embark on new dimensional concepts and design parameters. New forms of luminaires and lighting systems are possible including total integration into other building blocks (eg ceiling systems in offices)

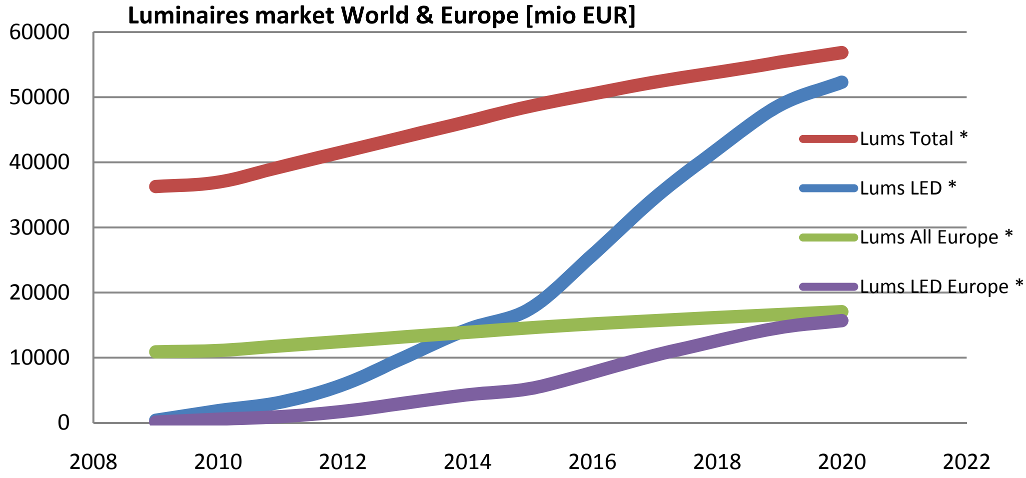
Quality dimension: Trough the dimensions and designs of SSL lighting solutions the quality and flexibility of the lighting installations can be significantly improved. For instance more light in the location where the light is really needed. And due to its controllability, in the required colour and with the required light spectrum.

2.1.2 Market value Europe and Global

The LED lighting market is split between replacement lamps and LED-Luminaires, the latter market covering such segments as architectural, consumer portable, residential, retail and refrigeration display, entertainment, safety and security, outdoor, off-grid, commercial and industrial luminaires.

The total luminaires world market is expected to grow to a level of € 55 Billion by 2020 of which the LED luminaire share will grow from a modest 14% in 2012 to over 90% in 2020. The European market is estimated to remain 30% of the total world market, also in relation to the share of LED luminaires. We estimate therefore the European LED luminaire market of 2020 at a level of roughly € 15 Billion.

Fig: 2.1

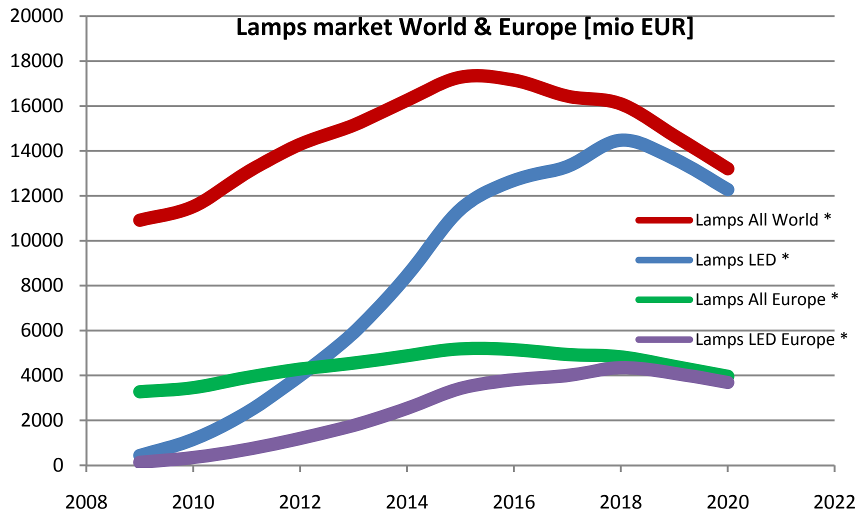


Source: ELC/CELMA

The (retrofit) lamp market shows a decline after 2015 as a result of the increasing lamp life of LED lamps and decreasing demand for replacement lamps.

We expect a quicker penetration of LED lamps in comparison to LED luminaires. At its peak in 2015 the world market for lamps (all technologies) will be at a level of € 17 Billion of which 66% will be LED-based. The figures for Europe are estimated again at a level of 30% of the world market.

Fig: 2.2



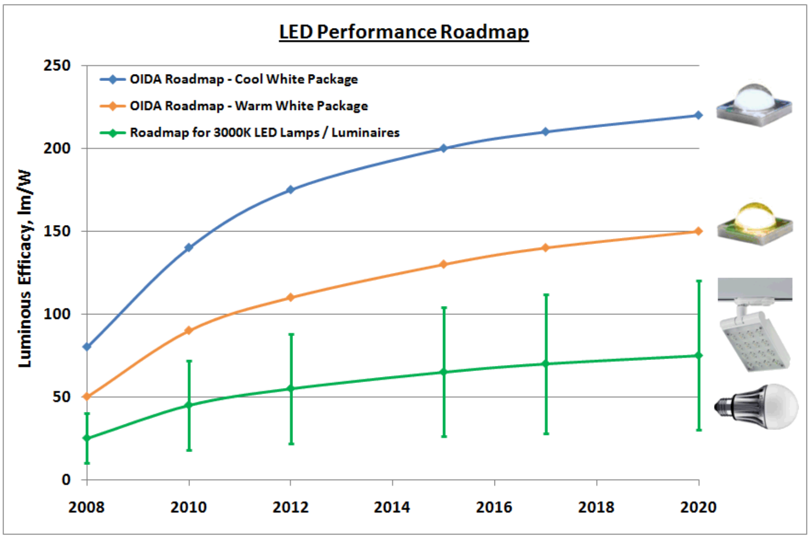
Source: ELC/CELMA

2.1.3 Technology Roadmap

The SSL technology is expected to further improve in the years to come. Various bodies (both government related and NGO's) have made roadmaps indicating the most probable efficiency increase. For further detailed information we refer to OIDA investigations, as well as various sources from Japan.

The graph below gives a summary of the expected development of the efficiency of SSL products, whereby a divide is made according to Colour Temperature (cool versus warm white) and on the basis of LED efficiency versus LED luminaire efficiency (at system level), the latter covering all the internal losses due to thermal constraints and the addition of optical equipment. The vertical lines illustrate the wide range of performance between good and poor products.

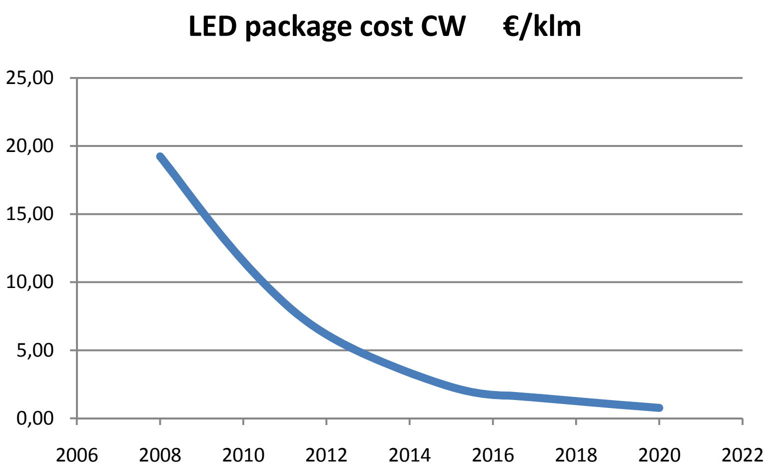
Fig: 2.3



Source: OIDA data 2010

In addition the projected cost development of a LED package (in €/1000 lm) is given (vs. halogen and cfli today: € 1-3).

Fig: 2.4

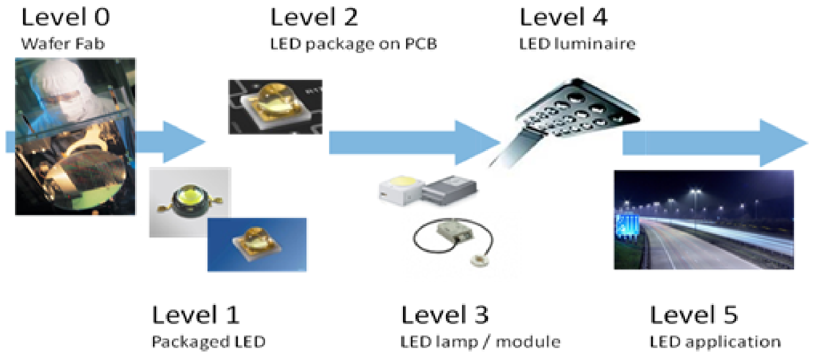


Source: OIDA data 2010

2.1.4 Value Chain

The SSL value chain is built-up from the initial process of manufacturing LED-chips (LED die level 0) in a Wafer fab), which are "packaged" into LED's in the next phase (level 1). In this form they can be used to be mounted on printed circuit boards (level 2) or even in LED lamps or LED modules (level 3) before being placed (together with corresponding control gear if applicable) in a LED luminaire or similar device (level 4). The application of level 4 products, including the integration and/or communication with other systems is sometimes called level 5.
Certain LED applications will show an even further increased grade of integration by direct mounting of LED-chips (level 0) on electronics (level 2) without having an additional LED packaging steps and separated electronic building blocks in the resulting LED modules (level 3).
Appropriate control gear is a separate contribution to level 3 not directly linked to the (semiconductor) activities on levels 1 and 2.

Fig: 2.5



What becomes clear from this graph, however, is that the current understanding is one of a classical value chain of the electrical industry in its square of manufacturers, wholesalers, lighting designers and installers. It appears to be necessary to include into this value chain those industries that are not immediately related to lighting but responsible for the overall design of built environments, namely town planners, the construction industry and, very prominently, architects.

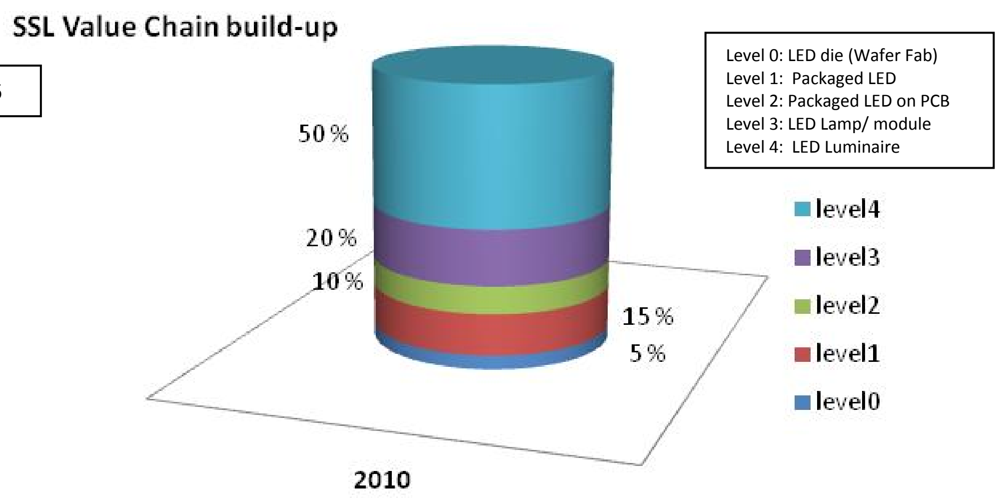
Compared to « classical » and predominately product related technologies, SSL technology offers the possibility to be more widely integrated in systems. The term « system » in this context should not be limited to lighting systems, but needs to be understood in a broader application as a system that integrates different components in the built environment. Such components may consist of building or infrastructure design, construction materials used for the realization of the design, information technology available in buildings and its surroundings as well as similar items that make the built environment.

The example of safety in inner cities might illustrate this concept. Safety for individuals depends largely on the presence of well-designed and well lit public spaces. It is obvious that in order to generate individually perceived safe structures in such public spaces the lighting design cannot be separated from the general spatial design and construction of the space. SSL technology can open new dimensions in creating a safer environment by offering adequate general lighting or adaptive tools for orientation. In this context we could speak of integrated lighting services. This, however, can only be the case when the lighting design and the lighting system is a part of the integral planning of the space from the beginning and not something that is arbitrarily added after the conclusion of the project.

Against this background it is advisable to enhance the understanding of the value chain for SSL technology and integrate spatial planners, architects and the construction sector into the chain.

The value being added in each of the steps of the SSL chain is presented in the following graph. It is observed that there is an increasing value towards the later phases (or higher levels). The relative comparison in value per level is presented here for the year 2010. Please note level 5 is not included as it is yet premature to quantify this value although it will be a very promising new area of business development.

Fig: 2.6



Whereas the overall cost (levels 0-4) is expected to decrease in the period up to 2020, it is expected that the relative contribution of levels 2 and 3, and of level 4 to a lesser degree, will increase in the period till 2020. The relative contribution of levels 0 and 1 will thus become less. This is presented in the next graph.

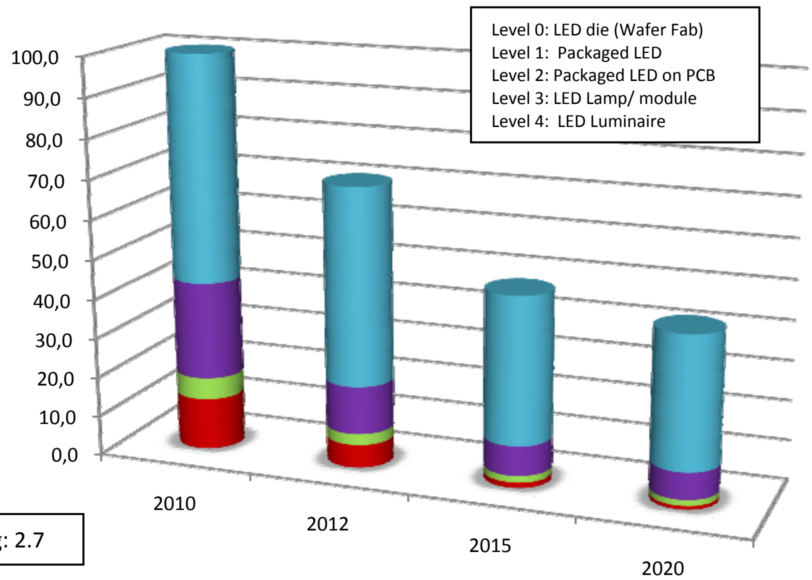


Fig: 2.7

2.1.5 Government policies, conditions setting and implementation

Certain countries in the world have meanwhile recognised the potential contribution of SSL in achieving their overall objectives in the area of energy and environment. This has been laid down in national policy documents and is accompanied by local supportive measures in both financing the further development of SSL as well as achieving a quicker market penetration (obtaining tangible results in energy saving as soon as possible).
In Europe so far only a few countries support SSL by a dedicated stimulation programme.
Examples of such countries having a clear policy statement on the contribution of SSL are illustrated hereafter.

Country	Korea	China	USA	Japan
Dedicated program	V	V	V	V
Funds	V	V	V	V
CO2 saving target			V	V
Social impact assesment	V	V	V	
Quality scheme			V	
Market surveillance			V	
Penetration target	V	V	V	V

2.1.5.1 Korea

The Korean government announced the “Low Carbon, Green growth” strategy in 2009 and SSL forms a major part of the plan.
Korea plans to invest 540.1 billion KRW (€ 355 Million) in the next five years, to accelerate eco-friendly segments such as SSL. The government also allocated 4.5 Billion KRW (€ 3.0 Million) for retrofitting existing lamps to LED lamps (second half of 2009).

As of now, Korean researchers have only developed LED technologies of 60 lm/W, but are projected to develop technologies of up to 120 lm/W by 2010, and 140 lm/W by 2012.
Distribution of LED lights will be progressed in phases, in line with the level of technology.
Current technologies only allow LED lights to be used for the following:

Current use	Traffic lights, emergency exit lights, signs, LED displays, car dashboards, backlight for small displays, stop lights

However, with developments, as luminosity increases, LED will be able to be used for the items below as well:

Future use	Lights, street lights, headlights for cars, lights for medical devices, light source for growing plants, backlight for large display's, camera flashes, light source for projectors

In addition by 2015, Korea expects that technologies are developed enough to use LED lights in houses and office buildings.

In order to drive the 'LED Light 15/30 Distribution Project' forward, an estimated 350 billion KRW is to be funded by the government with effects of 4.6 times the investment. Expected energy savings are estimated to be around 4 million TOEs-worth 1.6 trillion KRW. (Estimations by Korea Energy Management Corporation <KEMCO>)

List of Items to be Funded (Proposal)
1. Traffic Lights
2. Exit Lights / Lane Lights
3. Exchange of Halogen Lamps
4. Exchange of Incandescent Lamps
5. Channel Signs
6. Exchange of Fluorescent Lamps
7. Street Lights

Funding of traffic lights, exit lights/lane lights, and exchange of halogen lamps began already in 2007.

Distribution will be divided into 3 phases:
1. Early Phase
    a. Certification of Highly Efficient Energy Materials
    b. Test Distribution Business
2. Growth Phase
    a. Funding Policy
    b. Loans & Tax Credits
3. Mature Phase

<Distribution Scenario for LED Lights & Equipment>

Category	'07	'08	'09	'10	'11	'12	'13	'14	'15	Note
Traffic Lights	Certification ('02) Funding for District Energy Business				MEEP					
Exit Lights/ Lane Lights/ Exchange of Halogen Lamps	Certification Test Distribution		Subsidy					MEEP		
Exchange of Incandescent Lamps/ Channel Signs			Certification	Test Distribution		Subsidy				MEEP ('18)
Exchange of fluorescent Lamps/ Street Lights				Certification	Test Distribution		Subsidy			MEEP (/20)

**MEEP: Minimum Energy Efficiency Policy

The domestic LED market size is forecast to be valued at 15.4 trillion KRW in 2015 – the target year for having up to 30% distribution of LED lights.

2.1.5.2 China

During the past few years, LED industry in China enjoyed a rapid growth due to the special characteristics of the technology and favorable government policies. To streamline the various policies on the local level and further push the industry forward, on 12 Oct 2009, National Development & Research Commission (NDRC), together with five other ministries (Ministry of Science & Technology, Ministry of Industries & Information Technology, Ministry of Finance, Ministry of Housing, Urban & Rural Development and Administration of Quality Supervision, Inspection and Quarantine) issued *Comments on the Development Semi-conductor Lighting Energy-saving Industry* (the "Comments")[3]. The Comments outlined a few pressing industry problems which need to be tackled such as locally made LED extension material, middle/low end chips, above 80% LED chips based on power type, dependence on import as well as repetitive investment. The *Comments* also set forward the goals of 30% year-on-year increase by 2015. Several types of policy directions were

3 Please refer to attachment 1 for an unofficial English translation of the "Comments".

outlined in the *Comments* including overall coordination on local level, support through national key projects/funds, encouraging industry clustering, standardization, favorable customs tax rules, energy efficiency catalogue, etc.

Examples of China's supportive governmental policies and growing SSL industry are abundant. China's '863 program' provides financial support to local SSL enterprises on R&D. Seven regional SSL clusters have been set-up, bolstering about 700 LED manufacturers. The central government also advocates for the change-over to SSL in road lighting application via the "10,000 lights in 10 cities" program. The program was recently expanded to cover 21 cities in 2009. Further expansion to 50 cities by 2012 is foreseen, resulting in about 2 million installed LED light points.

Wang Yanwen, the deputy to the National People's Congress has submitted the proposal "To draw up the LED Industry Promotion Law" in order to intensify the support to LED industry.

Another major coordinated programme by the Chinese ministry of education and technology is underway for LED lights to be used in over 20 experimental cities. It is estimated SSL will create over 1 million job opportunities. The ultimate ambition set by the government is to build the local SSL industry into a business with $30 Billion (€ 22 Billion) export value.

2.1.5.3 United States of America (www.energy.gov)

Energy Savings Potential of Solid-State Lighting in General Illumination Applications (DOE Feb 2010)

The U.S. Department of Energy (DOE) has developed a comprehensive strategy to accelerate the development and market introduction of energy-efficient solid-state lighting for general illumination. The energy savings potential of this technology is significant, and the U.S. will benefit by focusing their resources and maintaining their global leadership in this technology.

The proposed Strategy of "Vision 2020" (DoE publication of March 2000)

Market Transformation Strategies 1 – 4:

Strategy 1:	Develop clear definitions and standards for lighting quality
Strategy 2:	Increase demand for high-quality lighting solutions by quantifying, demonstrating, and promoting life-cycle benefits to broad audiences
Strategy 3:	Strengthen industry education and credential lighting professionals
Strategy 4:	Accelerate the market penetration of advanced lighting technologies and systems, by providing incentives for R&D and reducing barriers inherent in today's specification and distribution methods.

Technology Development Strategies 5 – 7:

Strategy 5:	Develop advanced source and ballast technologies that enhance quality, efficiency, and cost effectiveness.
Strategy 6:	develop lighting controls with high levels of intelligence, interface capabilities, multiple levels of control, and ease of configuration.
Strategy 7:	Develop luminaires and systems that enhance quality and flexibility of light

The DOE report *Energy Savings Potential of Solid-State Lighting in General Illumination Applications* forecasts the energy savings potential of solid-state lighting sources compared to conventional lighting sources (e.g., incandescent and fluorescent). Using an econometric model of the U.S. lighting market, two scenarios are evaluated—one considering light-emitting diodes (LEDs) and one considering organic light-emitting diodes (OLEDs). For brevity, and since the two scenarios have similar estimated savings potential, only the LED scenario is discussed below.
The projections of efficacy, retail price, and operating life are based on work conducted cooperatively between DOE and the Next Generation Lighting Industry Alliance, a solid-state lighting technical working group managed by the National Electrical Manufacturers Association.

- Under the LED scenario, in 2030 the annual energy savings from solid-state lighting will be approximately 190 terawatt-hours, or the equivalent annual electrical output of about 24 large power plants (1,000 MW electric). At today's energy prices, that would equate to approximately €15 billion in energy savings in that year alone. Assuming the same mix of generating power stations, these savings would reduce greenhouse gas emissions by 31.4 million metric tons of carbon. The total electricity consumption for lighting would decrease by roughly 25 percent (with an assumed market penetration of SSL <50%) relative to a scenario with no solid-state lighting in the market—representing enough electricity to illuminate more than 95 million homes in the U.S. today. The total savings have a potential of even doubling this amount if the penetration would be higher (potential saving over 50%).

- Over the 20-year analysis period, spanning 2010–2030, the cumulative energy savings are estimated to total approximately 1,488 terawatt-hours, representing approximately €120 billion at today's energy prices. Assuming the electric power plant generating mix is held constant over the next two decades, these savings would reduce greenhouse gas emissions by 246 million metric tons of carbon.

The U.S. Department of Energy (DOE) conducts a comprehensive research, development, and commercialization program to systematically accelerate this groundbreaking technology. The overriding purpose of DOE's involvement is to encourage higher levels of SSL efficiency and quality than might otherwise be achieved. By 2025, DOE's research and development (R&D) goal is to develop advanced SSL technologies that—compared to conventional lighting technologies—are much more energy efficient, longer lasting, and cost competitive, targeting a product system efficiency of 50 percent with lighting that accurately reproduces sunlight spectrum.
As SSL technology matures, different funding mechanisms are available to support its development. Research partners and projects are selected based on such factors as energy savings potential, likelihood of success, and alignment with the SSL R&D plan.

The U.S. Department of Energy (DOE) has developed a comprehensive national strategy to guide market introduction of solid-state lighting (SSL) for general illumination. DOE's commercialization support plan draws on key partnerships with the SSL industry, research community, standards-setting organizations, energy efficiency groups, utilities, and others, as well as on lessons learned from the past (Full information and documentation is available on DOE's web site at www.energy.gov). DOE's role is to:

- Help consumers, businesses, and government agencies differentiate good products and applications.
- Widely distribute objective technical information.
- Coordinate SSL commercialization activities among federal, state, and local organizations.
- Communicate performance targets to industry.

2.1.5.4 Japan

Japanese lighting market by 2020: 100% of sales are LED / OLED (Published: 2010-8-5)

According to the 2010 revised Japanese *Energy Basic Plan*, carbon emissions in 2030 will be reduced by 50% (target value) as compared to 1990 emissions. The Japanese electricity consumption related to lighting will contribute for about 5% of the above figure. In 2005 about 15% of Japan's carbon dioxide emissions were caused by electricity for lighting. In order to reduce carbon dioxide emissions the Japanese government is convinced that the use of high efficiency LED lighting will be indispensable. The Japanese Government expects that by 2020 lighting equipment sales will consist of 100% of next generation high efficiency lighting products. By 2030, the implementation of next generation high efficiency lighting will be 100% (currently less than 2%) and the policy objectives will have been met. In the period 2010 to 2015 focus will be on policy implementation, while research and development aim to achieve a LED light emitting efficacy of 200 lm/W. In parallel OLED lighting will enhance the luminous efficacy to a level of 130 lm/W and reduce production costs to acceptable levels. Research and development programs are currently under the Japanese Ministry of Economy: it is led by the independent administrative corporation "New Energy and Industrial Technology Development Organization (NEDO)".
In addition, the Japanese government will make policy incentives to encourage businesses and the public to use LED lighting products:

- At a national level, Japan will propose energy tax relaxation, thereby forcing large companies to switch over to energy-saving products. Many local governments will recommend the use of energy-saving LED lighting products and provide subsidies at a local level.
- Regulations on subsidy and introduction programs of Japanese cities and counties may vary, but most will promote the use of energy-saving LED products. If LED lighting products meet the standard, they can apply for a subsidy of one fifth of the installation cost.

Because of the introduction and implementation of the subsidy policy, Japanese people show a high degree of interest in energy-saving products. Popularization of LED lighting will not only actively promote the objectives of the Government, but for those wishing to enter the Japanese lighting market, Japan's policy of LED lighting also provide a clear direction for future development.

2.1.6 Standardisation and product requirements:

Reference is made of the published and regularly updated ELC / CELMA Guide about LED standards: http://www.celma.org/archives/temp/CELMA_LED(AH)003C_CELMA_ELC_Guide_LED_related_Standards_2nd_edition_April2010.pdf. Note: version 3 to be published soon.

In order to benchmark the European initiatives in the area of standards and regulations on SSL, it is required to make a comparison with similar standards and regulations in other parts of the world.

The Green Paper should also be a format that identifies possible gaps in standardisation (eg new standards for CRI, and impact on EN 12464) and that contains possible remedies to fill these gaps. From a point of view of the European lighting industry it is important to approach this issue as a joint exercise with relevant stakeholders, e.g. CIE (Int.Commission on Illumination). As SSL technology is relatively new, and in order to make fair comparisons, it is important to have proper measurement methodologies or parameters in place which is currently not the case.

Presently various initiatives are running to obtain a complete overview of standards and regulations in place for LED lighting around the world. The following project activities should lead to the creation of a (preferably common) database on SSL product standards on safety and performance:

- International Energy Agency IEA Annex 4E SSL project www.iea.org/techno/iaresults.asp?id_ia=43
- UNEP en.lighten project www.enlighten-initiative.org
- Global Lighting Forum (GLF) LED WG www.globallightingforum.org

Further analysis should lead to an overview of potentially conflicting areas as well as remaining open areas still to be covered. Follow-up programs have to be initiated and brought to the attention of relevant bodies responsible for these standards and regulations.

Gap analysis:

Electro technical, standard not available yet. (under construction)
- performance for lamps with supply voltage smaller or equal 50V
- performance for double-capped LED lamps (retrofit)
- quality requirements for LED components
- lifetime prediction of LED modules, LED lamps and LED luminaires
- binning of LED components – luminous flux
- binning of LED components – forward voltage
- safety for double-capped LED lamps.
- safety for lamps with supply voltage smaller or equal 50 V
- safety of LED lamps, non-ballasted
- performance of LED lamps, non-ballasted

Electro technical, standards published at IEC, to be transposed as European standard
- terms and definitions, IEC/TR 62504
- performance of LED modules, IEC/PAS 62717
- performance of LED luminaires, IEC/PAS 62722-2-1
- safety of LED lamps with supply voltage greater 50 V, IEC 62560

Electro technical standards, where IEC and EN version are finalised and published
See afore mentioned web link

Light technical, at CIE under consideration, to be reviewed
- CIE standard on test methods for LED lamps, luminaires and modules: “To prepare a CIE standard on test methods for photometric and colorimetric performance of LED lamps, LED luminaires, and LED modules in cooperation with CEN TC 169 WG 7 and TC 34”

Light technical, at CEN
- EN 13xxx: “Measurement procedures for the photometry of LED lamps, modules and luminaires and the presentation of data”

As a guiding principle the European lighting industry calls for standards that facilitate a clear and undisputable comparison of conventional and SSL product solutions. Development of relevant standards for SSL products is of immense importance. As a guiding principle the European lighting industry calls for standards that facilitate a clear and undisputable comparison of conventional and SSL product solutions to be monitored via active market surveillance

2.1.7 Future Potential Threats for European Industry

The European lighting (light sources and luminaire) industry with an annual turnover of € 20 billion is the global market leader. It currently employs over 150,000 people and consists of thousands of luminaire companies in Europe, most of them SME's.

The whole value chain is covered in Europe: from equipment and LED manufacturers to lamp and luminaire manufacturers. In Europe we find one of the leading manufacturers of MOCVD machines, the number 3 producer of LED components. The European lamp companies hold a very large market share in the global lamp market and there are numerous larger companies and SMEs in the luminaire sector.

However, a critical analysis of future challenges will need to determine how the world of lighting / luminaires will look in the next decade and what impact this might have on European employment.

The lighting industry is confronted with a paradigm shift: Solid State Lighting (LED/OLED) will change the traditional world of lighting. SSL is more efficient, longer lasting and without the environmental concerns linked to fluorescent lighting.

New powerful semiconductor and consumer electronics industry players (particularly from China and Korea) will enter the (lighting) market and those companies (helped by their governments as outlined in Chapter 2.1.5.1 and 2.1.5.2 above) will manage to build up lead-markets, standards and new business and contractor models that will have a competitive advantage in the new markets.

These circumstances result in increasing competition for the European lighting industry, whereby it is important to compare the European situation with the one in China and the US. In Europe we have relatively fragmented R&D activities and only a few demonstration sites with little visibility and no experience sharing.

If Europe does not overcome this R&D fragmentation, over 150,000 European jobs--and potentially more in the growing SSL sector--are seriously at risk. The consequence of this not only relates to the lighting industry but has far greater reach and will severely affect adjacent sectors, such as the construction industry, the financial industry, etc.

2.2 Barriers and challenges for the implementation of SSL

The European Technology Platform Photonics 21 tries to bundle the R&D community in their workgroup "Emerging lighting, electronics and displays", but does not however have a particular SSL group. The European Lighting Industry fully concurs with the findings of the Photonics21 Platform, which states that there are many aspects influencing the speed of penetration and change-over to SSL products in the market. They range from inadequacies of the technology itself down to the burden of high initial investments before cost saving begins. This paragraph lists a number of such aspects; each one has to be addressed in order to speed up the market penetration of SSL and start harvesting its intrinsic benefits.

2.2.1 Research and infrastructure

Despite outstanding efficiency increases within just a few years, (O)LEDs have only recently started to enter the lighting market and there is still tremendous potential for improvement in order to become more competitive. In order to illustrate a broad and successful market penetration, two key factors are dominating R&D: performance and cost. It is crucial to address these factors across the whole product chain, from equipment and materials up to lighting systems.
The lack of integral management of existing research instruments results in an inconsistent approach due to priority setting per instrument. This notably holds for the calls on (nano)materials and production processes in NMP on the one side and the calls on photonics in the ICT programme on the other side. Topics across the product chain which are not directly linked to either materials or photonics are neglected, such as electronics or thermal management issues. The present approaches have the danger of bringing non-optimal products to the market, beating alternatives on one specific property, but clearly underperforming in other functionalities.
A collaborative approach across all relevant research areas as depicted below is needed in order to fulfil all relevant market needs.

Three overriding research themes are identified for the future:

- The need for *new materials* realizing better performance at lower cost. SSL will clearly be able to outperform incumbent lighting technologies in terms of efficacy, without sacrificing colour rendition. This performance however comes at costs substantially higher than today's lighting technologies.
- *Device integration and system architecture* to serve the different applications targeted. There is a clear tendency that SSL components need to be integrated in larger intelligent lighting systems to really serve the market needs. System architecture is the way to deal with the diversity of the different segments targeted, while creating volume leverage with standard processes and components.
- The need for *cost-down manufacturing*. Not only the materials but also the manufacturing processes and equipment have a substantial impact on the final cost build-up. High-speed assembly processes, larger area deposition and patterning processes as well as a much higher degree of automation will be key in order to bring cost down from the present level.
- Research on biological efficient lighting is still very young and should be further strengthened and accelerated to take full advantage of potential benefits

A more detailed list of research topics can be found in the second *Strategic Research Agenda of Photonics21*.

The absence of a value chain approach results in a strong emphasis on breakthrough research and less attention to the cost intensive down-stream activities of industrialization and commercialization, i.e.: applied research, system integration and market validation. Although breakthroughs in research are at the heart of successful innovations, one needs to tap into other competences and skills in order to translate them into successes in the market. As an example, the DoE over the last years has put substantial resources into applied research, product development and manufacturing next to basic research. The EU can be highly instrumental by developing instruments focusing on the downstream part of the value chain. It speaks for itself that this shift towards downstream activities should not happen at the expense of the upstream activities, but will require an increase of the overall budget devoted to SSL.

Although standardization is high on the agenda of the 7th EU Framework Programme (FP7) for Research, putting too much emphasis on it in the early stages of the innovation cycle might backfire and even become counterproductive. Standardization is a means to achieve volume leverage, balancing what technology can offer and what the market needs. Consequently, industry and SME's should be in the driving seat and the exact timing to embark in a standardization effort should be left to the dynamics of the market. In addition to the device level, Europe should also take the lead at the system level by setting open standards guaranteeing interoperability of the lighting solutions introduced on the market.

SSL requires massive investments in development and engineering infrastructure. Without coordination, similar infrastructures are built all over Europe, covering all potential application fields. It is recommended to give the existing centres a clear application focus and to make them better accessible to involved parties.

Europe's classical strength in lighting and its photonics industry, growing much faster than the rest of the world, make it the perfect place to build an effective eco-system and make a success out of solid-state lighting. Only by embedding start-ups and new entrants in this eco-system, will we generate future solutions, offering quality lighting at a lower carbon footprint. The knowledge sharing inside the eco-system will also be instrumental in boosting the speed of technology development beyond today's practice.
Speed in R&D on SSL is extremely important and also requires instruments that are less time and resource consuming than the existing ones.

2.2.2 Economics and policy

To better safeguard the successful implementation of SSL, the European Lighting Industry has adopted the policy to secure that all SSL products shall fulfil minimum performance requirements as laid down in the EU (Ecodesign) Regulations. Requirements for "Non-directional household lamps" have been published in the EU Ecodesign Regulation 244/2009 and the Lighting Industry is awaiting similar requirements for Directional lamps and other SSL products (Ecodesign Regulation Part 2).

Performance requirements for SSL products have not been explicitly formulated in Regulation 244/2009 which has led to confusion on the actual requirements for SSL products in the market. The Industry assumes that corrective measures on the lacking performance requirements for SSL products will be included in the expected Ecodesign Regulation Part 2. At present (Ecodesign) requirements for SSL products relate to (1) minimum efficiency for non-directional LED lamps and to (2) product information in general and lumen equivalency with incandescent lamps more in particular.

Some manufacturers have launched (cheaper) products that did not fully comply with the available EU Regulations and did not live up to market expectations. The danger that may result from these unsatisfying experiences with low quality products is that customers may postpone their purchasing decisions or even refrain from purchasing SSL products forever. This uncertainty about the level of quality of SSL products has to be removed from the market as quickly as possible.

To overcome the situation that (SSL) products do not meet the minimum requirements of relevant regulations, effective market surveillance in the EU is indispensable. At present market surveillance is the responsibility of each individual EU member state. The Lighting Industry observes that the execution of effective market surveillance on these products is very limited or not existing at all, due to the low priority assigned to the subject in many EU member states.

The EU Lighting Industry calls upon the EU to address the need for effective market surveillance as a key condition for (re)installing customer trust in the SSL products and in this way obtain a tangible contribution of the SSL technology in achieving the overall EU objectives in the area of energy and environment.

Major European SSL players cannot afford to launch products that don't fulfil the ruling EU requirements. The risk of creating an "unlevelled playing field" due to the absence of market surveillance is rising and may even lead to economic disadvantage for the EU Industry.
The recent changes in the EU within the Ecodesign framework Directive for energy related products, 2009/125/EC in particular, has led and will lead to the introduction of product performance information systems which in many cases are new for the consumer or user of the product. The same applies for the lighting market and the SSL market in particular.

The Lighting Industry believes that a joint approach of EU and industry is required to better inform the market (and all players therein) on the changes and new performance criteria and units. An active information and communication approach is necessary to accompany the market change-over to new SSL product solutions if we want to achieve the overall EU objectives in the area of Energy and Environment. It is also suggested to install a clear measurement protocol and standardized set of parameters and representations to create a clear set of verifiable performance indicators allowing end users to compare products easily.

SSL products are presently introduced at elevated price levels if compared to conventional lighting products. As lighting products have been generally perceived in the past as "low value" products, this creates a major barrier for a fast change over to SSL products in the consumer market. Purchasing decisions are not made on the long term total costs of ownership but only on initial costs. Although in the B2B environment the TCO is more often considered as a driver in the decision making process, the initial cost remains an important factor.

Although it is expected that SSL cost levels will decrease in the years to come (compare with similar scenarios in the consumer electronics markets: computers, flat-screen TV, etc) the issue of high initial cost is considered a major purchase hurdle for the average consumer who will remain confronted with the fact that an upfront investment is required (even if the overall pay-back for SSL is evident and convincing).

This may necessitate the introduction of specific tools or arrangements whereby the initial financial penalty for the purchase of SSL products is relieved. Reference is made of similar initiatives in some countries, both within and outside the EU. As the introduction of such arrangements requires a close tuning and coordination of financial and fiscal measures at EU and Members State level, the European Lighting Industry invites the EU to initiate and address this subject at the earliest possible moment.
Certain countries in the world have meanwhile recognised the potential contribution of SSL in achieving their overall objectives in the area of energy and environment. This has been laid down in national policy documents and is accompanied by supportive measures in both financing the further development of SSL as well as achieving quicker market penetration (obtaining tangible results in energy saving and emission reduction as soon as possible).

It should also not be omitted that there exists consumer behaviour in the domestic as well as in the tertiary sector that is characterized by a certain hesitation to make purchasing decisions in favour of LED solutions. This is not only owed to price barriers but also to a lack of proof of concept. Purchasing decisions are still too often guided by an approach to wait for the rapidly available "better solution" which results in a "wait and see what comes next" attitude of customers. It may also be the case that the long life time of LED might even deter customers (especially in the domestic sector) if there is no full and well communicated guarantee of that large life time span of more than 25.000 hours. The lifetime expectations customers have of familiar lighting products are much shorter and customers must adjust expectations to the tremendous capabilities of LED technology, in order to avoid disbelief and non-acceptance.

Moreover, it has to be pointed out that for many customers the benchmark of lighting quality is still the incandescent light bulb and improvements on the quality side are of utmost importance.

At present the European Union does not have an overall and coherent policy on SSL. It is of utmost importance to the European Lighting Industry that the publication of the EU Green Paper on SSL becomes the start of an active approach in which the objectives and opportunities, as well as the generic conditions for achieving these objectives, have been laid down as a consistent basis for action for all involved DG's.

SSL component manufacturers around the world are presently heavily investing in large scale manufacturing capacity. This is primarily a consequence of the foreseen mass introduction of LED backlighting for LCD TV (instead of Cold Cathode Fluorescent lamps), but also because of the expected take-up of general lighting applications in the immediate future. There is the potential risk that the ramp-up of SSL production capacity is confronted with a lack of market demand due to the hesitating SSL penetration in the general lighting market.

2.2.3 Industry

The European lighting industry presently employs about 150.000 people (*source: Eurostat*). If we apply a split-up according the value chain as provided in chapter 2.1.3 we can provide the following split-up per level, whereby it is necessary to combine the levels 0 and 1, as well as levels 2 and 3 as those products are mostly made by the same company.

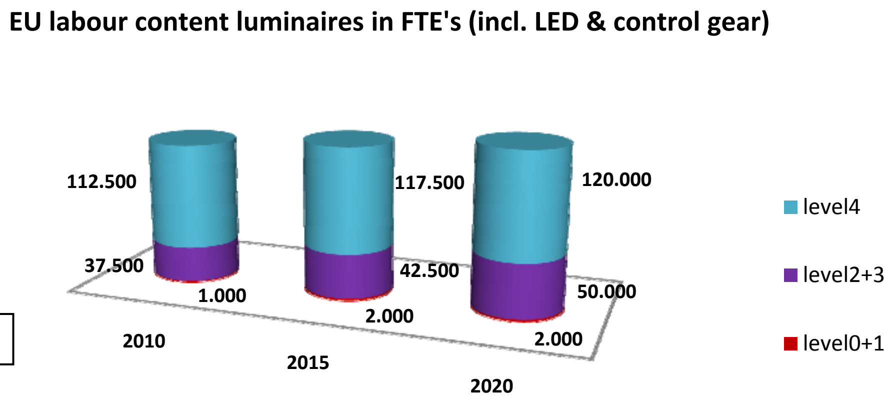


Fig: 2.8

It can be noticed that the employment size of level 0 + 1 manufacturing is (although technology-wise of importance) relatively low and will decrease as a percentage of total employment in the lighting sector towards 2020. We also observe that the relative contribution of level 2 + 3 will increase as we expect the content of these products to become more important, because of the growing market of LED modules in luminaires but also because of the increasing “intelligence“ of such modules being able to communicate with the outside world and other systems.

The European lighting industry is also convinced that SSL can become a growth opportunity for European SMEs. In particular the possibility of delivering tailor-made solutions to clients in the domestic or tertiary sector based on LED technology can boost SMEs’ market presence.
There are already a multitude of examples available where creative start-ups, off-springs from technical universities and family run companies with a long tradition in “classical” lighting have taken up the possibilities the new technology offers for creative lighting design and savings opportunities.

In this context the European lighting industry regards the Green Paper also as an appropriate tool to support SMEs in their market access, research funding and to increase their overall visibility. It could be value adding to concentrate on a better information stream towards SMEs that can enable them to better react to market and funding opportunities. The positioning of SSL as a future key enabling European technology vis-à-vis already existing SME networks should also be addressed. A comprehensive strategy and roadmap will help SME’s to identify sustainable business opportunities and business models. Last but not least further growth of the lighting industry and sector will have a spin-off to other sectors like finance, construction etc.

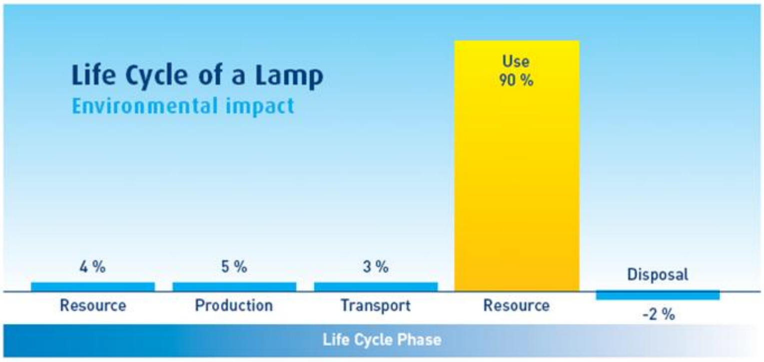
2.2.4 Environment

From an environmental point of view the question of whether a fully functioning European WEEE recycling scheme for SSL products exist, remains important. But equally important is whether all Members States have the same perception and interpretation of EU legislation on the applicability of WEEE.

Life Cycle Perspective of SSL

In order to evaluate the environmental impact of lightsources like SSL, it is important to look into the total life cycle of a lamp. During the life of a lamp 90% or more of the lamps environmental impact is represented by the use phase, which is the energy consumption of a lamp. The environmental effect of energy consumption originates from the power generation, where fossil energy carriers like oil, natural gas or coal are converted into electricity. Resources (materials), lamp manufacturing and lamp disposal have a small impact on the environment compared to electricity consumption during lamp use. From an environmental point of view this means that energy efficient lamps like SSL are the most beneficial to the environment.

Fig: 2.9



Source: ELC

Material scarcity

In order to earmark SSL materials as scarce one of the three following criteria should apply:

- The material is highly suited for the application and cannot be replaced (3) or alternatives with competitive cost performance ratio are still not available (2)[4]
- The natural sources of the material will be exhausted within 50 years from now[5]
- More than 20% of the material supply is consumed by the electronics Industry

Material	*Application*	*Suitability*	*Exhaustion*	*Electronics*
Aluminium	Heat sinks	1	OK	**> 20%**
Arsenic	LED	**3**	OK	< 20%
Europium	Phosphors	**3**	OK	< 20%
Gallium	LED	**3**	**n OK**	< 20%
Indium	ITO	**2**	**n OK**	< 20%
	LED	**3**	**n OK**	< 20%
Yttrium	Phosphors	**3**	OK	< 20%

All materials mentioned in the table above except for aluminium are hard, if not impossible to replace. For two of them, i.e. Gallium and Indium, the projected usage till 2050 largely exceeds the existing natural sources. The need for heat sinks in combination with LEDs will even increase the demand for aluminium by the electronics industry and its dependence on this material.

Material toxicity

The shift from incumbent technologies towards SSL will enable us to efficiently generate light without the need to rely on mercury.

In the recent months, proposals have been submitted to upgrade the toxicity level of GaAs and InP. Both are only relevant to SSL as far as red (Ga As) and orange (AlInGaP) LEDs are concerned. Their Arsenic content however is very low , i.e 1.7E-09 & 4.8E-08 grams per LED. This is compliant with Proposition 65 Legislation in USA (max. intake 10 microgram/day). So LEDs have very low content of this alleged toxic material; and these are structurally bound, so not prone to leeching. InP is not present in any LED as such. InGaP (indium gallium phosphate) is used and is a different material than InP (indium phosphide). However the regulators may consider this to be the same from a toxicity perspective.

The implication of the proposed new classification would mean a much greater effort in releasing products based on these materials, largely slowing down the deployment of the promising SSL technology. Therefore, any new classification should be done carefully with special attention on the applicability/relevance of SSL.

The environmental evaluation of a new technology such as OLED technology faces many challenges, although at the same time it is an opportunity to take action, in early stages of development, to prevent potential negative effects on the environment. Recyclability of OLED tiles and modules and toxicity of novel component materials must be addressed to enhance the eco-design of OLED lighting.

2.3 Opportunities for the further development of SSL

It has been pointed out already and is a guiding principle in this paper that in regions outside Europe there appears to be a more advanced status of acceptance and market penetration of SSL. The Green Paper should address this issue by proposing a benchmarking process that should enable a deeper understanding of the reasons for such advantages. Such a

[4] N. Morley and D. Eatherly, Materials Security – Ensuring resource availability for the UK economy, Oakdane Hollins, Chester, UK (2008), 36

[5] K. Halada, M. Shimada and K. Ijima, Forecasting the consumption of metals up tp 2050, j. jap. Inst. Metals, 2007.71(10): p. 831-839

benchmark study was already suggested as part of the "AcceLed project" proposal that had been submitted under the call for support actions issued on 28 September 2010. It is of high importance for the European LED value chain, including the regulatory bodies on national and EU level, to clearly understand the socioeconomic and political drivers behind a more successful market situation for SSL outside Europe.

In this context it becomes clear that the European lighting industry in all circumstances prefers activities on an EU level to those on merely a national level. Although a number of EU Member States have taken highly value adding measures, especially in the field of funded scientific research, the future challenges related to market penetration, international benchmarking, as well as definition and implementation of technological leadership have to be addressed on a European level. The European lighting industry calls upon the EU Member States to integrate their efforts in the field of SSL and make the development of this key enabling technology a joint effort.
The need for concerted and integrated European policies is also obvious when looking at the supply and demand side of industry:

Supply side:

- Collaborative effort is needed to increase the performance of SSL solutions: from LED chip, lamp to luminaire and lighting solutions – cost and quality is in the focus.
- The lighting and SME based luminaire industry needs to act at the European scale to overcome fragmentation and to gain critical mass in latest SSL development and broad deployment.
- To assure a broader acceptance of SSL, industry needs to establish European standards and quality schemes jointly. National rules and regulations will not have any impact compared to the huge initiatives from the US or China. (Note: Early CFL products were generally unregulated, and it allowed low-quality products onto the market which hampered the transition to energy efficient lighting).
- Show cases should be stimulated and promoted on a European scale

Demand side:

- Only a SSL lead market at the European scale will offer the potential to significantly reduce CO_2 consumption in Europe and create jobs in this growing market.
- Deployment of SSL in Europe needs to go hand in hand with European regulation and public procurement in order to have any significant impact.
- Development of business oriented financing models based on a European SSL quality / energy efficiency scheme with the public (communes) and business community (contractor)

The European industry is convinced that co-operation and cross fertilization has to be ensured on a global level. The need for increased international co-operation exists on all levels of SSL technology, from chip production to integrated SSL systems and installations. In this context it is evident that non-integrated policies have the potential to harm the development of the European industry.

2.4 The role of OLED in the SSL revolution

Next to LED based SSL technology, over the last year Organic Light Emitting Diodes (OLED) have entered the market.)
OLEDs are light-emitting diodes (LED) in which the emissive electroluminescent layer is a film of organic compounds which emit light in response to an electric current. This layer of organic semiconductor material is situated between two electrodes. Generally, at least one of these electrodes is transparent.

Today all OLED manufacturers focus on the high end luminaire market in order to explore with lighting designers the added value potential this technology can bring to the market.
Although different technology options are still open, in the lighting domain all manufacturers make use of small molecule MOCVD deposition on glass substrates. Most products available on the market show an efficacy of around 25 lm/W, the best in class number being 45 lm/W. The typical size of OLED tiles today is limited to 50 cm^2, while the selling price pivots around 10,000 €/m^2. Consequently there is still a long way to go in order to reach a price performance ratio competitive with the existing lighting technologies, inclusive (inorganic) LED technology. The major technical hurdles to be taken are improved light out-coupling on the one side and better performing blue emitters on the other side.
Even when OLEDs for lighting would reach an efficacy of 100 lm/W at a cost of 100 €/m^2, they are not able to outperform slim LED solutions, similar to the ones used in flat panel backlights. The added value of OLED technology should come from its size, flexibility and from cost prices at the €/m^2 level. This would probably require the use of printing technology on metal or plastic foils, technologies lagging behind for a few years with respect to the present OLED technology.
Consequently it is expected that OLED technology will play no substantial role yet in the massive market uptake of SSL in the coming decade. In view of the anticipated strengths of printed flexible OLEDs the present research effort on OLED technology should be continued, because it might herald the next wave of SSL in the lighting domain of the future.

Worldwide the lighting industry is experiencing a radical change as a new era of lighting offers a completely new way of illumination. This change is driven by the need for environmentally friendly light sources exhibiting high efficiency; no environmentally harmful components; elongated system life-times; and rapid progress of technologies for Solid State Lighting (SSL) such as inorganic and organic LEDs.
The lighting market today demands higher energy efficiency and longer lifetime on component levels as well as system approaches for intelligent light control. These factors compensate for increasing energy prices while reducing global CO2 emissions. SSL is a perfect solution to these issues, since if offers the potential for the highest efficient light source. Classical lamp components will be replaced by solid state lighting solutions, delivering dedicated light only when it is needed. The long lifetimes of SSL will replace the traditional lamp-replacement market, and will change the importance of well-designed luminaires. And OLEDs will migrate to totally new applications where today none of the existing lighting solutions are applicable.
This change will have great impact on the current lighting market and business models, and is comparable with the change from vacuum radio tubes to the transistor or from CRT picture tubes to LCD. This technology platform transformation will offer many opportunities for new players to enter the lighting domain.
Compared to inorganic LEDs which are already in a relatively mature technology state, OLEDs have some advances yet to make for broadly entering the general lighting market.

OLED technology is covering an integrated value chain as depicted in picture 2.10. This value chain starts with material production, covers tile fabrication and module manufacturing and also includes application solutions. This figure is furthermore meant to clarify the use of the terms *tile, module* and *system.*

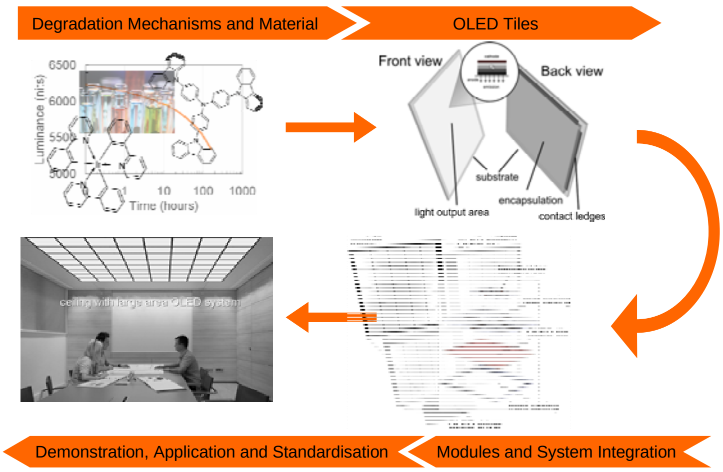


Fig: 2.10

One of the major applications for large area OLED usage is general lighting. The global general lighting market is a Euro 60 billion market, which consists of lamps, electronics, controls and luminaire systems. Europe is still in the lead for this market, with over 150.000 employees in several thousand companies working on lamps, materials, production, equipment, designs, and lighting fixtures.

Two other important areas with respect to the market have to be considered: For *broad* penetration early standardisation is necessary; for *successful* introduction wide acceptance has yet to be reached. Furthermore, market acceptance for OLEDs in the very conservative general lighting industry has to be achieved. This is highly dependent on standards: luminaire manufacturers can contribute to the rapid distribution of OLEDs in different application areas much better, if standards for connects, drivers and usability of tiles are established.

2.4.1 Economical Impact

As stated in the Strategic Research Agenda of the European platform for Organic & Large Area Electronics, the classical worldwide lighting industry is led by European Companies and has a European R&D base. In the classical lighting business, the key European players hold a worldwide market share of more than 40% of the lamp market. The large industry delivers standard light sources to the luminaire manufacturers who produce individual luminaires for various application fields.

In Europe, more than 1000 companies are in the business of luminaires and electro technical components for luminaires. These 1000 producers from more than 13 European countries include a majority of small- and medium-sized companies and directly employ over 100,000 people that generate more than 15 billion Euros annually. Moreover, Original Equipment Manufacturers and other companies within the supply chain are benefiting from lighting industry to a large extent.

Today this lighting industry has to face a paradigm shift! SSL is becoming the most efficient lighting technology which is able to migrate into more and more application fields towards a broad market. The high brightness LED market reached US$ 5.1 billion in 2008 and is forecast to grow at a CAGR of 24.0% to US$ 14.9 billion by 2013 according to a study by Strategies Unlimited11. The biggest push in the SSL market is expected to occur after 2012 with the broader penetration of LEDs in general lighting.

However new players, historically coming from consumer electronics in Asia, are also quickly migrating into the solid state lighting market. Since OLED is seen as the second solid state lighting technology, this SSL push will also increase the market opportunities for OLEDs. Because of its nature as a thin and large area light source, OLEDs will not substitute for any of the classical point source lighting technologies. Instead OLEDs will open up new application cases next to the point source LED.

The potential for OLEDs in the general lighting market is predicted to be huge by different market forecast institutes. The potential could lead to a new era in the lighting business. The global market size for OLED overall (display and lighting) is forecasted to reach € 4 Billion by 2015 (Source Photonics21). This will be dominated by the broad implementation of OLED displays within smart phones or larger TV applications, while OLED lighting will be a minor percentage. OLED lighting devices will be ubiquitous in our everyday life if the underlying technology roadblocks to efficiency and processing costs are addressed.

The overall success in the market of Organic and Large Area Electronics (OLAE) lighting largely depends on OLED display and OLED lighting in general. Followed by other technologies, like organic photo-voltaics, as the next wave. The overall OLAE market potential globally is estimated at more than € 100 Billion in the mid-to long-term future. Europe possesses a full set of excellent technical competences for realising OLAE opportunities. Thus Europe is presently in the driver seat because of the successfully funded consortia like OLLA and OLED100.eu. For obvious reasons it is imperative to maintain this R&D position-- even expanding it--to maintain global leadership, jobs and solid state lighting innovation in Europe—and lead in OLED technology. Key for making OLED lighting applicable in different application scenarios is not a new efficacy record but a well-balanced combination between acceptance, performance (in particular quality of light which is by far the biggest problem with both LED and compact fluorescent sources) and cost.

Europe has to have the opportunity to develop a strong position to maintain and extend its leading position in the lighting business. Large integrated projects including European production facilities are necessary to keep that lead. Such projects will not only have a huge impact on the opto semiconductor, lamp and electronics industry with its OEMs but moreover serve as leverage to push the OLED luminaire business in Europe. Thus a great impact on the broad lighting industry in Europe and beyond is expected.

Besides solving technological issues, the key for the lighting industry will be to manage the paradigm shift across the whole value chain and reach broad acceptance and standardisation. OLED lighting in SSL is a completely different light source compared to today's offerings and thus requires fast learning and adaptation especially from luminaire manufacturers as they need to shift their focus towards electronics and thermal management which for many is a totally unknown field.

And last but not least, the luminaire manufacturers need to better understand what OLED lighting can offer and what the end user wants in terms of dim-ability and colour tune-ability. Broad acceptance and perception studies have to be carried out offering invaluable help to all luminaire manufacturers. Dissemination actions such as workshops will make sure that European luminaire manufacturers can profit from results achieved.

Besides the economical impact for companies currently involved in OLED lighting, one of the broader goals of pushing OLED research and development is to strengthen the luminaire business in Europe in the near and mid-term future.

External OLED market predictions have shifted backwards over the years, because the application development was not developed as fast as the device technology. Today luminaire companies do not yet have suitable solutions to connect and integrate OLED panels in lighting systems and high efficiency drivers are still missing.

Due to the huge costs from the R&D equipment used today to produce small series, only the design market could be addressed. In 2008 the first design luminaire was introduced by OSRAM OS and Ingo Maurer. Uncertainties are still connected with technological roadblocks, reliable production of reliable and durable tiles and the broad market acceptance as well as cost issues. First small series engineering products have been commercialised in 2010, targeting demonstrations and smaller high end markets which are less price sensitive. From this point the OLED lighting market will gradually develop towards usage as general illumination within the next five years. A broader market introduction will be only possible once efficiency and cost levels are comparable with other luminaires.

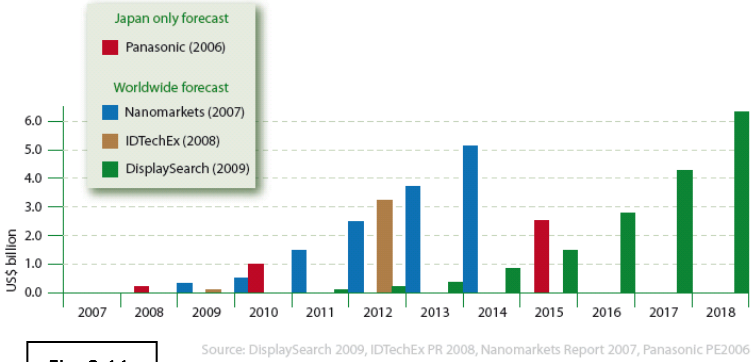


Fig: 2.11

Figure: Overview of OLED lighting market predictions from several market research companies. Note that some predictions also include luminaires. (Source Cintelliq, 2009, http://www.cintelliq.com)

With the imminent threat of diffusion of this technology to the Far East, as happened to OLED displays, combined and integrated effort is necessary to keep the European lead in lighting and OLAE.

2.4.2 Technology

Together with LEDs, OLEDs are currently entering the lighting market as novel light sources and alternatives to existing lamps. To develop the OLED lighting market, massive investments in research and development are required. For the next five years the R&D focus will be on small and medium sized tiles to reach high efficacy and luminance levels with appropriate color quality on rigid substrates, including transparency. Due to its very specific form factors (compactness, lifetime, robustness, flexibility, transparency and color changing) OLEDs create totally new application fields for lighting (e.g. ambience creation, light embedded in all kind of products like furniture, staircases, walls, floors, curtains, etc.) Beyond 2014 the R&D for OLED lighting needs to focus on low cost area approaches (for both R2R and glass). This will enable to migrate OLED technology into the general lighting market.

As OLED are area lights, it should be noted here that OLEDs are a different type of light sources, which combines the lamp and fixture trough its specific form factor. In order to spread the usage of OLED lighting, close cooperation with the large number of European luminaire manufacturers as well as acceptance by end-users, is essential for the overall success of this lighting revolution.

Individual records in efficiency OR lifetime OR brightness of single devices have been achieved in the past proving the tremendous potential of the technology, but now concentration on an integrated approach is necessary. An overall performance of the complete OLED system AND lowered system costs has to be combine with fostered awareness.
We believe that the unique features of OLEDs: high efficiency and exceptional quality of light with unrivalled aesthetic appearance, justify further effort.

To make OLED lighting a success story the following objectives will have to be tackled:

- Remaining technological roadblocks must be removed for market acceptance, but widespread use is only possible with reasonable costs.
- Cheap OLEDs with great performance rely on market acceptance and standardisation work for the implementation in general lighting.
- A certain threshold performance should be reached by OLEDs if they are to measure up against competing technologies, even if costs are in a reasonable range and unique selling points have been clearly demonstrated.

Europe is able to address the whole OLED lighting value chain: from materials and technologies, over equipment development, OLED panel manufacturing, electronics and assembly, luminaire design and all integration aspects. To advance the development of the European OLED lighting industry, three top priority R&D fields are selected:

Priority 1: High quality white light devices for general lighting based on OLED technology

Priority should be given to maximizing the external quantum efficiency, reliability and lifetime of OLEDs (beyond > 100lm/W at > 10,000 hours lifetime) at higher brightness levels (5000 cd/m2) through stack development and testing procedures, as well to developing integral solutions for OLED at the luminaire system level, such as OLED tiling concepts, concepts for efficient and integrated driver electronics, or cost-effective and reliable encapsulation enabling 10-15 years shelf life. Practical simulation tools with good predicting power for optical, electronic and thermal OLED stack simulation are encouraged to lower the enormous stack development efforts.

In the long run, projects are needed which target the development of flexible, conformable and transparent devices, including suitable materials (substrates, barrier layers) and cost effective processing.

Priority 2: Novel materials for highly efficient, low cost and innovative OLED solutions.

Projects that target breakthrough materials such as highly efficient (blue) emitter, charge transport and injection materials, and materials specially suited for high speed solution processing, or materials optimized for high temperature vapour phase deposition, with the intention of shortening throughput times. Also materials with higher conductivity that enable ticker layers and more robust designs are desired.

New, predictive quantitative analysis methods for materials properties are needed, supporting the screening of novel OLED materials.

Further interest is in projects targeting low-cost thin film encapsulation, enabling very high shelf-life and application robustness, and supporting low cost and flexible substrates.

As a next stage, the development of OLED materials stable in air would mean a breakthrough in this respect making encapsulation obsolete. It is expected however, that these materials will have lower efficiency than state of the art materials.

Special attention should be given to cost effective alternatives for (printable) ITO, transparent electrode materials and to low-cost bendable substrates.

Priority 3: Novel, very low cost production processes for OLEDs.

Priority should be given to projects that will bring gas-phase deposition for OLEDs below < 100 €/m2, and integrate lamination or printing processes for (parts of) OLED panels. Special focus should be put to R2R production aspects for manufacturing, as well as process and know-how development for large scale industrialized production, such as modelling and control systems for fabrication. R2R manufacturing may rely on gas phase based deposition of the functional organic layers in the first phase. On the long run high definition and ultra-fast printing needs to be addressed. The interaction between processing and integration aspects in its final applications should also be investigated.

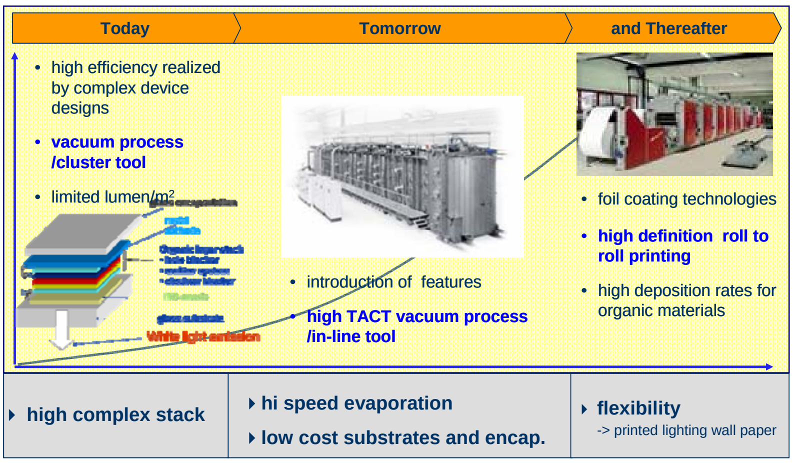


Fig: 2.12

Research Topic	Technical Objectives	Short term	Mid term	Long term
OLED Materials	Highly efficient emitter materials and materials for charge transport and injection;	Suitable for gas phase processing	Suitable for solution processing.	Air stable and materials with high conductivity (R&D)
	Materials suitable for high process operation temperatures		Suitable for high speed deposition	High temperature stable materials (automotive)
	Improved electrode materials	ITO with printed metal shunt lines	TO alternatives	Percolation Anodes
	Encapsulation enabling high shelf-life time;			
	better packaging materials for perfect light out-coupling (nanostructured optic layers)	Stable under ambient conditions	Also stable under high temperature conditions (e.g. automotive)	>20 years stable for integration in architecture
OLED Devices	Device efficiency	>100 lm/W (R&D)	>100 lm/W (prod) @ high lifetime & lum	>120 lm/W (prod)
	Reliability (at higher temperature, less differential ageing)	25°C	50°C	80°C
	Less short circuits	Stack development	Stack development	
	High lifetime/ high shelf life-time	>10 y / >5 y	>15 y/ > 10 y	> 20 y/ > 15 y
	High quality white (CRI, Color over angle, homogeneity)	>80 CRI	>90 CRI	> 95 CRI
	Transparent devices	50-60%	65%	>70%
	Conformal/flexible devices	rigid	conformal	flexible
	Drivers (high efficient, new concepts (integrated design, miniaturized))	Miniaturized high efficient tools	Integrated design	Advanced tools with predictive power
	Simulation tools for modelling devices		advanced tools	
OLED Production	Novel low cost & high throughput production processes	Low-cost vacuum deposition	Hybrid OLEDs with > 1 layer from solution	R2R in vacuum ord ander ambient conditions
	OLED technologies development	CVD	Also laminating & printing	
	Equipment development, in line diagnostics & up-scaling	OVPD		Also R2R
	Cost decrease	Decrease	< 100 €/m2	< 70 €/m2

2.4.3 Early Applications and Acceptance

In March 2007 the European Council agreed to save 20% of green house gas emissions by 2020. The potential for energy saving through better efficiency is enormous as 20% of worldwide energy consumption is utilised for lighting. With system efficiencies of 100 lm/W, OLEDs will be among the most efficient light sources. Further characteristics of green light sources include high energy efficiency throughout the life cycle, reduced toxicity and the recyclability of tiles, modules and systems, and additionally efficient material use and possible recycling during production. These aspects have to be elaborated for OLEDs to install OLED lighting as a true green, environmentally friendly light source.

Requirements for OLEDs have changed in the last years, high efficiency and very high life-times are no longer strong necessities. The market demands the unique selling points of OLEDs, namely: aesthetics, high fill factor, "nice-to-look-at", inherent broad band emission, high quality of light in terms of CRI, light and colour control. Especially the aesthetics and the light quality give OLEDs an added value as compared to competing technologies such as LED flat lights. In terms of

efficiency and life-time LEDs are far more mature and they are getting thinner and thinner, so that thinness no longer stands as USP of OLEDs. Light quality and illumination quality with the soft shades brought out by OLEDs however cannot be offered by competing technologies. The aesthetics of OLEDs: pure glass, glossy surface, possibility of mirror-like off-state appearance will enable OLEDs to be real design objects. The multiplication of the awareness of OLEDs as an "illuminating piece of art" is a necessary asset; OLEDs will have to be installed as a must-have that will change general lighting with new concepts and applications.
For the purpose of fast market acceptance, all aspects of light quality (high CRI, angle dependency, differential aging and colour binning) demonstration and user acceptance studies should be an integral part of all projects.

Special attention should be paid to early standardization of OLED metrics, devices and electric drivers, so that interoperability problems can be solved in an early market phase.

In a later stage, the design of luminaires offering illumination beyond the present state of the art should be addressed. Only in this way will the full potential of OLED lighting be achieved.

Research Topic	Technical Objectives	Short term	Mid term	Long term
OLED luminaires	High system efficiency Tiling concepts Luminaire design Acceptance studies (well-being)			
OLED Standardization	Standardization of OLED devices and drivers	Measurement metrics	Standardization	

2.5 SWOT

Strengths	Weaknesses
• Presence on and /or access to global markets • Strong R&D (social & technological, covering both LED and OLED) • Many large industries and many innovative SME's (in particular luminaries) • Leading Luminaire systems and controls technology • Good relationship through the lighting value chain. Platform for discussion cooperation and joint research • Application know how • Large leaders have substantial IP portfolio • Strong European industry in high power semiconductor modules • Expertise in associate materials and electronics technologies • Well respected lighting design community • Installation and management capability • Public sector commitment to supporting energy efficiency	• Dependency on a few large LED chip suppliers (level 0,1) • Lack of SSL product quality certification and specific labelling • Lack of large scale demo projects with proof of economic & ecological benefits., limited market awareness • Lack of education of SSL benefits & outside perception of SL as unproven technology • Lack of coherent EU strategy on SSL • Lack of EU market surveillance • Fragmentation of EU research. Lack of reaching critical mass for SME's due to scattered research • EU standards & regulations: no final LED standards available today + no mandatory lighting standards in the EU, no mandatory minimum performance requirements • Strengths of EU industry in conventional/traditional lighting is a potential weakness for SSL (hesitation to change)) • Poor investment in sector • Fragmented market and supply chain • SME manufacturers lack scale to command global market and support growth • Next generation of engineers-shortage of students specialising in lighting technologies • Cost: devises, installation (retrofitting), maintenance • Lifetime, quality of light and cost are not mature • Lack of full building models incorporating lighting
Opportunities	**Threats**
• Sustainable living standards → demand for more sophisticated fixtures • The phase out of incandescent lamps and new (green) legislation • Large public procurement sector • Improved light quality • Biological efficient lighting • New SSL applications for buildings • World energy situation-energy efficiency, cost savings and energy security • Meeting EU CO2 emission targets • Capture fast growing world market for SSL solutions • EC Public-Private Partnership (PPPs) "Energy-Efficient buildings" • Market opportunities-Wireless sensor networks, data gathering and processing, intelligent control, power electronics for actuation and control • Development of effective exploitation infrastructure • SMEs can act as diffusion of technology	• European market will be taken over by foreign manufacturers (China & other Asian countries) • External companies will benefit from the R&D done in Europe • Dominance of Asian LED & OLED display production • Limited market awareness resulting in limited demand and limited awareness on benefits for SSL • Phase out of Incandescent lamps and (green) legislation • Scarcity of rare earths • Insufficient long- range planning and coordination of technology policy • Slowness of end-users to adapt to new technology • Public focus on ICT only, limited awareness of SSL • Key European industries could be taken over by competitors from Asia (M&A) • Strong engineers resources in emerging countries in Asia (China, Taiwan, India) • Failing numbers of graduates in technical courses • Slow responsiveness by universities to rapidly-evolving technologies and poor articulation of industry research needs • Low cost incumbent lighting technologies • Non-EU Governments strongly supporting or subsidising an SSL value chain • Attractive incentive regimes elsewhere • Reliance on rare-earth elements for LED Phosphors-China main product

Section III: The options for European leadership in SSL

3.1 "Integrated systems approach" for Europe

In the context of the new EU Energy Strategy and the assessment of the European Energy Efficiency Action Plan from 2006, the European lighting industry is calling the European regulators to complement the existing Ecodesign Legislation for tertiary sector lighting products (EC Regulation N°245/2009) by developing a new EU wide Lighting System Legislation (LSL) to help the European Union achieving its 20-20-20 Energy Efficiency targets as well as to improve the quality of light.

Lighting is responsible for 14% of all the electricity consumption within the EU. The magnitude of this energy consumption can be more than halved by employing modern efficient products in well designed, installed and operated lighting installations. According to the lighting industry estimation, in addition to the 15% energy savings that will be achieved by the existing ecodesign measure on lighting products in the tertiary sector, a further 40% savings could be achieved via legislation on lighting systems (a total of 55% of savings).
Based on independent measurement it is proven that with intelligent switching more than 55% savings can be achieved.

LSL does approach a lighting installation as a system taking into account both the 'Quality of Light' and the 'Energy Usage' of a system. LSL will cover design, installation, commissioning and maintenance. Key to the Energy Efficiency part is the use of controls (presence detection, daylight control, etc), technology that is available today but not widely used. Moreover, adding intelligent metering systems will add to the awareness of usage and will further support the energy saving process.

3.2 New (ICT) opportunities

Key to the integrated systems approach is the use of controls (presence detection, daylight control, etc), technology that is already available today but not widely used. But apart from the use in offices or similar buildings this entire approach can be applied to the interaction and cooperation of any system in relation to (SSL) lighting to secure minimum energy use for lighting.

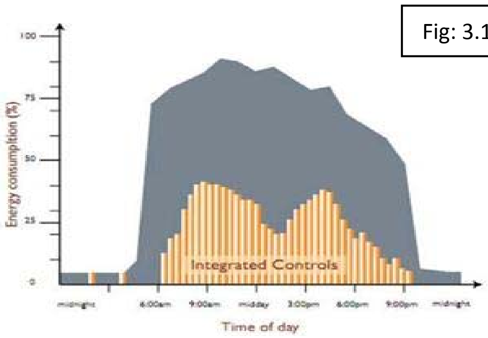


Fig: 3.1

Potential savings by using controls (ICT)	Saving potential	Penetration indoor
Permanent (on-off)	0 %	97 %
Daylight linking	20-40 %	< 8 %
Presence detection	15-30 %	< 8 %
Time management	5-15 %	< 4 %
Constant illuminance level	10-25 %	< 3 %

The next logical step is to extend the communication and interaction between various (formerly independent) control systems for improving or optimising the quality of lighting for a particular application: SSL solutions enhancing people's life is a new, yet unexplored market. This should include public and road lighting applications, as well as making the logical connection between transport and vehicle safety on the one side and lighting on the other.
It is evident that any communication between the various (so far independent) systems asks for (the development of) "universal" protocols.
The European industry should take the lead in SSL as a building block towards intelligent controls and communication systems in both professional and domestic applications. This will extend and reinforce our industrial position in the world, as well as secure employment in the European lighting industry.

3.3 Technology impact on business models

At the moment the primary focus of the consumer SSL market is on replacement lamps for GLS, halogen reflector lamps and fluorescent tubes. This approach offers quick access to the market, because existing market channels can be used.

As a consequence the potential of SSL cannot be used to the full extent i.e.: dim-ability, switch-ability, colour change and lighting dynamics. Some manufacturers may be supported by the development of SSL modules that next to electrical and mechanical interfaces also makes use of standardized thermal and communication interfaces. In this way OEM's will be able to make use of the possibilities offered by LED technology without going through the painstaking process of mastering new technological competences to the full extent. A limited amount of more advanced OEM's will be able to integrate directly LEDs in their luminaires without relying on standardized modules. This definitely holds for OLED based solutions, where the distinction between lamps and luminaires becomes quite blurred.

In both scenarios, due to the much longer life of the LED based products, the present business models, pivoting around the recurring revenues of replacement lamps, will become obsolete. After the initial boost in the sales of LED based lamps and modules a strong sales decline is anticipated once SSL becomes the standard solution in the market.

Although the economic cost of LEDs for a lot of applications are already lower than for conventional lighting solutions in some application domains and this cost is anticipated to become best in class for all application segments in the coming years, due to the anticipated cost performance improvement of SSL, the higher initial cost of SSL solutions will remain a major hurdle for many potential customers. By embarking in innovative financing models where a third party (or eventually the supplier) covers the difference in initial cost and recovers his investment from part of the energy savings, a clear win-win situation can be created for all parties involved. It speaks for itself that such an approach will only make sense for complete lighting systems.

The business models around lighting systems can even be brought to a next level, thanks to the combination of SSL with intelligence. Installation and commissioning of intelligent SSL systems will become much easier. The status information of the different light points allows for optimization of the operation of the system, but also for the optimization of the system maintenance schemes. This opens the way for business models where new players take the responsibility for lighting as a service. Notably in the field of outdoor lighting more and more public private partnerships are emerging, that take the responsibility for public lighting over periods of 20 to 30 years. Similar developments are anticipated for the commercial building segment.

Consequently the advent of SSL is not only a change-over to a new technology, it will also largely impact lighting as a business. While at present the lighting market is dominated by product champions, lighting system providers are bound to enter the market. These systems open the way to the emergence of new services built around lighting. The digitalization of lighting will trigger a gradual shift from selling lamps to selling lighting systems and ultimately to selling light.

3.4 European approach for "Quality of light"

The overall objective of the EU Lighting Industry for SSL products is to ensure that the European market is served with high quality products. At present one of the problems is that there is no quality scheme for SSL products in the EU to distinguish good from poorly performing products. Too often, products can be found in the market which over-promise and under-deliver.

"Product quality" is the result of fulfilling a combination of many different product requirements: safe, fit-for-use, reliable, long-life, etc. Such requirements have been formulated in (many) different standards and/or regulations. Whether a product fulfils relevant requirements of a particular standard or regulation is in most cases indicated on basis of "self-declaration" via the CE marking.

Normally customers (buying SSL products on the EU market) should be able to rely on the automatic assumption that all products fulfil mandatory EU requirements. However, because conformity assessment is based on "self-declaration" and market-surveillance is in many cases non-functioning, this assumption is not always realistic.

The EU Lighting Industry is of the opinion that it has to be secured that all SSL products fulfil minimum performance requirements of EU (Ecodesign) Regulations via effective market surveillance. In addition the industry is considering the development and introduction of a quality scheme on a European scale to further increase and promote customer trust and guidance in SSL products. In particular it proposes to study the options of an EU SSL quality scheme for LED lamps based on an existing EU label (e.g. EU ECOLABEL) or based on a completely new EU quality framework. This quality scheme for LED lamps should become an overall recognized, marketed and supervised scheme in the EU for SSL products. It is thereby felt necessary to make the SSL products more easily comparable for customers.

It should be noted that at present many EU initiatives include the obligation to provide new and additional product performance data. This relates to mandatory requirements coming from the Low Voltage Directive (on Safety), Ecodesign

Regulation (on minimum performance levels) and Energy Efficiency Labelling (on energy use and cost). In a number of cases the same performance data is requested for.

The EU Lighting Industry calls for one harmonized approach to prevent duplication of efforts. In the joint EU and Industry approach for a European SSL Quality scheme for LED lamps this aspect should be addressed.

The Green Paper should not call for an import of the "Energy Star" approach of the USA into the EU, but to develop a European quality scheme. In this context the Green Paper should invite the industry and competent DGs in the European Commission to develop together a Quality Label for LED lamps as part of a comprehensive quality scheme.

In particular the Green Paper should address the following pre-conditions:

- Marketing, awareness and education campaigns (joint EU and Industry approach)
- Effective Market Surveillance scheme
- Workable Criteria Catalogue (defining comparable and truthful product performance requirements)

3.5 Biological efficient LED lighting

The European Union is facing unprecedented demographic changes (an ageing population, low birth rates, changing family structures and migration). In the light of these challenges it is important, both at EU and national levels, to review and adapt existing policies.

Following a public debate, a 2006 EU policy paper identified five key policy responses to manage demographic change:

- Supporting demographic renewal through better conditions for families and improved reconciliation of working and family life
- Boosting employment – more jobs and longer working lives of better quality
- Raising productivity and economic performance through investing in education and research
- Receiving and integrating migrants into Europe
- Ensuring sustainable public finances to guarantee adequate pensions, health care and long-term care.

The policy responses identified under points 2 and 3 of the above enumeration can serve as a reference point to address the issue of biological effects from lighting and to embed this issue in the larger political framework of demographic change.

Moreover, point 5 is being addressed by biological effects of light as it supports the rhythm of the elderly, reducing the effort for night-time care and attention, especially in persons with dementia. (Main reason for transfer of persons with dementia into care homes is the need for 24/7 attention, which cannot be solved in the family environment).

Biologically efficient lighting is based on a recently identified receptor system in the human eye and its corresponding nervous pathways in the brain. This (non-visual) system is activated by short-wavelength light and controls body functions by synchronizing them with the natural light/dark rhythm. It modulates the hormonal system and affects the sleep/wake cycle, alertness, cognition, and even wellbeing and health (where the physiological mechanisms are not yet fully understood). Artificial lighting can be tuned to activate this system. To achieve this, lighting conditions have to be adjusted in terms of light spectrum, spatial distribution of light and lighting dynamics. Optimizing these lighting parameters for specific applications, while maximizing energy efficiency, is one of the key challenges in lighting research.

The Green Paper on SSL should address the issue of biological effects from an angle to establish European industry leadership. The concept to make positive use of lighting, in this context predominately SSL, should be highlighted in the Green Paper as a contribution to innovation in the lighting sector. Such innovative approaches will require embedding the technical and scientific development into the larger picture of demographic changes. The Green Paper should be designed to address proactively this issue and to call for concrete legislative or political measures to extend the visibility of the concept and pave the road towards concrete implementation. In the immediate future the Green Paper should encourage additional research activities in this field and should propose to establish a platform for biological effects of lighting that can provide for a value adding information exchange among all relevant stakeholders and that can help to identify and address research gaps. These gaps are likely to be found when evaluating the following items:

- How can we further enable LED technology to provide for better working conditions for elderly people?
- How can we further enable LED technology to contribute to higher productivity and better conditions at work places and educational facilities?

Lighting can contribute in a variety of facets to coping with these challenges. Particularly the manifold benefits offered by biologically effective lighting should be taken advantage of.

The benefits offered by biologically effective lighting to society and health system are diverse:
Recent research has shown that the biological effects from lighting improve human cognitive performance and enhance alertness and contribute, hence, to higher productivity. In addition, an adequate stimulation of the biological system during the day results in better nocturnal sleep and stabilizes the day/night rhythm with great potential for the society's health system. Besides direct effects on persons with sleep/wake or affective (not only seasonal) disorders, also consequential costs of inadequate nocturnal regeneration and sleep quality will decrease. Studies in elderly care units have proven effectiveness of improved dynamic lighting installations on day/night rhythm of inhabitants with positive effects on daytime activity and night time rest, reducing the effort for nocturnal care while at the same time improving quality of life.

The technology of choice for biologically effective lighting systems will be Solid State Lighting (SSL). Though generally well suited for this application, further research is needed to optimize SSL technology to best provide the features required for the just recently discovered biological effectiveness of lighting. On the technological side, it remains to be studied, how to best design SSL solutions to allow for appropriate dynamic modulations (e.g. of colour temperature) and output optimization. On the physiological/psychological side, studying the mechanisms underlying the biological effects in a technology-oriented manner will significantly improve the efficiency of such systems, reveal further areas of application in health and society and contribute to basic science knowledge.

Addressing these questions will not only help to boost SSL technology and biologically effective lighting system which, in return, help solve demographic, public financial and health challenges, but also enforces European technology leadership.

3.6 Develop joint approach with electrical installers/ building construction industry

The European lighting industry is proactively reaching out to all stakeholders in the field of technology and construction in order to share and explain the huge benefits SSL technology offers. The Green Paper should address the need for holistic solutions in energy efficiency in the built environment and outline a roadmap for a better integration between manufacturers, installers, clients and all other players along the value chain. SSL will only be able to fully exploit its potential when embedded in an overall understanding of interdependency with other technologies and solutions used in the built environment and must be perceived as an integral component of the built environment and not as a replaceable product.

The construction sector will need to take up the role of a pacemaker in addressing the European 20 – 20 – 20 targets. The European lighting industry will contribute to this paramount task by having the following impact on the need to achieve the European climate targets:

- Lighting consumes 14% of electricity production in Europe
- Next generation SSL can reduce lighting energy consumption by up to 70%
- Lighting offers the second largest (close behind improved insulation) potential for cost and CO_2 savings (Vattenfall analysis on abatement costs of carbon reduction)

The EU Lighting industry concludes that there is a huge potential: lighting offers an "easy to realize" potential to cut down CO_2 emissions significantly and cost-effectively at short term.
A problem is observed that although installations of indoor / outdoor SSL are cost effective due to reduced energy consumption (~payback time 2-15 years), the shift to SSL is slow due to higher upfront costs compared to conventional lighting and a lack of independent and reliable proof of concepts.

3.7 Scarcity of rare earths

Transform the current threat "scarcity of rare earths" into a potential strength by looking into opportunities to develop new light sources technology which are independent from these rare resources.

The industry is calling the EU to develop research activities to overcome this strategic resource issue:

- Supporting the search for alternative resources in other area's
- Supporting recycling of rare earth
- Promoting SSL with less rare earth elements than Fluorescent tubes and CFLI

Section IV Industry Expectations & Recommendations towards an EU SSL Policy

The European Lighting Industry has the following concrete expectations of the Green Paper. The Green Paper must ensure the creation of a framework in which the issue of an improved market situation for SSL in Europe and leadership potential for the European industry on a global level is addressed. The following should serve as a basis and should be taken as recommendations to shape the follow-up activities after the Green Paper endorsement.

In general industry expectations and recommendations relate to taking concrete measures to stimulate demand, ensure a level playing field on the supply side and define concrete support actions considered to be necessary to achieve the expected improvements on both sides of the market.

4.1 Supporting supplies

In order to create a basis to support SUPPLY, the following issues need to be addressed in the Green Paper:

- Coordination and Direction of Industry Efforts
- Identification of priorities

In order to accommodate these needs, Europe will need a widely comprehensive communication and information exchange platform. Such platform should concentrate on visibility, and outreach communication, and a co-ordination tool for all relevant lighting stakeholders (including the wider construction sector).
Closely related to such stakeholder platform, and possibly an integral part of it, is the need to determine suitable and value adding R&D Programs tailor made to meet the challenges of the SSL sector. The funding of relevant research projects and making their results widely available should be at the core of such activity and is a focal recommendation from the European industry. As is the required ssupport for (setting up) manufacturing in Europe (pilot lines e.g. OLED, R&D on automation processes etc)

A platform needs to be established to reach out to all relevant stakeholder groups. It is necessary to create an implementation platform for the findings of the Green Paper to ensure the hosting of the development of a co-ordinated industry effort, including the establishment of priorities and enable for their concrete implementation

4.2 Creating demand

With regard to creating DEMAND, the public sector is initially in the focus of deliberations and should become a role model for other sectors, including the domestic sector to provide for an accelerated take up of SSL in all lighting applications. In line with one of the findings of the European Commission's 2011 Energy Efficiency Action Plan that also foresees concrete contribution from the public sector, the Green Paper should concretely contain recommendations to enhance procurement of new lighting products and systems towards better quality and higher energy efficiency and should concretely address refurbishment of existing installation, preferably by outlining concrete targets.

It is self-evident that such actions on the demand side will only be underperforming if not accompanied by awareness, Education and Promotion Programs. Evaluation of SSL installations and communication of results has to be part of the action.

Horizontal support actions to accompany such recommendation to stimulate demand and to support the supply side will need to be addressed. The overall aim in this context is to embed all concretely recommended actions on communication, R&D, stimulation and awareness into a horizontally integrating framework. This framework will need to consist of the following:

- EcoDesign Regulation on lighting products to set minimum requirements for LED performance
- European SSL Quality Scheme in order to enable consumer to make an informed choice on products, this approach might also need to address a quality scheme
- Effective Market Surveillance in order to ensure the compliance of products and eventually systems with European legislation.
- Close the gaps in standardization preferably on a global level (testing performance, definitions ect)

One further support for the European industry may arise from the identification and exploitation of synergies with approaches in other World Regions. Concretely the evaluation of the US DOE Approach and draw suitable conclusions for the European industry. In this context SSL should become part of the Trans Atlantic Business Dialogue (TABD).
Any approach on expectations to the Green Paper would be incomplete without addressing the need to significantly increase the visibility of the lighting sector to political and socio-economic stakeholders outside the larger lighting value chain. In order to accommodate that need it appears to be worthwhile to create institutionalized ties to political decision

makers and influential streams in the European societies to better position the enhance possibilities in lighting quality and energy efficiency coming from SSL. Such approach on enhancing visibility should not be limited to “sell” technical applications, but to address holistically the artistic, energetic, aesthetic, adaptive and biological dimension of SSL technology and its benefit for the natural and built environment as well as for citizens. Such an integrated and holistic approach will require a dedicated physical and virtual platform that needs to be closely linked to and visible to all relevant groups of society. The implementation of this approach will lead to a definition and implantation of European leadership potential in SSL technology.

4.3. Steps to European leadership

Whereas the deliberations above predominately address the market situation, the political visibility of the sector and to support the accelerated take up of SSL in the European market, the matrix below aims at complementing this approach by identifying concrete steps to European leadership potential in the context of the deliberations outlined in the paragraph above. Moreover, a prioritization of actions and approaches is necessary in order to be able to fully structure the continuation of the Green Paper exercise.

Leadership potential	**Timeframe for Concrete Actions and Initiatives**		
	Short term <2 yrs	**Medium term 2 – 4 yrs**	**Long term > 4 yrs**
Energy efficient and quality enhancing lighting systems and services	• Establish a framework for European wide scheme for lighting systems with a focus on SSL • include lighting in European Fund for regional Development and Cohesion Funds (DG REGIO) • Organize workshops on the deployment of EU Regulations on ECODESIGN requirements in the Neighbourhood countries (DG RELEX and ENER) • Review the allocation of financial means in order to use these funds in a most value adding way (e.g. for acceleration of existing building stocks)	• Revision of ecodesign implementing measures on lighting • Make sustainable (“green”) procurement happen	
Biologically Efficient Lighting	• Include in 2012 CIP pilot actions, e.g. Alzheimer’s Disease • Prepare tailor made input into European R&D schemes to enable more and better research on this issue • Prepare a EU wide information scheme on the biological efficiency of light to address socio-economic developments like ageing societies	• Make biologically efficient lighting marketable and further enhance knowledge	• Establish biologically efficient lighting as a “natural” application, next to general lighting
Save raw materials, recycling, “urban mining”	• Supporting the search for alternative resources in other area’s • Promoting SSL with less rare earth elements than Fluorescent tubes and cfli	• Supporting recycling of rare earth materials	
Exploit the full potential for SMEs	• Include SSL into horizontal SME programs, access to finance,		
Quality / Awareness / Market Stimulation / Market Surveillance	• European SSL Quality Scheme, concerted subsidies schemes • Embark on EU-wide awareness raising programs, proactive reach out to consumers and public target groups • Increase the focus on developing a functioning EU-wide market surveillance scheme on ECODESIGN • Strategy forum between industry – retailers – consumers to commit to the supply of compliant products, teach purchasers in retailers on conformity requirements • Call for a concerted approach of the EU27 Member States to create programs on fiscal stimulation (funding schemes, etc)	• Foster interregional co-operation; embark on a cross learning exercise and evaluate congruencies and overlaps; address patent protection	

4.4. Implementation:

Concrete examples and consequences of above mentioned implementation measures could be:

Energy & Climate dimension:

1. All public Buildings (exiting and new buildings) have by 2020 a 100 % SSL based lighting system
2. Same for other office buildings, by 2020 regulations demands a 100% SSL based lighting system
3. Minimum performance standards DIM 1 & 2 lead to energy savings: a measurement program is available to report progress of realised vs. planned savings
4. New set of “lighting in building” regulations is defined and regularly updated EU wide
5. Financing is available on SSL products via utility companies
6. Post calculation of quality of installations and savings realised

System dimension:

1. New set of “lighting in building” regulations is defined and regularly updated EU wide
2. On dimming and connectivity, a connection with ICT players, and other players in buildings is created
3. A link with green building organisations has been established

Business dimension:

1. (Financial) stimulation programs have been introduced in all member states by 2014
2. SSL minimum requirements should apply in EE projects using Structural Funds
3. Supporting business models like (financial) guarantees
4. Subsidy program for small cities etc. for street lighting (Korea and China are doing this!)
5. Database of evaluation data reference projects and learning to accelerate market growth
6. EU wide support on communication initiatives
7. Education programs implemented for consumers on lighting
8. Education programs implemented for press and journalists. Proactive availability of position papers. Video from industry

Biological dimension:

1. “Biological effects of light” research 2012-2014, has lead to concrete stimulating and implementation programs in the EU by 2015

Quality dimension:

1. An effective market surveillance program is in place in all 27 member states by 2014
2. IEC performance documents available for SSL in order to facilitate proper comparison between products (apples to apples)
3. Quality schemes implemented
4. Lighting System Legislation
5. European equivalent of US CALIPER program for market surveillance has been put in place
6. A Truth label for luminaires has been defined, implemented and is surveyed
7. Flux measurements (like LM79) defined by CIE and/or CEN

Design dimension:

1. An EU wide R&D program has been set up by 2012 for replacing scarce material in LED components

Other:

1. A review of the EU green paper on SSL is planned for 2013
2. A platform is created to steer and monitor progress of the green paper program and goals
3. LED market penetration data available via member states (associations do not cover all). EU template on statistics via member states
4. Benchmark the green paper to DOE program
5. Leverage of European strengths (compared to US) like “green “industry
6. Create an EU SSL organisation (“DG SSL”) to facilitate SSL project and green paper program