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Author:	Reine Karlsson, LU reine.karlsson@luopen.lu.se
Co-authors:	Jos Kunen, TNO Tove Karlsson, LU Markus Johannesson, LU Håkan Lagerquist, LU Marc Steen, TNO Peter Bracke, KU Leuven

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Abstract

The lighting technology, procurement, value chains and user value potential are changing quite radically. This is awakening a lot of interest from big business actors and seems to initiate a transformation of the global lighting business sector. This is a challenge for Europe; both for the users that often find it much more difficult to make appropriate lighting choices and for the actors in the established lighting sector. The new freedom-of-action is enabling much better lighting solutions. However, there is also a risk that dubious and/or less knowledgeable business actors are using the freedom-of-action to reduce their own cost and simultaneously profit on the present interest in LED, not least in the present hype after the Nobel Prize for the blue LED.

This report presents a list of smart applications that have potential to make the new technology much more appreciated and simultaneously save significantly more electricity than the earlier European ambition to save 100 TWh. The ongoing energy saving replacements involves a risk for rebound effects due to not appreciated products and also due to continuation of the earlier trend to install ever more luminaires with static lighting. From technical point of view, new systems with intelligent dynamic lighting can already enhance the user value by dynamically providing the right light, in the right place, at the right time and ever more solutions are becoming commercially available. Simultaneously, we estimate that in 2017 this enables a saving of 85 % of the lighting electricity when an existing installation from 2000 is replaced with intelligent dynamic lighting.

The transformation of the lighting market is a great business development opportunity for knowledgeable entrepreneurial business actors, for actors within ICT and from the traditional lighting sector, and also for SMEs and start-ups. The SSL-erate project is aiming to enhance the business opportunities for the serious knowledgeable business actors so that they can engage in open innovation collaboration, show positive examples and better safeguard the market against more dubious business actors. One basis is to mobilize public procurement actors in Europe to take advantage of the present potential to invest in lighting environments that support a sustainable societal development, leading learning processes and meaningful business development.

This FP7 CSA project is aiming to activate European business development experiments that demonstrate the user value potential of the combination of the present SSL, solid-state sensors, hard- and software ICT and user interfaces. We are eager to show the crucial importance of a solid knowledge foundation, to enable appropriate choices between the varieties of presently marketed products. The innovation platform *Lighting for People* aims to clarify the health and well-being aspects of various kinds of lighting, from a scientific point of view. The knowledge about those circumstances is integrated in the selections and descriptions of the suggested fields of business development opportunities.

This survey of market openings shows great business development opportunities for the actors that make use of the energy saving resources as a base for demonstration of the advantages of smart systems. Our assessment is that, the presently most promising fields of application are 24/7 shift-work, education, meeting rooms, 9-5 work, health care, outdoor, automotive, decorative lighting, living environments for elderly and residential homes.

The investments in those application areas are vital for the European learning about the user value potential of the present and upcoming smart SSL technology. This is crucial for the pupils and the ageing population in Europe, i.e. it is a societal social responsibility for the public procurement in Europe to use the potential to support a sustainable societal development. Furthermore, this is a grand opportunity for intelligent lighting actors.

1 Introduction

This report constitutes deliverable D2.6 “Priority list of suggestions for demonstration and business experiments”. The purpose is to support decision-making and action in companies willing to invest in SSL-based innovation and to participate in the business experiments of WP4. SSL-erate provides the companies with support for the right decisions and actions as well as support in their internal and external processes of anchoring/marketing these decisions and actions in exchange for their commitment of time, money and other resources.

The report describes the business areas that are assessed to have the best potential for innovative sustainable business development and explains why these areas have been selected. The report includes SWOT and Cost Benefit analyses for the respective areas. Most of the suggested business development areas focus on indoor Solid State Lighting (SSL) and especially value adding human-centric and intelligent lighting. The latter is the focus of the SSL-erate project and the related societal sustainability aspects are most relevant for indoor lighting. Also, quite a number of smart SSL projects are already up and running for out-door lighting.

The recommendations have a basis in the first year of SSL-erate work. They are built primarily on the outcome of application workshops held with cities’ representatives and local stakeholders [ref – D2.2, D2.3 and D2.4], workshops within local lighting clusters, inventories of sustainability issues [ref - D2.1] and compilation of research on lighting for health and well-being [ref – D3.1 & D3.3], and on various renewal oriented smart lighting and HCL contacts and dialogues, e.g. at conferences.

Financial assessment has been based on studies of the existing lighting market and potential for HCL, e.g. Lighting Europe, ZVEI and AT Kearney market study for HCL¹ and the 2012 McKinsey market study for global General Lighting Systems (GLS)²

In the McKinsey market study the global lighting market is divided into three major sectors: general lighting, automotive lighting and back lighting³. The backlighting use of blue LED for various screens was the market-need that motivated massive investments in production of blue LED. General lighting is by far the largest sector, and is classified into six building or location specific applications – residential, office, shop, hospitality, industrial, outdoor lighting – and one functional application – architectural lighting. The LightingEurope, ZVEI, A.T. Kearney market study, focusing on HCL, introduces two more functional applications – health and education lighting. The latter applications are contained in the office and residential lighting applications of the McKinsey classification.

The overall aim of the business area selection is to identify specific focus areas with potential for innovative business development, such as facilitated within the SSL-erate project by the regional lighting clusters.

In Figure 1 the global lighting market is schematically shown, divided into the seven mentioned applications in the general lighting sector and the automotive and backlighting sectors. The selected twelve lighting areas, which will be presented more in detail in Section 2.3, are depicted in the respective applications and/or sectors.

¹ *Human Centric Lighting: Going beyond Energy Efficiency*, Market study by LightingEurope, ZVEI and A.T. Kearney, 2013

² *Lighting the way: Perspectives on the global lighting market*, Second edition, McKinsey, 2012

³ The blue LED light (440-480 nm) can be transformed into the other visible colors; for screens by mixing with red and green LED light, for “white” lighting applications by light conversion phosphors.

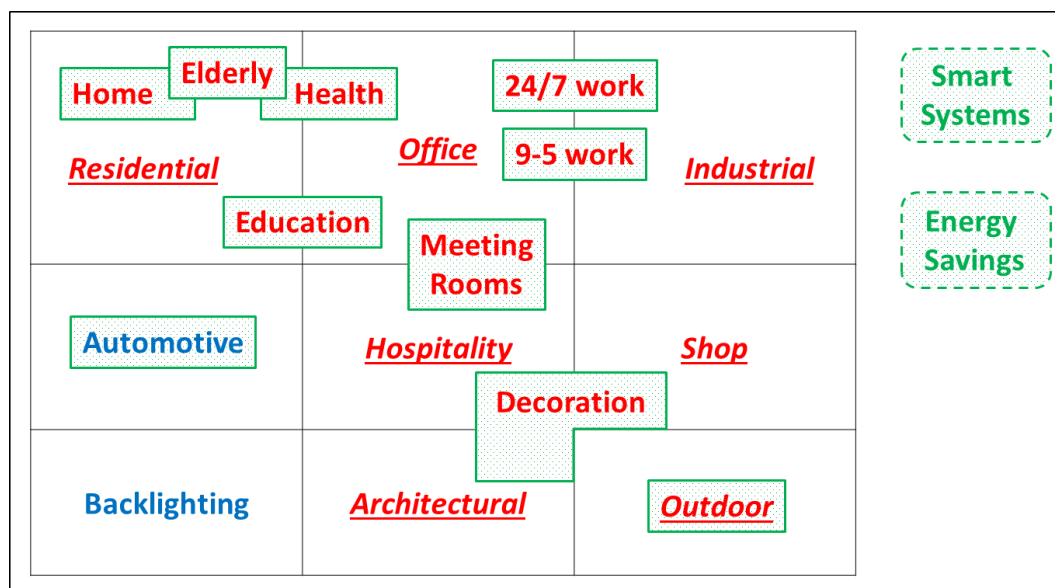


Figure 1: Map of the ten focus areas (with green shade and solid line) and the smart systems and energy savings business perspectives (with green shade and dotted line), all twelve suggested in this report. The ten focus areas are projected on a background map with the nine segments often used for the lighting market statistics: the seven general lighting services (GLS) (in red, underlined) and the automotive lighting and the backlighting segments.

Most of the ten suggested focus areas have applications in two or more market segments. Health, Education, and Elderly have their roots in both the residential and office lighting, 24/7 work and 9-5 work in both office and industrial lighting, Meeting rooms in the office and hospitality lighting, and Decoration in hospitality, shop and architectural lighting. The Smart Systems and Wise Energy Saving resources can be applied, in various ways and to some extent, in all the market segments.

The selection process took one starting point in the very large freedom-of-action that is enabled by today's SSL, sensor, hard- and software, communication devices and user interfaces. Another starting point is that this technical potential makes it more relevant to develop and mobilize new and old knowledge about the significance of dynamic context and user adapted lighting for human health and wellbeing. A third starting point is that investment in HCL to improve the working and living conditions, e.g. in schools and for elderly people and shift workers, is considered to be a Societal and Company Social Responsibility (SSR/CSR). It is equally important to remember that the new light sources, controllability and systems development enable significant energy savings.

1.1 Definitions of HCL and ILS

This report is aiming to provide guidance for SSL demonstrations and business development and to describe the global business development potential for a selection of potentially interesting concrete market segments. The green business development potential is related to both the added values that Human Centric Lighting can provide and to Intelligent Lighting control and supervision. Here we start by defining HCL and ILS:

Definition of Human Centric Lighting

The HCL business development goal is difficult to define. At one extreme it tends to be delimited to the now scientifically known circadian effects of the daily variation of the relative amount of 460-500

nm light. At the other extreme the description tend to include all kinds of light that in some way is said to be better for and/or more appreciated by humans, in reality virtually all lighting. In this report we use the definition:

Human centric lighting here is all kinds of light that improves the sum of the visual, biological and emotional aspects, compared to the kind of light that adhere to the traditional lighting perspective.

The blue part of the columns in the Figure 2 illustrates the share of interest in traditional lighting aspects and design priorities, that hardly has included the now topical way of expressing the (e.g. melatonin related) biological considerations. The red parts show the possible HCL user value improvements. Consequently, a solution that reduces the visual functionality is questionable from human centric lighting point of view.

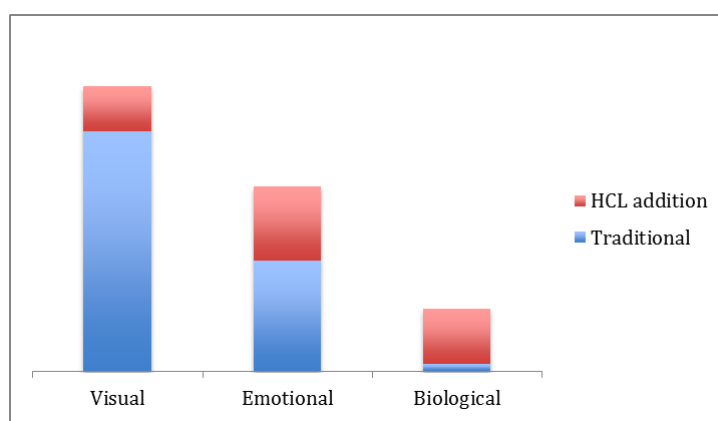


Figure 2: The change of perspective from traditional lighting (blue) to HCL (red).

Definition of Intelligent Lighting Systems

The technology of today is enabling virtually unlimited development potential for ILS and synergies with development of smart cities. One dimension is to enable supervision and user and context dependent lighting control functionalities that surpass the fixed dimming schedules. The other dimension is to enable utilization of lighting related data and system solutions as a part of the evolution of smart cities. In this report we use the definition:

Intelligent Lighting Systems focus on multifaceted utilization of smart systems, both to create more intelligent lighting and for value enhancing development of lighting related installations in synergy with other smart systems.

This innovation dimension is related to creative developments of and additions to smart system solutions, in the spirit of the Digital Agenda for Europe, ILS is focusing on systemic developments.

Synergies between HCL and ILS

The creation of positive interaction between HCL and ILS can enhance the total business potential. SSL has a strong connection to knowledge-intensive development of the user value, and ILS is strongly linked to technology-oriented system knowledge. It might be argued that there is a risk for double counting of activities that relate to both HCL and ICL. But from innovation point of view this synergy may enlarge the markets for both HCL and ILS.

2 Business development potential

In a green business development perspective it is vital to have the right light, in the right place, at the right time. In a global social sustainable development perspective there is a need for more and better lighting. In Europe there are strong reasons to enable the ageing people to get more light when that is needed, e.g. when reading. Our visual system is adapted to the dynamic strength and character of the light in nature and it is a political priority to enable people to get daylight. It is also vital to get sufficient darkness, e.g. to reduce the amount of activating light in evening time. The growing interest in avoidance of light pollution is coherent with the importance of energy savings. The topicality of intelligent lighting solutions is a growing concern in the smart city perspective, e.g. in relation to the digital agenda, see also *Lighting the Cities*. It is difficult to estimate the market potential for smart lighting in a smart city perspective, but it is obvious that it is significant innovation priority in ever more cities.

Figure 3 illustrates Human-Centric Lighting as a goal for the Green Business Development spiral driven by the SSL-erate Green Societal Sustainable development priorities. To achieve attractive results, lighting design continues to be important and to make qualified use of the new technology Systems engineering now also is becoming ever more crucial.

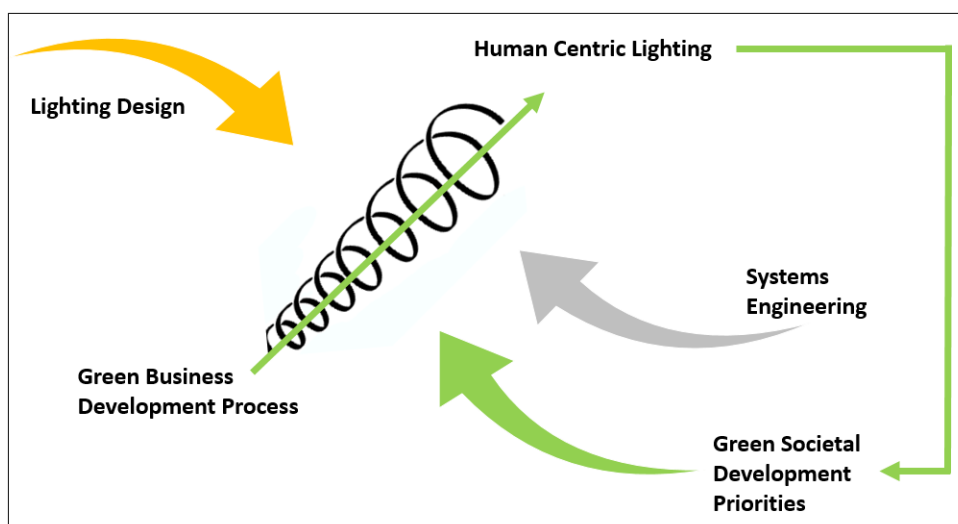


Figure 3: Human-Centric lighting as a goal for the Green Business Development spiral driven by the SSL-erate Green Societal Sustainable Development priorities.

From a rational point of view the productivity, health, wellbeing and attractiveness advantages of better lighting for working and living environments ought to be an obvious business case. However, in the aftermath of the Hawthorne studies quite a bit of confusion arose that still seems to be difficult to overcome⁴. And indeed, it is difficult to assess the indirect productivity advantages of various kinds of lighting in a scientific way. As a seller of health and wellbeing related lighting products and services it is vital to be aware of opinions about the so-called “Hawthorne effect”, in

⁴ *Was there Really a Hawthorne Effect at the Hawthorne Plant? An Analysis of the Original Illumination Experiments*, Levitt, S.D. and List J.A., 2009, <http://www.nber.org/papers/w15016>
(Hawthorne effect, as commonly described: there is no systematic evidence that productivity jumped whenever changes in lighting occurred.)

order to be able to overcome this skepticism. The simplistic interpretation of the “Hawthorne effect” was that it is hardly possible to evaluate the effect of more light, because the productivity was found to increase both when the light was increased and when it was decreased. New statistical analyses of the productivity data from the three Hawthorne illumination experiments show however ‘inconsistent associations between lighting and productivity, but these analyses are limited by data inadequacies and flaws in the experimental designs not previously described’⁵. Therefore, the user’s appreciation of a new lighting environment is a market opportunity. But, to avoid that the new freedom-of-action is used in a misleading way it is crucial to build scientifically sound awareness.

So far the user advantages of smart lighting have been rather unclear. One reason is that the previous inability to proof the health and wellbeing related effects of lighting have limited the ability to move ahead with a positive development of the Figure 3 spiral. A company that learns how to handle the placebo and hawthorn effects can be forerunners in the business growth of HCL.

2.1 The ten suggested business development areas

SSL-erate has one important foundation in the health and wellbeing considerations that are being shown in ever more scientific studies. The functionality enhancement potential of ILS is already attracting attention among lead customers. In combination with solid-state sensors, dynamic control and tunable color-control there are vast market opportunities to make the working and living environments more functional and attractive. There is a significant productivity gain when being able to influence the alertness among employees and a large societal concern to introduce circadian adapted lighting for pupils and elderly, and also e.g. to provide better illumination for elderly so that they do not fall and break a leg. The productivity advantage of being able to better read each other’s facial expressions may be significant, e.g. in board rooms, between pupils and teachers, and between patients and hospital staff. Furthermore, the new lighting is a tool to attract staff and to make various facilities more attractive and valuable.

Table 1 lists suggested topical business development areas starting with two generic headings and continuing with ten specific application areas. The smart systems approach and the resources that presently are available for energy saving projects are interesting for all fields of application. The list of the ten applications areas starts with the five areas that presently are most interesting for renewal oriented business development. The list continues with three areas with already numerous LED projects on-going, and end with two large and important application areas where it’s more difficult to get started.

One significant business circumstance is that the procurement settings are quite different between the indoor lighting and most of the outdoor energy saving projects so far. Outdoor city lighting is often bought in quite large projects where the customer can influence the development of the selected solution. Indoor lighting tends to be purchased as a commodity and it is very unusual that the customer has any significant influence on the design of the products. Furthermore, the organizational settings are quite different; the procurement of outdoor lighting tends to be influenced by city architects and traffic authorities, the procurement of indoor lighting tend to be made as a standardized cost-minimizing procurement for large volumes of bulk products or as a small activity for a large number of various facility managers.

⁵ *Shining New Light on the Hawthorne Illumination Experiments*, Izawa M.R., French R.D. and Hedge A., Human Factors, 53, 2011, pp. 528-547

Lighting in Smart Systems

Smart buildings and smart cities has a huge market and human value potential but it is unclear how and when this possibility can be realised. From the Digital Agenda and Innovation point of view there is very large strategic interest in development of Smart Cities and Smart Buildings. The freedom of action provided by today's possibilities to combine SSL, sensors, ICT hard- and software, intelligence, big data and user interfaces is enabling supervision and intelligent dynamic control that combine safety, ambience, guidance etc. This is coherent with the strategic development ambition in "Lighting the Cities"; which mention Intelligent Lighting Systems, Adaptive Lighting, Health & Wellbeing, Integrated Lighting and Solar Systems & Networked Lighting.

Some cities that are developing advanced lighting in a Smart City perspective are Amsterdam <http://amsterdamsmartcity.com/projects/detail/id/93/slug/smart-light> and the ENIGMA cities, e.g. Eindhoven that has an advanced Road map and Espoo that is aiming to make use of the new lighting as a branding "tool" for the city and Aalto University.

The smart functions that are provided through lighting, e.g. guidance and adaptation to the citizens' health condition (e.g. temperature, heart frequency, breathing, speed, acceleration, pupillary movements and aggregated data like sleep rhythm and jet lag) and mood are visible to each and every one. Smart lighting is visible innovation that has the potential to strengthen the city image and attract people to come to the city and settle down.

The intelligence of smart cities and buildings requires the collection of a lot of data on which basis intelligent algorithms can adjust the systems to the actual, local conditions and requirements. The rollout of such a sensing system is complex to realize, as the sensors need to be present, wherever there are relevant activities going on. Lighting products are regarded by many as the ideal rollout platform for smart city and smart buildings sensing devices. In this way lighting products will be able to create significant added value beyond the lighting functionality itself.

Wise Energy Savings

At present there is a large amount of funding available for energy saving investments.

In this market there is an evolving competitive advantage for the front-runner companies that can provide solutions with the right light, in the right place, at the right time. The standard for LCA (ISO14040, 1997) focuses on the quotient:

Environmental load

Functional unit

The functional unit shall be a useful measure that describes the major function. For lighting environments the most relevant side-effects that should be avoided are glary, disturbing and ugly lighting; in outdoor lighting the term 'light pollution' is often used for some of these adverse side effects. Those aspects are negative for numerator and denominator of the LCA quotient; they simultaneously reduce the functional value and waste energy.

In a few years perspective we expect a change of focus for the public funding from energy saving to a smart user-centric systems perspective that promotes local attractiveness, regional innovation, green jobs and European business development. The basic synergy is that solutions that provide dynamic user adapted light and avoid glary, ugly, disturbing, useless light are optimal, not only for the single users but also from sustainable development point of view.

An important saving that can be realized is by properly adjusting the lighting in accordance with the (free-of-charge) daylight that is already present. This should be done in such a manner that the users are happy with the solution provided.

1. **24/7 work places**

The scientifically most proven health and wellbeing effect of a particular kind of light is the melatonin reducing effect of 460-490 nm light⁶. The circadian rhythm is crucial for shift workers and consequently this is an interesting application for business development activities with this starting point. There are many shift workers, e.g. in hospitals, control rooms, ships and the hospitality and service sectors. Work in the 24/7 facilities field may be used to build knowledge and a business profile that is interesting for larger market segments.

2. **Education**

Advanced dynamic lighting systems with intelligent color and dynamic intensity control are interesting as ambience control tools for teachers. The pedagogical opportunities and also the potential to improve health and wellbeing have been noted. Productivity improvements in terms of better learning and socio-cultural advantages have been shown, but have not yet proven. The long-term market potential is large, but market growth so far has been rather slow due to budget restrictions and conservative cost minimizing procurement principles. Some products are available and numerous demonstration installations are presently being made.

One possible starting angle is children with specific needs. Mental illness among the younger generation is increasing and there is an escalating use of sedative drugs. There is a tendency to alleviate various symptoms that are caused by distressing living environments and to neglect the underlying needs to invest in improvements of the living conditions. Smart adaptive lighting is a cost effective way to improve the pupils' living conditions and a possible angle to get funding from sponsors.

3. **Meeting rooms**

In one way this is part of the hospitality sector. Here we want to stress that the light character influences the feeling of ambience and how we perceive each other's facial expressions and skin color, which are vital social signals. It is probable that the work in a boardroom is more effective when the board members feel confident that they can "read" each other's reactions in a clear way. The conference room market itself is rather limited, see table 1, but still conference rooms may be an introductory market, not least because numerous owners and users of conference rooms have money.

4. **9-5 work places**

Comfortable lighting that supports our natural rhythms and is adapted to the task at hand increases our mood and sense of well-being. Dynamic lighting can bring the subtle patterns of the natural daylight inside the work place and keep us in tune with the world outside the office walls. The color and intensity of the sunlight mainly depends on the time of the day,

⁶ The activating effect of blue light has been noticed both within the scientific community as well as in business. The blue diodes with color converting phosphors have become cost-efficient as replacement light sources. What might not be known in the broader community is that, with increasing color temperature, more and more of the energy of those diodes is emitted at wavelengths below 475 nm, being the average melatonin suppressing wavelength. Furthermore, the size of our pupil depends on the total amount of light reaching the eye. When there is more light (in total, including all visible wavelengths) the pupil size is reduced and less photons reaches the retina, hence the retina also receives less 475 nm blue light photons.

cool white early in the morning up to high noon and warmer afterwards and during the evening. Clouds and rainfall also affect the light intensity and color. Artificial blue-rich light can help to keep us alert and warmer light can help us to calm down. So, light level and spectral distribution can be adjusted throughout the day to optimize the employee's productivity. Dynamic light can be used to counteract boredom.

Previous studies has found that, on average, Northern Europeans prefer "warm light", while Asians prefer cold, bright light and the light control unit needs to take this into consideration. Architects and office planners often recommend individually adapted lighting, but it is important to make sure that the neighboring employee is not affected in an adverse way. In the workplace, focus is often predominantly at functional lighting, neglecting the well-being of the employees. Light needs to be involved in the consideration of occupational health management.

5. **Health "gardens" and hospitals**

One market segment where the actors are used to invest in advanced technology is hospitals. Advanced forms of lighting are already used for medical purposes. The light for the doctors' examination of the patients is one application where it is understood that the color rendering is vital and for surgery it is clear that it often is better with much more than 500 lux. There is also research that shows that the visual experiences are important for the patient's wellbeing and speed of recovery.

6. **Outdoor lighting**

Dynamic lighting in the public space can be adapted to the people present and to other environmental factors. Light can be adapted to physical parameters, e.g. by measurement of heart frequency, cortisol and component of blue light, but it is important to take ethical factors into consideration. It is important to create a coordinated system, e.g. that the same color sends the same message, to avoid confusion and safety risks. It is important to control the lighting so that "fear spaces", such as parking garages or dark paths are sufficiently lit at night.

The light poles are possible to use for other purposes than only lighting, e.g. to collect information about traffic, weather and as Wi-Fi terminals. Many weather forecast companies and traffic report agencies are striving to get accurate, real-time data. One main consideration in the public space is to reduce light pollution, that can shine e.g. into the bedrooms of people and affect the quality of sleep. It is likely that we will see a decrease in lighting in the future public space. A significant part of the road lighting is more disturbing (glary) than useful.

7. **Automotive**

Luxury cars and business airplanes are leading development areas for more advanced functionalities. A growing part of the lighting for cars, other vehicles and various forms of transport infrastructure is already comparatively high-tech, user adapted and dynamic. The market for high-tech lighting and smart systems for luxury cars started a number of years ago. The interior lighting is interesting from a human-centric point of view; and the exterior lighting from a safety point of view.

The business actors in the high-end of this market segment have gained experience and branding advantages that are valuable as a basis for expansion in other market segments. The customers in this segment are prepared to pay for new added values, e.g. circadian adaptation for increased safety and wellbeing, closeness detection for increased safety and more comfortable driving. The economic freedom also allows for a higher freedom of design. However, the competition is tough.

8. **Decorative-lighting**

One “play-ground” for experimentation with new kinds of lighting effects is theatres and festivals. In volume this is a small lighting market, see table 1, but it is interesting as a basis for learning and branding. A similar kind of mood creating lighting interest now also applies for ever-more restaurants and hotels. This is an important market segment not only because of the significant potential market but also because it may have large leverage as it brings many people into contact with the more fancy aspects of SSL. Moreover, this type of lighting is important for interior and exterior illuminations of shops and other buildings.

9. **The ageing population**

The lighting functionality, e.g. visual guidance to avoid accidents, intensity variation and light character dynamics to improve the circadian cycle functionality, to feel more alert and get out of bed in the morning and to be able go to sleep in the evening, is particularly important for elderly people. Furthermore, the living circumstance for elderly is a major strategic priority in Europe. From a rational point of view this is a great business opportunity. However, there are a number of procurement channels and numerous hurdles related to the complexity of the value chains, e.g. as a part of the domestic sector.

10. **Smart home lighting**

The global domestic lighting market is extensive, 23 000 million Euro for SSL according to the McKinsey report behind Table 2. However, it is a complex market that is difficult to reach with new kinds of lighting solutions. For most end-users the energy savings on its own is not compelling enough to invest in SSL; new features and benefits should be added to change the perception of lighting from a ‘low interest purchase’ into a cool buy. It is difficult to introduce new kinds of high quality system solutions on the domestic market. Still, the domestic market contain a number of affluent persons that are very interested in new technology and new functionalities, and that can take their own decisions in a smooth way, to make their real-estates ever more intelligent and attractive. It is important to provide those forerunners with convincing arguments about why it is vital to invest in better lighting.

Table 1 presents an overview of the ten suggested focus areas, in a European framing. The two important business perspectives ‘Smart Systems’ and ‘Energy Savings’ are mentioned on top of the list and are applicable for all areas. The numbering, 1-10, is the D2.6 priority list of suggestions for demonstrations and business experiments and also the list of content for the descriptions below and in the appendices.

Table 1: Development situation for 10 Intelligent Systems and Human-Centric lighting innovation areas and the two generally applicable features, and their 2020 estimated European business potential. The basis for the market numbers is presented in Table 2 (on page 16).

	Suggested European development areas	Time for start up	Awareness, customer value & societal value	Political framing	2020 potential (million Euro)		HCL+ILS market (million Euro)	
					HCL	ILS	2017	2020
	Smart Systems	now	societal development	digital agenda	600	1900	900	2500
	Indoor				580	1220	400	1800
	Outdoor				20	680	500	700
	Energy Savings	on-going	sustainable development	energy saving	70	2030	2600	2100
	Indoor				50	1350	1600	1400
	Outdoor				20	680	1000	700
1	24/7 work	now	productivity, safety, health grades, SSR	challenge	180	60	100	240
2	Education	now			180	140	80	320
3	Meeting rooms	now			20	80	70	150
4	9-5 work	now			190	30	60	220
5	Health	now			120	120	50	240
6	Outdoor lighting	on-going	safety, security, esthetics	digital agenda	160	740	300	900
7	Automotive	on-going			200	300	300	500
8	Decorative lighting	on-going			40	220	80	260
9	Elderly	2017	wellbeing	challenge	90	10	50	100
10	Home	2016	status, wellbeing		230	120	40	350

2.2 Assessment of business potentials

The basis for the Table 1 numbers is explained in Table 2.

The way the McKinsey and LightingEurope, ZVEI and A.T. Kearney market data are used in Table 2 may appear to be overly optimistic. However, there is a hidden conservatism in that perspective which tends to assume that the level of customer value will remain almost the same as before. The SSL-erate observations, dialogues and reports indicate that it is possible to enhance the lighting related customer values.

Another basis that indicate that the innovation potential is quite significant is the rapid increase of the efficacy for the best LED lamps, which supports Haitz’s Law: Every decade, the cost per lumen (unit of useful light emitted) falls by a factor of 10, the amount of light generated per LED package increases by a factor of 20. This means that SSL now is a mature technology in terms of basic light-generating efficiency.

Furthermore, Haitz’s law and today’s flexibility to combine LED, sensors, hard- and software and user interfaces have enabled a very large freedom of action to build smart system solutions. However, the functionality and quality of the products that are becoming available varies quite a lot.

From a rational point of view, competent serious actors can use the market transformational challenges and market uncertainties as a competitive advantage.

Assessment relevance

It is always difficult to estimate the market potential for a not yet established field of business. In the field of lighting there are long time series of business statistics for lighting, but these numbers are not entirely relevant for the future value of intelligent human centric lighting solutions. Neglecting numbers that are difficult to assess, and assuming that such segments have zero business potential,

is an approach often encountered. Table 1 is aiming to present a relevant overarching perspective, including some numbers that are difficult to assess.

A table containing such numbers can be used to stimulate concrete dialogue and mutual learnings. The numbers in Tables 1 and 2 should not be read as proven true market potentials. However, they build on published reports, a lot of experience and numerous dialogues, not only within SSL-erate.

The Table 2 selections of suggested areas, estimates and data have a basis in SWOT and Cost Benefit analyses; see the Appendix, the SSL-erate dialogues and the reports D2.5, D2.4, D2.3, D2.2, D3.1 and D5.1. The selections of the cases have been done in parallel with the work on the SWOT analyses and Cost Benefit analyses in the Appendix to this report. The work on the SWOT analyses is based on the mentioned reports, and the experiences from the numerous workshops and also from dialogues at a number of 2014 conferences, e.g. Light & Building in Frankfurt, Smart Lighting in Barcelona and LED Professional Symposium in Bregenz.

Table 2: Background of estimated European business potentials for 10 Human-Centric Lighting [HCL] and Intelligent Lighting Systems [ILS] innovation areas of Table 1. Selection and ordering of business cases is based on SWOT and Cost Benefit analyses (see appendices), SSL-erate dialogues and reports D2.2, D2.3, D2.4, D3.1, D3.3 and D5.1. Financial assessment is based on report D2.5, and therefore, on studies of the existing lighting market and future potential for HCL (2013 LightingEurope, ZVEI and AT Kearney HCL market study, 2012 McKinsey Global Lighting market study).

	Suggested European development areas	Time for start up	Awareness, customer value & societal value	Political framing	2020 potential (million Euro)		HCL+ILS market (million Euro)	
					HCL	ILS	2017	2020
	Smart Systems	now	societal development	digital agenda	600	1900	900	2500
	Indoor				580	1220	400	1800
	Outdoor				20	680	500	700
	Energy Savings	on-going	sustainable development	energy saving	70	2030	2600	2100
	Indoor				50	1350	1600	1400
	Outdoor				20	680	1000	700
1	24/7 work	now	productivity, safety, health	challenge	180	60	100	240
2	Education	now	grades, SSR		180	140	80	320
3	Meeting rooms	now	productivity, wellbeing		20	80	70	150
4	9-5 work	now	productivity, health		190	30	60	220
5	Health	now	wellbeing	120	120	50	240	
6	Outdoor lighting	on-going	safety, security, esthetics	digital agenda	160	740	300	900
7	Automotive	on-going	branding, safety	challenge	200	300	300	500
8	Decorative lighting	on-going	branding, esthetics		40	220	80	260
9	Elderly	2017	wellbeing		90	10	50	100
10	Home	2016	status, wellbeing		230	120	40	350
Basis for numbers in Table above								
Smart Systems		McKinsey 2012: Table 3						
Energy Savings		McKinsey 2012: Table 3						
24/7 work		D2.5 Table: Office (10%) + Industrial (20%); Smart systems (5%)						
Education		D2.5 Table: Education (100%); Smart systems (2)						
Meeting rooms		D2.5 Table: Office (10%) + Hospitality (10%); Smart Systems (1%)						
9-5 work		D2.5 Table: Office (20%) + Industrial (20%); Smart systems (2%)						
Health		D2.5 Table: Health care (90%); Smart systems (2%)						
Outdoor lighting		D2.5 Table: Outdoor (100%); Smart systems (5%)						
Automotive		D2.5 Table						
Decorative lighting		D2.5 Table: Hospitality (40%) + Shops (20%) + Architectural (15%); Smart systems (2%)						
Elderly		D2.5 Table: Residential (5%) + Health care (10%); Smart systems (1%)						
Home		D2.5 Table: Residential (30%); Smart systems (2)						
D2.5 Table: Global and European 2020 market volume predictions of Lighting Services (LS), Solid State Lighting (SSL), Human Centric Lighting (SSL-HCL) and Intelligent Lightig Solutions (SSL-ILS)								
2020 (billion Euro)	Global				Europe			
	LS	SSL	SSL-HCL	SSL-ILS	LS	SSL	SSL-HCL	SSL-ILS
residential	31,6	23,0	1,9	1,2	8,4	6,1	0,70	0,31
office	15,0	8,0	1,0	1,6	2,9	1,5	0,20	0,30
shop	8,3	6,0	0,03	1,5	1,5	1,1	0,01	0,28
hospitality	5,6	5,0	0,04	1,3	1,2	1,1	0,01	0,28
industrial	5,4	2,0	1,0	0,40	1,4	0,52	0,26	0,10
outdoor	11	8,0	0,50	2,0	3,5	2,5	0,16	0,63
architectural	5,6	5,0	0,61	1,0	0,92	0,82	0,10	0,16
education	(4)	(2,4)	(0,60)	(0,48)	(1)	(0,6)	0,15	0,12
health care	(4)	(2,4)	(0,40)	(0,48)	(1)	(0,6)	0,10	0,12
automotive	18,0	6,0	3,0	0,30	2,7	0,90	0,45	0,05
backlighting	1,0	1,0	0,50	0,50	0,0	0,0	0,0	0,0
total	101	64,0	8,6	9,8	22,5	14,5	2,1	2,3
() included in office and residential numbers								

2.3 Life cycle economics

The global market volume for lighting products and installations is about 100 billion Euro according to McKinsey 2012 (see Table 2). In a green life cycle perspective it is relevant to compare this with the estimated global electricity use for lighting. In 2011 the electricity used globally for lighting was estimated to 2950 TWh⁷ and the average European household electricity price was 0,179 €/kWh⁸. With those numbers the yearly global cost for lighting electricity is estimated to be in the order of 500 billion €, i.e. a factor 5.

In Figure 4 the development of GLS investment and energy costs are schematically shown. The historic investment cost has a basis in McKinsey data. Three prospective cases are shown: (i) GLS without considering SSL systems, (ii) GLS including replacement of traditional lighting by SSL, (iii) total GLS market, now additionally including HCL and ILS value enhancing functionalities.

For GLS without SSL systems the life cycle cost factor of 5 for the 2011 ratio of energy cost and investment cost is used to calculate energy cost for the entire depicted period. When SSL replacement of new SSL systems started to be funded, around 2010, the investment cost started to rise and the energy cost to drop, showing the energy saving potential of SSL investments – the political ambition in Europe.

The Figure 4 red energy cost line shows the estimated savings by introduction of SSL. It should be noted that (i) this curve shows the total aggregated cost saving and (ii) that much higher savings have been reported for numerous projects. The red curve also shows the rebound effect that often happen for primitive “cost” reductions and which is a hot topic in environmental sciences. When the price/volume (here for light) decreases there is a tendency to buy more. This risk is considerable as long as people continue to think, “more light is better”. The risk is very large when people buy lighting that makes them feel dissatisfied.

The Figure 4 green energy cost line highlights the effect of the potential investment volume for the enhancement of the user values that are enabled by HCL and ILS. The new level of possible investment cost is related to the new higher user values and also to the energy effectiveness resulting from the possibility to provide the right light, in the right place, at the right time.

The total investment cost for HCL and ILS represents a significant amount of knowledge intensive service and installation jobs, i.e. green jobs. To oversimplify, WP2 suggests that we should try to change the European usage of lighting related money from expenses for electricity to investments in lighting solutions for better quality-of-life.

The green lines in Figure 4 illustrate the effect of a growing market volume for dynamic lighting solutions with added functionality (and simultaneous energy saving) by Smart Systems (the first business development area), in Table 1.

One aspect to consider here is that energy analyses can provide guidance to better user value by clarifying what it is that is that actually is the really wanted functionality. This perspective is similar to the Quality Function Deployment (QFD) method. Similar indirect advantages are noted in the recent IEA publication *Capturing the Multiple Benefits of Energy Efficiency*:

⁷ <http://www.iea.org/textbase/npsum/III.pdf>

⁸ http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Energy_price_statistics

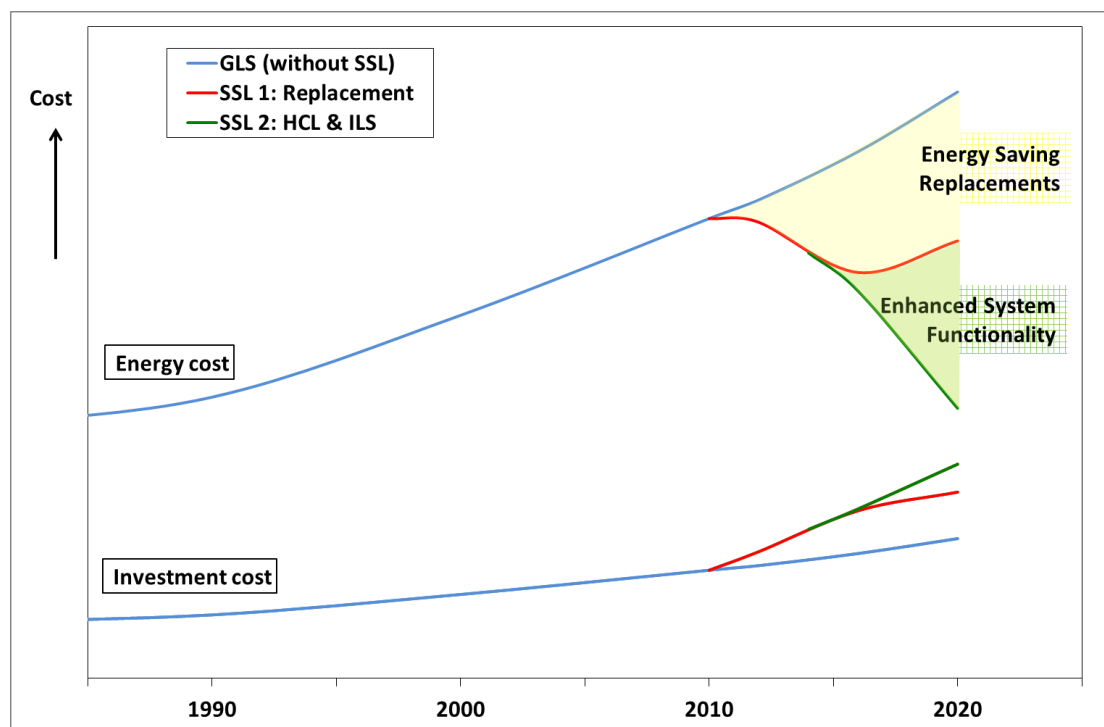


Figure 4: Estimated development of investment and energy cost for lighting in Europe. Three cases are considered: GLS without SSL systems, GLS including SSL replacement of traditional lighting; GLS including value enhancing human centric lighting (HCL) and intelligent lighting solutions (ILS) systems.

Research has brought to the fore a range of areas, beyond energy demand reduction and lower GHG emissions, in which clear benefits of energy efficiency have been documented (Figure ES.2*). Most of these benefits are relevant to IEA member countries and non-member countries alike, although prioritization by individual countries is likely to vary. Experts increasingly acknowledge the important role of energy efficiency in generating a broad range of outcomes that support ambitions to improve wealth and welfare – goals that the public and policy makers both understand and aspire to achieve.⁹

* Figure ES.2 in the IEA report includes the benefits: energy security, energy prices, macroeconomic impact, industrial productivity, poverty alleviation, health and wellbeing, local air pollution, public budget and disposable income.

⁹ Page 3 in <http://www.iea.org/Textbase/npsum/MultipleBenefits2014SUM.pdf>

3 Background for green business development

3.1 Green as a competitive advantage

One starting point for awareness of the potential synergies between the business logics and the sustainable development perspective was presented in the Harvard Business School paper 'Green and Competitive'¹⁰. This perspective on Environmental Management Systems builds on the same basic principle as Quality Management Systems, e.g. the development spiral Plan–Do–Check–Act¹¹. Another background document is the book 'Factor Four'¹² with its 50 examples of quadrupling resource productivity.

The main SSL-erate Sustainable Development focus, see also D2.5, is societal health and wellbeing, by meaningful SSL investments and green jobs. D2.6 is aiming for an open mind-set and an integrative (green) sustainable development perspective¹³. A methodological example is that we have done our best to include all relevant factors and numbers, also those that are difficult to estimate. Of course, it is quite unlikely that we have managed to mention all the relevant aspects and factors that will be found in a couple of years – that's the nature of transformative change. But, we have tried to show in a condensed way today's "complete" picture for and around our selection of the ten suggested business development areas. D2.5 includes a number of conceptual tools for border-crossing renewal oriented dialogues.

3.2 The Environmental Significance of SSL

It has been very difficult to estimate how much of the produced electricity is consumed by lighting. In a major study published in 2006 OECD and the International Energy Agency¹⁴ estimated that grid-based electric lighting consumed 19% of total global electricity production. The greenhouse gas emissions from lighting were estimated to be 1900 Mt of CO₂ per year, equivalent to 70% of the emissions from the world's cars. One reason behind part of the emission from lighting is that kerosene and similar fuels was used to provide lighting for more than one-quarter of the world's population, causing 189 Mt of CO₂ emissions.

The OECD/IEA report estimated that; "if the rate of improvement of lighting technologies does not increase, global lighting electricity demand will reach 4250 TWh: almost twice the output of all modern nuclear power plants. Furthermore, without further energy-efficiency policy measures, lighting-related annual CO₂ emissions will rise to almost 3 gigatonnes by 2030."

Putting this in perspective, the European electricity generation in 2006 was 14% of the global generation. The European lighting electricity saving potential is estimated to be about 100 TWh¹⁵ in 2020 and assessing this as a saving of electricity from coal fired boilers¹⁶ the European CO₂ saving

¹⁰ *Green and Competitive: Ending the Stalemate*, Porter, M. E. & Van der Linde, C. Harvard Business Review 73, no. 5 (September–October 1995).

¹¹ *The PDCA Cycle*. Edwards, W. The Deming Institute. www.deming.org/theman/theories/pdsacycle, 2014

¹² *Factor Four – Doubling wealth, Halving resource use*, Von Weizsäcker U. et al. Earthscan, 1998

¹³ *Our Common Future* (the Brundtland Report), World Commission on Environment and Development, 1987

¹⁴ OECD/IEA, *Light's Labour's Lost, Policies for Energy-efficient Lighting*, 2006

<http://www.iea.org/publications/freepublications/publication/light2006.pdf>

¹⁵ <http://www.energimyndigheten.se/Foretag/Ekodesign/Produktgrupper1/Belysning/>

¹⁶ <http://www.iea.org/media/workshops/2011/cea/ito.pdf>

would be 80 Mt/year¹⁷. This is most important as a positive example for the rest of the world and it should be noted that with the application of SSL systems the resulting decrease in use of fossil fuels is a vital environmental advantage – here the relative saving is even much larger than for the replacement of incandescent bulbs.

Policy makers have been implementing measures to encourage more efficient lighting since the 1970s. “These measures have resulted in impressive returns. In cumulative terms the policies implemented since 1990 saved almost 8% (2960 TWh globally) of lighting electricity consumption up to 2005 and 670 Mt of CO₂ emissions; the policies are also forecasted, when not changed, to save another 14500 TWh and 8500 Mt of CO₂ (17% of the total) from 2006 to 2030. In addition they have been remarkably cost-effective avoiding net costs of USD 253 billion by 2005 and are on course to save USD 1.5 trillion by 2030.” (OECD/IEA 2006)

Indoor illumination of the service sector buildings uses at least 34% of the global service-sector electricity consumption. Outdoor stationary lighting, including street, roadway, parking and architectural lighting as well as outdoor signage, uses less than 10% of global lighting electricity consumption, OECD/IEA 2006.

In recent years the potential to make intelligent lighting systems has increased substantially; the combination of SSL, sensors, ICT hard- and software, and user interfaces now enable much more advanced functionalities than foreseen in the OECD/IEA 2006 report. On the other hand the efficiency of LED light sources on the market has not increased as much as expected in the report and in most countries it has been rather difficult to attain the wanted market growth for LED technology. This is a main reason for SSL-erate to highlight the value enhancing potential of the SSL controllability as an enabler for better functionality, attractive lighting environments, and health and wellbeing improvement.

We share the OECD/IEA view that for a large part of the world’s population there is a need for better lighting. Consequently, there is a vital social sustainability reason for market growth. On the other hand there are products that integrate LED and solar-cells, which is vital for off-grid applications. From technical point of view it is now feasible to save 85 % of the lighting electricity, in comparison to the average lighting that was installed in 2000. Simultaneously smart SSL systems enable significantly improved user value.

3.3 Political priorities as a base for funding possibilities

The new opportunities to create better living and working environments, green more meaningful jobs and transformative change of the lighting sector mean that HCL and ILS are related to several overarching political priorities.

3.3.1 Funding opportunities for energy saving projects

At present, a large source of funding for SSL is the money that is available for energy saving LED investments. It is crucial to make use of the energy saving money in such a way that we build positive European user interest in the new opportunities to create better lighting, exemplified by the

¹⁷ CO₂ emissions savings depend on the mix of electricity generating plants in operation. Savings can be as large as indicated when electricity is mainly generated with coal based plants, but will be smaller when generation is based on hydro or nuclear power.

Smart Systems and the ten selected areas in Table 1. If significant parts of the energy saving investments are done in such a primitive way that it results in dysfunctional or ugly lighting there is a risk that SSL will become unpopular and Europe will miss the long-term business development opportunities for Smart Human-Centric Lighting. Advanced knowledge about the user value will be a significant starting point in the creation of more effective energy savings.

There are numerous sources of guidance and funding for energy saving investments locally, regionally, nationally and from the European Union. Nationally most energy agencies have resources for energy saving investments and many countries are promoting innovative procurement. The long-term cost advantages mean that this field is interesting for venture capital actors, e.g. the European Investment Bank, EIB and electric utilities when pursuing service based business developments to sell light instead of kWh.

3.3.2 Grand challenges

The Initiative for Science in Europe (ISE) 'Statement on Grand Challenges and Horizon 2020' (2011)¹⁸, shows the following five challenging themes:

- Building resilient societies: investigating challenges to European societies because of demography, migration, the need for sustainability and cultural identity;
- Social innovation: looking into ways public sectors etc. change with entrepreneurship and creativity;
- 'Actor Europe:' researching into the Globalization-effects on society, governance and democracy;
- Education and employment policies in the modern society: investigating equity in employment policies and the how educational systems can develop and
- Capacity and support activities: foresight, indicators, networks, infrastructure, and capacities.

The Lund Declaration (2009) "Europe Must Focus on the Grand Challenges of our Time"¹⁹ highlights the following challenges, see also ISI's 'Contribution to Grand Societal Challenges' (2010)²⁰:

- Global warming
- Tightening supplies of energy, water and food
- Ageing societies: As the life duration of people increases, this raises numerous issues among which economic, social inclusion, accessibility.
- Public health
- Pandemics
- Security

3.3.3 The Digital Agenda for Europe

The Digital Agenda for Europe (DAE) aims to reboot Europe's economy and to help Europe's citizens and businesses to get the most out of digital technologies. It is the first of seven flagship initiatives under Europe 2020, the EU's strategy to deliver smart sustainable and inclusive growth. The digital economy is growing at seven times the rate of the rest of the economy.

¹⁸ http://www.initiative-science-europe.org/pdf/ISE_statement_Grand_Challenges.pdf

¹⁹ http://www.se2009.eu/polopoly_fs/1.8460!menu/standard/file/lund_declaration_final_version_9_july.pdf

²⁰ http://ec.europa.eu/invest-in-research/pdf/download_en/isi_contribution.pdf

The DAE's policy objectives are also supported by EU investment in ICT Research through the Horizon 2020 programme. This seeks to maintain Europe's competitive edge through increased coordination and elimination of Europe's fragmented efforts.

The full implementation of the updated Digital Agenda would increase the European GDP by 5%, or 1500 Euro per person, over the next eight years, by increasing investment in ICT, improving eSkills levels in the labor force, enabling public sector innovation, and reforming the framework conditions for the internet economy. In terms of jobs: up to 900.000 digital jobs are at risk to go unfilled by 2020 without pan-European action while 1.2 million jobs could be created through infrastructure construction. This would rise to 3.8 million new jobs throughout the economy in the long term.²¹

One foundation for successful digitalization is it that it is vital to promote interoperability²² and relate evolving forms of formal and de-facto standardization and modularization. In the ENIGMA project one basic aim is that the smart ICT-based lighting solutions should enable Adaptability, Interactivity, Modifiability, Modularity and Openness²³.

It is interesting that there is lighting everywhere, more and more including sensors for supervision and smart control in parallel with the ambitions of Internet of Things. The preface in *Lighting the Cities* was written by the Vice Chancellor for the Digital Agenda for Europe.

3.4 Stakeholders

Most of the descriptions of the SSL benefits relate to the end customers and lighting users. However, there are numerous intermediate business actors, e.g. facility owners, facility managers, financiers, service providers and installers. D5.1, D2.4 and D2.3 contain some information about such stakeholders.

It may be suitable to focus on some of the intermediate actors because they oversee different application fields for the lighting solutions on offer. Taking an active role in some of these business areas might be potentially interesting for some of the smart lighting actors. The fragmentation of the present value chains is a shortcoming of which the remedy is vital; see also D2.2, D2.3 and D2.4. There is a need for capacity building and for creating openness and user engagement in development dialogues.

²¹ <http://ec.europa.eu/digital-agenda/en/digital-agenda-europe>

²² Palfrey John and Gasser, *Interop: The Promise and Perils of Highly Interconnected Systems*, 2012

²³ http://www.enigma-project.eu/en/upload/docs/PIN/ENIGMA_Sounding_prospectus_FINAL.pdf

4 Conclusion

D2.6 presents a priority list of 2 + 10 suggested business development areas, in a European framing. The report presents four areas with specific user value; Meeting rooms, Decorative lighting, The ageing population and 24/7 shift work. The market areas Education, Automotive, Health and Home adhere to the traditionally used structure of market segments. Smart Systems is related to Smart Buildings and Smart Cities, and can, to some extent and in various ways, be applied in all market segments. The “Energy Savings” focuses on a value enhancing approach aiming to make the resources for the investments useful to build positive European user interest in the new opportunities to create intelligent lighting. The smart lighting system applications already have potential to make the new lighting significantly more appreciated and simultaneously save 85 % of the lighting electricity in comparison to an installation from 2000.

The report focuses on innovative business development for Human Centric Lighting and Intelligent Lighting Systems. HCL starts with knowledge about the users’ needs and wants, e.g. from health and wellbeing point of view. ILS focuses on the customer advantages of developing Smart Lighting in synergy with and as a driver for entrepreneurial development of broader applicable smart system solutions.

A motive for innovative investments is that it has become a Societal Social Responsibility (analogous to Corporate Social Responsibility, CSR) to invest in HCL in order to improve the working and living conditions, e.g. in schools and for elderly people and shift workers.

Appendices with SWOT and Cost Benefit assessments

The following SWOT analyses, for the two generally applicable features and the ten different application areas, summarize the learning's from the SSL-erate application workshops and subsequent dialogues within the project and among a number of leading participants in following conferences:

- Light + Building, Frankfurt
- Smart lighting, Barcelona
- LpS, Bregenz
- ICT Key Enabling Technologies, Rome
- Electronica, Munich
- Lux Life, London

The Cost Benefit Assessments are based on the SWOT analyses and “translated” into a financial business perspective.

Smart System Development

Lighting as a part of Smart Societal development, related to the digital agenda, smart cities and smart buildings.

Interesting for a renewal-oriented company/department that want to engage in integrative collaboration with both ICT-actors and lighting actors.

SWOT

Strengths <ul style="list-style-type: none"> • Meeting of minds • Topical business idea • Topical network • ICT business logics (Moors law) 	Weaknesses <ul style="list-style-type: none"> • The goal is rather vague • Hardly any value chain yet • Immature conceptual basis
Opportunities <ul style="list-style-type: none"> • Great political priority • Market with basis in value enhancing business logics • Part of the Digital Agenda • Inter-operationability and smart systems is a topical subject • Most lighting actors not yet active 	Threats <ul style="list-style-type: none"> • Competition from strong business actors with a basis in ICT • Difficult to surpass the lighting oligopoly • Difficult to surpass the traditional lighting thinking • Competition from other groups

Cost/Benefit in a Product/Service market perspective

Cost aspects <ul style="list-style-type: none"> • So far limited scale of business, i.e. relatively high product cost • Need to build awareness • Need to develop solutions that deviate from the traditional • Need for competence development 	Benefit aspects <ul style="list-style-type: none"> • Cost effective smart systems build-up • Basis for smart supervision and interconnection with Big data • Enabling dynamic user adapted lighting with higher user value • Energy effectiveness • Branding potential as renewal oriented customer
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Cost/Benefit in an innovative business development perspective

Cost aspects <ul style="list-style-type: none"> • Need to invest in “new production” • Need to build a new value chain and maybe also a new business model • Need for competence development • Need to build VC awareness • Need to prove a new business case 	Benefit aspects <ul style="list-style-type: none"> • Possible opening to a growing market • Branding potential as innovative business actor • Exciting as partner for renewal oriented actors • Attractive workplace for renewal oriented experts and entrepreneurs
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Wise Energy Savings

The basis for this approach is that quite a lot of resources are available for energy saving projects. It is important that those resources are deployed to create attractive light environments and appreciated systems functionalities. This is a competitive advantage for the players who show that they can supply HCL and ILS in an effective way.

Interesting for an innovative company/department that is able to use activities enabled by energy saving money as basis for their development.

SWOT

Strengths <ul style="list-style-type: none"> Trustworthiness in making wise use of energy saving money Business model that relates to a large basis of present funding 	Weaknesses <ul style="list-style-type: none"> Difficult to specify what it is that signifies a wise investment
Opportunities <ul style="list-style-type: none"> A lot of funding available Topical political priority 	Threats <ul style="list-style-type: none"> Limited general awareness about the sustainable development importance of wise lighting investments Competition from cheap energy saving projects Procurement that only focuses on lowest possible cost Political priorities that focuses on volume

Cost/Benefit in a Product/Service market perspective

Cost aspects <ul style="list-style-type: none"> Higher investment than solutions with minimum initial cost More demanding design and installation Difficult to find trustworthy competent collaborators 	Benefit aspects <ul style="list-style-type: none"> User appreciation Properly working functionality Upgradeability Branding potential as sensible customer that care for the users Energy saving
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Cost/Benefit in an innovative business development perspective

Cost aspects <ul style="list-style-type: none"> Need to modify the tradition value chain and maybe also business model Need for competence development Need to build VC awareness Need to prove the business relevance of the wise energy saving approach 	Benefit aspects <ul style="list-style-type: none"> Plenty of funding available Branding potential as intelligent company that care for the users Interesting as partner for renewal oriented energy saving actors and stakeholders
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1. 24/7 work places

Lighting for health, wellbeing and safety in 24/7 work facilities, e.g. in hospitals and control rooms.

Interesting for a renewal-oriented company/department that want to engage in collaboration with researchers from different disciplines.

SWOT

Strengths <ul style="list-style-type: none"> • Environments with specific needs enable development of user values • Interesting from health & wellbeing point of view • More productive staff • Reduce stress and absenteeism 	Weaknesses <ul style="list-style-type: none"> • Relatively small market • Difficult to prove the health benefits
Opportunities <ul style="list-style-type: none"> • Interesting test environment for circadian regulation • Interesting test area for how light affects us during night-time 	Threats <ul style="list-style-type: none"> • Procurement that only focuses on lowest possible cost

Cost/Benefit in a Product/Service market perspective

Cost aspects <ul style="list-style-type: none"> • More demanding design and installation 	Benefit aspects <ul style="list-style-type: none"> • May reduce the risk of accidents • May reduce the number of sick days • Reduced cost for sickness leave
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Cost/Benefit in an innovative business development perspective

Cost aspects <ul style="list-style-type: none"> • Need for competence development • Need to prove the value of the cost increase 	Benefit aspects <ul style="list-style-type: none"> • Branding potential as renewal oriented company/city/region
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2. Education

Lighting for increased results and improved health and wellbeing for teachers and pupils.

Interesting for a renewal-oriented company/department that want to build a profile of being engaged in the future, on a local as well as on a larger scale.

SWOT

Strengths <ul style="list-style-type: none"> • Possibility to increase education results • Possibility to improve social climate • Possibility to reduce the number of diagnosis (e.g. hyperactivity) • Enabling context adapted environments 	Weaknesses <ul style="list-style-type: none"> • Increased initial cost • Limited proof of effects
Opportunities <ul style="list-style-type: none"> • Large long-term market potential • Significant room for improvements • Great political priority • Large available amount of floor space 	Threats <ul style="list-style-type: none"> • Budget restrictions • Conservative cost minimizing procurement principles • Difficult to find funding possibilities

Cost/Benefit in a Product/Service market perspective

Cost aspects <ul style="list-style-type: none"> • Higher investment than solutions with minimum initial cost 	Benefit aspects <ul style="list-style-type: none"> • Possibility to reduce the number of diagnosis • Possibility to increase education results
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Cost/Benefit in an innovative business development perspective

Cost aspects <ul style="list-style-type: none"> • Need to build VC awareness 	Benefit aspects <ul style="list-style-type: none"> • Branding potential as sensible customer that care for the users
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3. Meeting rooms

Lighting for improvement of productivity and wellbeing in meeting rooms.

Interesting for a renewal-oriented company that want to want to show that they have good working environments, e.g. in the board room and in the hospitality sector, in particular for luxury faculties.

SWOT

<p>Strengths</p> <ul style="list-style-type: none"> • Better contact between the meeting participants, when they can read each other's facial expressions more clearly. • Circadian alertness advantages • Limited area that is relatively easy to grasp and develop 	<p>Weaknesses</p> <ul style="list-style-type: none"> • Difficult to prove the productivity advantage • Complex structure of value chains
<p>Opportunities</p> <ul style="list-style-type: none"> • Customers with available money • Conference rooms in hotels and influential meeting places Potential productivity advantages • Customers interested in new experiences 	<p>Threats</p> <ul style="list-style-type: none"> • Conservative customers • The ventilation sector is taking all the money

Cost/Benefit in a Product/Service market perspective

<p>Cost aspects</p> <ul style="list-style-type: none"> • Higher investment than solutions with minimum initial cost • More demanding design and installation 	<p>Benefit aspects</p> <ul style="list-style-type: none"> • Customers with available money • Branding potential as sensible customer that care for the users
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Cost/Benefit in an innovative business development perspective

<p>Cost aspects</p> <ul style="list-style-type: none"> • Need to prove the value of the cost increase 	<p>Benefit aspects</p> <ul style="list-style-type: none"> • Customers with financial assets
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4. 9-5 work places

Lighting for productivity, health, wellbeing in 9-5 work facilities, e.g. in offices and factories.

The productivity is influenced by the alertness among employees and the quality of the visual environment. Furthermore, the productivity advantage of being able to better read each other's facial expressions is significant. The visual appearance of the working environment is interesting in recruitment situations and for a renewal-oriented company/department that want to engage in preventive health measures and reach out to a larger population.

SWOT

Strengths <ul style="list-style-type: none"> • User adapted environments • Preventative health • Reduce stress and absenteeism 	Weaknesses <ul style="list-style-type: none"> • Increased initial cost • Limited awareness about productivity advantages • Difficult to prove the health benefits • Difficult to assess the specific needs • Different users have different priorities
Opportunities <ul style="list-style-type: none"> • Large potential customer group • Reduction of stress • Higher productivity & accuracy • Improved visual ergonomics • Positive work environment • Prevent work place accidents • Branding as a good workplace • Energy savings 	Threats <ul style="list-style-type: none"> • Procurement that only focuses on lowest possible cost • Competition from other types of work environment improvements • The rigidity of the established lighting norms and lighting value chains

Cost/Benefit in a Product/Service market perspective

Cost aspects <ul style="list-style-type: none"> • Increased initial installation cost • Need to educate the staff 	Benefit aspects <ul style="list-style-type: none"> • Higher productivity • May reduce the number of sick days • Reduced cost for sickness leave • Energy savings
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Cost/Benefit in an innovative business development perspective

Cost aspects <ul style="list-style-type: none"> • Need for competence development • Need to prove the user and business value of the investment 	Benefit aspects <ul style="list-style-type: none"> • Branding potential • Positive work environment • Part of CSR for the employees
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5. Health “gardens” and hospitals

Lighting to promote the development of health centers.

Interesting for a renewal-oriented company/department that want to engage in the development of advanced technology for health & wellbeing.

SWOT

<p>Strengths</p> <ul style="list-style-type: none"> • Possibility to increase health and wellbeing • Possibility to increase the safety • Possibility to focus on health rather than illness • Possibility to make use of circadian adaptation • Speed up recovery • Reduce anxiety • Great political priority 	<p>Weaknesses</p> <ul style="list-style-type: none"> • Difficult to prove health and wellbeing effects
<p>Opportunities</p> <ul style="list-style-type: none"> • Customers are used to invest in advanced technology • Increased interest in health and wellbeing • Interesting test environment for circadian regulation • Great political priority 	<p>Threats</p> <ul style="list-style-type: none"> • Procurement that only focuses on lowest possible cost • Strength of existing supply chain

Cost/Benefit in a Product/Service market perspective

<p>Cost aspects</p> <ul style="list-style-type: none"> • So far limited scale of business, i.e. relatively high product cost • Need to build awareness • Higher investment than solutions with minimum initial cost 	<p>Benefit aspects</p> <ul style="list-style-type: none"> • Possibility to reduce the number of sick days • Possibility to reduce the number of accidents • Speed up recovery
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Cost/Benefit in an innovative business development perspective

<p>Cost aspects</p> <ul style="list-style-type: none"> • Need for competence development 	<p>Benefit aspects</p> <ul style="list-style-type: none"> • Branding potential as sensible customer that care for the users • Branding potential as renewal oriented company/city/region
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6. Outdoor lighting

This area includes lighting for streets, highways, tunnels, and other public and non-public outdoor areas, such as parking lots, and stadiums. Outdoor lighting has to fulfill three criteria, safety, security and esthetics. Safety means adequate lighting for visibility, security is required as a deterrent to crime, and esthetics is important to create inviting, intimate atmosphere.

Interesting for a renewal-oriented company/department that is searching a starting point for smart city development and aiming for integration of ICT and lighting.

SWOT

Strengths <ul style="list-style-type: none"> • Already developed starting point for ICT and lighting infrastructure • Strong political energy saving priority • Application area for smart societal development and smart city 	Weaknesses <ul style="list-style-type: none"> • Limited renewal level in the present projects • Limited connection to health and wellbeing • Difficult to bring in the health dimension • Replace ability
Opportunities <ul style="list-style-type: none"> • Smart outdoor lighting is visible innovation and city branding potential • Increased safety • Use of light poles as “hot spots” • Reduction of light pollution • Increased visibility • Energy savings • Affluent customers 	Threats <ul style="list-style-type: none"> • Procurement that only focuses on lowest possible cost • Already developed competition • Difficult to coordinate all the lighting in the public space • Difficult to standardize

Cost/Benefit in a Product/Service market perspective

Cost aspects <ul style="list-style-type: none"> • Increased installation cost • Need for competence development 	Benefit aspects <ul style="list-style-type: none"> • May reduce the risk of accidents • Energy savings • Project customers with money
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Cost/Benefit in an innovative business development perspective

Cost aspects <ul style="list-style-type: none"> • Need to prove the added customers value by the investment 	Benefit aspects <ul style="list-style-type: none"> • Branding potential as renewal oriented and attractive city/region
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7. Automotive

Lighting for cars, other vehicles and various forms of transport infrastructure.

Interesting for a renewal-oriented company/department that want to take a leading position in development of high-tech lighting solutions.

SWOT

<p>Strengths</p> <ul style="list-style-type: none"> • Comparatively high-tech to other lighting areas • Experience and branding advantages • Possibility to take a leading role in development of renewal oriented lighting solutions • Limited area that is relatively easy to grasp and develop 	<p>Weaknesses</p> <ul style="list-style-type: none"> • Difficult to relate to energy saving processes
<p>Opportunities</p> <ul style="list-style-type: none"> • Upgradeability • Enhanced safety with closeness detection • Increased safety and wellbeing with circadian regulation • Leading development area for more advanced functionalities • Freedom of design 	<p>Threats</p> <ul style="list-style-type: none"> • Highly developed competitors • Strength of existing supply chain

Cost/Benefit in a Product/Service market perspective

<p>Cost aspects</p> <ul style="list-style-type: none"> • High investment cost 	<p>Benefit aspects</p> <ul style="list-style-type: none"> • Branding potential as high-tech customer
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Cost/Benefit in an innovative business development perspective

<p>Cost aspects</p> <ul style="list-style-type: none"> • Need for competence development • Need to prove the value of the cost increase 	<p>Benefit aspects</p> <ul style="list-style-type: none"> • Can raise the price of the whole vehicle • Customers with financial assets • Branding potential as high-tech company • Interesting as a partner for high-tech companies
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8. Decorative lighting

Lighting for theatres, festivals, restaurants, hotels, shops, museums and other areas where the lighting atmosphere is a visualization tool, an attractor and branding factor. The leading “festival” installations are a possible “play-ground” for experimentation with new kinds of lighting effects.

Interesting for a renewal-oriented company/department that want to play with new kinds of lighting effects and take a leading role in the creation of interest for new kinds of lighting.

SWOT

Strengths <ul style="list-style-type: none"> • “Play-ground” for experimentation • Interesting for learning and branding • Possibility to take a leading role in development of new kinds of lighting effects • Experience and branding advantages 	Weaknesses <ul style="list-style-type: none"> • Small volume • Customers need money to be able to invest in this kind of “add on” functionality
Opportunities <ul style="list-style-type: none"> • Great political priority • Part of the Digital Agenda • Enhanced aesthetic attractiveness • Possibility to increase tourism 	Threats <ul style="list-style-type: none"> • Competition from other groups • Highly developed competitors

Cost/Benefit in a Product/Service market perspective

Cost aspects <ul style="list-style-type: none"> • Advanced technology 	Benefit aspects <ul style="list-style-type: none"> • Possibility to increase tourism • User appreciation
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Cost/Benefit in an innovative business development perspective

Cost aspects <ul style="list-style-type: none"> • Need to cover the investment cost 	Benefit aspects <ul style="list-style-type: none"> • Branding potential as renewal oriented company/city/region
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9. The ageing population

Lighting for enhanced quality of life and improved health and wellbeing for elderly.

Interesting for a renewal-oriented company/department that want to build a profile of being engaged in the future, on a local as well as on a larger scale.

SWOT

<p>Strengths</p> <ul style="list-style-type: none"> • Increased safety • Increased health and wellbeing • Possibility to focus on health rather than illness • Possibility to improve circadian cycles • Increase independency and self confidence • Reduced risk for accidents • Reduce sleeping disorders and depression • Reduced need for healthcare 	<p>Weaknesses</p> <ul style="list-style-type: none"> • Limited willingness to pay among elderly • Complex value-chain with very many users and the main procurement via ordinary shops • Unclear proof of the indirect effects
<p>Opportunities</p> <ul style="list-style-type: none"> • Extensive market • Major strategic priority in Europe • Controllability to reduce disturbing light at night-time • Large long-term market potential • Significant room for improvements • Great political priority • Increased interest in the living conditions for elderly 	<p>Threats</p> <ul style="list-style-type: none"> • Budget restrictions • Conservative cost minimizing procurement principles • Difficult to find funding possibilities • Strength of existing supply chain

Cost/Benefit in a Product/Service market perspective

<p>Cost aspects</p> <ul style="list-style-type: none"> • Higher investment than solutions with minimum initial cost • So far limited scale of business, i.e. relatively high product cost • Need to build awareness 	<p>Benefit aspects</p> <ul style="list-style-type: none"> • Possibility to reduce the number of sick days • Possibility to reduce the number of accidents • Speed up recovery
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Cost/Benefit in an innovative business development perspective

<p>Cost aspects</p> <ul style="list-style-type: none"> • Need for competence development • Need to prove the value of the cost increase 	<p>Benefit aspects</p> <ul style="list-style-type: none"> • Branding potential as sensible customer that care for the users • Reduced need for healthcare
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10. Smart home lighting

Lighting for the domestic market, as a part of Smart Societal de smart cities and smart buildings.

Interesting for a renewal-oriented company/department that want to be engaged in the complex, large domestic market. The new features and benefits that ILS and HCL will draw the attention of the innovators and early adaptors within the domestic market.

SWOT

Strengths <ul style="list-style-type: none"> • Increased safety • Increased health and wellbeing 	Weaknesses <ul style="list-style-type: none"> • Lifetime uncertainty
Opportunities <ul style="list-style-type: none"> • Extensive market • Affluent persons that can make their own decisions. • Controllability to reduce disturbing light at night-time 	Threats <ul style="list-style-type: none"> • Complex market • Slow acceptance

Cost/Benefit in an Product/Service market perspective

Cost aspects <ul style="list-style-type: none"> • Higher investment than solutions with minimum initial cost • So far limited scale of business, i.e. relatively high product cost 	Benefit aspects <ul style="list-style-type: none"> • Branding potential as high-tech customer • Properly working functionality
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Cost/Benefit in an innovative business development perspective

Cost aspects <ul style="list-style-type: none"> • Need to build awareness 	Benefit aspects <ul style="list-style-type: none"> • Affluent persons
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