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Accelerate SSL Innovation for Europe

D2.4 Compilation of examples of green SSL business and solutions

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Table of Contents

Summary	4
1 Introduction.....	5
2 Workshop summary - New SSL opportunities and barriers	6
2.1 Barriers to the implementation of SSL.....	6
2.2 New SSL ideas and opportunities.....	7
2.2.1 Lighting for indoor environments	7
2.2.2 Lighting for outdoor areas	8
3 Areas of particular development potential	9
3.1 Schools.....	9
3.2 Elderly Homes	9
3.3 Light as a mediator of information and experience	10
3.4 Storytelling	11
4 Compilation of smart lighting examples.....	12
4.1 State of the art	12
4.2 Future potential functional areas for smart lighting	14
5 Difficulties and opportunities with the new freedom of action	17
5.1 Tools to navigate in the new freedom of action.....	18
6 Conclusion	19

Summary

The aim of the SSL-erate project is to accelerate the uptake of SSL in Europe by means of open innovation. Solid State Lighting and ICT enable a huge freedom of action that can be used and, unfortunately, also misused. Therefore, focus is needed on the new added values, like aesthetic attractiveness and positive impact on human health and wellbeing. It is important to clarify and visualize this potential.

This report summarizes examples of new green SSL business and solutions based on the outcome of the application workshops organised in the European cities, the cities storytelling of what they want to procure and an extensive search for innovative green SSL solutions. A table summarizing soft co-benefits has been added in order to give an idea of the added values that the new lighting can provide.

In this search the focus has been on the functional unit, the value of the new solution, and not so much on the reduction in environmental load. The gap between what is already on the market and what we want to accomplish has been clarified, describing existing state of the art examples and formulating the desires of the customers.

With the new opportunities it's becoming obvious that light is a mediating contact medium between human beings and with the world around them. This shift of perspective can help us to figure out new ways to create interactive lighting. We need to shift the focus from products to light environments.

Key is to read the situation, understand the need and to lay the puzzle in accordance with usability and controllability for the specific situation, in order to make the right lighting system. We are aiming for smarter solutions and to categorize the proposals regarding their ability to provide user adapted solutions.

A new standard which gives a fair presentation of what smart lighting can provide would further facilitate the introduction of SSL.

A business development strategy should be outlined where a common language and conceptual world are important elements among others in order to facilitate the communication of the added values to a buyer. This will support start-up and performance of business experiments and promote SSL lighting business growth.

1 Introduction

The aim of the SSL-erate project is to accelerate the uptake of high-quality Solid State Lighting (SSL) in Europe by means of open innovation with and by bringing validated information to all relevant stakeholders. Within WP 2 workshops with an open dialogue setting are organized with at first the city partners and then their local network to create awareness. In the workshops efforts are being made to address opportunities and obstacles for public use of SSL solutions, to create commitment among broader new groups of actors and to support Green Business development ambitions.

In the recent past, Europe already has had a large number of Energy Saving projects, but the projects hardly have resulted in any significant positive follow-up activities. There is a need to focus on the new added values possible with SSL, like aesthetic attractiveness and positive impact on human health and wellbeing. It is important to clarify and visualize this potential.

SSL in itself is not good or bad, but the combination of SSL and ICT creates a new large field, a field with a huge freedom of action. All the new technical components can be combined to meet both visual and non-visual needs, presenting many new opportunities. At the same time, it is possible to make poorly engineered products - including LEDs and other types of light sources - or poorly implemented lighting systems to cause harm. For sustainable development, there is a need for more intelligent guidance and choices, and the green development potential has to be made attractive.

This report summarizes examples of new green SSL business and solutions based on the outcome of the application workshops that have been organised in the European cities, the cities storytelling of what they want to procure and an extensive search for innovative green SSL solutions. A table summarizing some soft co-benefits – the positive aspects given by human-centric lighting for health and well-being – that have been mentioned during the workshops has been added in order to give an idea of the added values that the new lighting can provide.

In the SSL-erate D2.2 report a compilation of energy saving projects with a focus on green business and/or health and wellbeing was made. In this report we start from the other end by searching for exciting new products and ideas and then look at their contribution to green business and/or health and wellbeing. In this search the focus has been on the functional unit, the value of the new solution, and not so much on the reduction in environmental load.

We try to clarify the gap between what is already on the market (e.g. IBM, KNX, Intel, Zigbee and Dali) and what we want to accomplish in order to find the meeting point between wishes and needs of users and the possibilities of available technical components.

2 Workshop summary - New SSL opportunities and barriers

This chapter summarizes and reflects on the outcome of the SSL application workshops that have been organized in European cities. The workshops are intended to identify the barriers, the green business opportunities, and the drivers and the hurdles for accelerated deployment of SSL solutions with higher user value, in Europe.

2.1 Barriers to the implementation of SSL

The barriers in the following section are of a general nature and applicable to both indoor and outdoor environments. The barriers are withdrawn from the discussions between different stakeholders during application workshops.

In order to build real interest to invest in SSL we need to shift the focus from energy savings to healthier light environments with the right light at the right place at the right time.

The lack of information from the consumer point of view is a hurdle in the development of SSL solutions. As long as the industry does not succeed to represent human perception in intelligible units and to communicate lighting information better, the consumer will only accept LED products hesitantly and continue to look for old light bulbs on the Internet.

Today buyers are willing to spend hundreds of euros to get the right design of the lighting fixture in e.g. their living room: this indicates that when people clearly see the added value they are willing to spend serious money. Our challenge is to get the new added value proven and communicated.

Therefore, it is important to educate and train both the actors that are procuring and installing the lighting, and the users. When we build more advanced systems, we need to learn how to handle and make full use of them.

If we are aiming today for specific light properties, such as output, brightness and durability, light sources must always be ordered as a system from the same manufacturer. The lack of uniform information is one of the main reasons why lighting designers and planners complain and want to see standards imposed on the industry; the actual light properties too often do not correspond to information conveyed by the producers. A new and standardized way to measure light quality and output is needed to give a true and fair view of what the new dynamic user adapted light can provide. To develop the standard can also be a part of a new and interesting business opportunity.

Many of the companies attending the SSL-erate workshops are rather small and have only an interest in developing ideas suitable for their municipality. Skepticism towards international networking and business opportunities abroad is a crucial barrier that needs to be addressed. The internationalization of the new concepts is required as without sufficient business volume both companies and buyers may not be interested (because of high “niche” prices).

Policies, legislations and regulations are double-edged swords in the sense that when they anticipate emerging markets and help them bloom they work as drivers; if they lag behind they work as millstones on the industry’s neck. One example is that national legislation setting strict limits to light pollution has forced municipalities to find solutions to reduce light emitted at nighttime.

There is a lack of tools to describe and define the wanted light. What is the right balanced, user adapted light and how can it be specified? There are many parameters, for which we need to

develop a specification method. Furthermore, it is important to improve communication between professionals in different fields.

One of the most critical barriers to the acceleration of the European deployment of SSL is the large variation in individual perception of light and wellbeing. The perception of light is dependent, among other factors, on the region in which a person grew up. In general it is common to say that Northern Europeans prefer warm light, while Southern European citizens and most Asians prefer cold, bright light. Therefore it is a challenge to find the optimal light control that is able to adjust to both the actual circumstances and the user preferences.

According to some lighting designers participating in the SSL application workshops too much value is still placed on functional light in offices and as a consequence of the wellbeing of the employees is neglected. Moreover the individually adjustable lighting, as often recommended by architects and office planners, is not always the ideal solution, because the light field of the neighbouring employee is affected as well.

2.2 New SSL ideas and opportunities

While the barriers in the previous section are more general and fundamental to the development in all different areas the opportunities are more specific. The possibilities mentioned in this section are deduced from the discussion between different stakeholders during application workshops.

The importance of easily accessible user interfaces cannot be stressed enough when the number of technical features increases. One possible business opportunity in relation to this can be to focus on the user side of the user interface and to become expert on simple and easily accessible/changeable user interfaces. A student could for instance investigate – in collaboration with a company/companies – different user interfaces and collect information on common characteristics of a good user interface using a test panel.

2.2.1 Lighting for indoor environments

We spend most of our time inside buildings and as a consequence artificial indoor lighting has a huge effect on our health and wellbeing. This also means that improvements in indoor lighting, e.g. in hospitals, elderly care centers, schools and offices, has a great potential to be beneficial to our health. But, we cannot yet benefit from all the potential positive effects of user adapted context dependent lighting, such as increased motivation and better health, because those opportunities are still not adequately taken into account in the design of lighting installations.

Lighting in schools is still adapted to the old work situation with paper and pen whilst in the current work situation screens are often used. Glare and reflections in the screens have become a common but unwanted phenomenon. In the classrooms of today it is hard for children to find their own space. Many children need their own space and the new lighting technology provides a possibility to create such small spaces in the big room.

The effect of blue light on teenagers can be harmful. When they get a message and pick up the phone during the night they are exposed to such activating light, which prevents them from falling asleep again. A SSL business opportunity could be to work with dynamic light to reduce as much of the light pollution at night as possible. The International Agency for Research on Cancer (IARC) has issued a warning that electric light during night-time increases the risk of cancer.

2.2.2 Lighting for outdoor areas

In the cities the choice of theme for the application workshops has been mainly towards outdoor applications. Outdoor lighting is seen as one of the most valuable means in promoting a city and facilitating tourism. Furthermore lighting actions in the public environment are visible to the citizens (and voters!).

One business opportunity, which was identified at almost all the workshops, is the creation of hotspots; e.g. lampposts can be used to provide light on the street but also can include other functionalities such as sensors for dynamic street lighting and real-time traffic information, mobile phone towers, Wi-Fi terminals or collecting information for weather forecast companies. Beyond the direct scope of lighting these hotspots can also be combined with charging points for electrical cars or bikes and can be turned into communication stations for other sensors (e.g. noise level in street).

Another possibility can be to install special light sources emitting modulated wavelengths on the dashboard of cars and trucks: such a special light helps the driver to keep focused, preventing road accidents. Dynamic lighting can be used to lead visitors along different pathways indicated by different lights. Another idea of Intelligent Green Business opportunity is the development of transparent paints that can use SSL technology to illuminate monument surfaces. Some business representatives in Hamburg presented the idea of making LED power programmable, so that the installer who purchases in large quantities, can program the required LED power for each use.

Improved street lighting means more safety at night and a better living environment. It is especially important that so-called "fear spaces", such as parking garages or dark paths are sufficiently illuminated at night. With SSL and control systems it is possible to achieve very accurate illumination which means that light pollution can be kept to a minimum. Street lighting can shine into bedrooms and affect the quality of sleep. Some examples in Norway show that intensive lighting in areas around pedestrian crossings has increased the rate of accidents. Two probable reasons for this is that more light increases the drivers' sense of control and that too strong light attracts the eyes and create glare.

Safety is not only related to lighting. In public areas people need places with sufficient amounts of people to feel safe. Control systems can be used to keep track of the movement of people in different parts of the city and this can be used to create suitable meeting places and also to detect unwanted happenings (accidents, assaults etc.).

Dynamic lighting in the public space can be individually adapted. The adjustable, probably coloured light can signal emergencies, can provide guidance to tourists or road users in case of a detour, etc. In order to use light as a communication tool it is important that we manage to create a uniform system, e.g. that a specific colour indicates the same thing everywhere in order to avoid confusion and increase safety risks. Individually adapted lighting will give information about the users in the space and therefore it is important to consider ethical concerns as well.

3 Areas of particular development potential

This section presents some areas with specific development potential. The choice of subject areas has been based on demographic trends, specific interest among different lighting actors attending the SSL workshops, on internet searches, and on views of different collaboration universities and other project partners. The interest in “human centric lighting” was specifically inventoried at the 2014 Light + Building fair in Frankfurt.

3.1 Schools

The school faces a number of socioeconomic challenges; messy classes with poor discipline, declining results and a growing number of diseases. Research shows that the school environment and thereby the students’ health can be significantly improved with better lighting; there is a correlation found between flickering light and the disturbance level of individuals particularly sensitive to disturbances.

Better lighting in schools has the potential to improve learning results, reduce the number of mistakes and achieve a better social climate. It is popular to install motion sensors to reduce the energy consumption, but in order to create real interest to invest in SSL we need to shift the focus from energy savings to healthier light environments. It is important to think about the possible effects on users, e.g. that automatic light can be disturbing for sensitive individuals. Dynamic light with more gradual changes could be a solution.

A barrier for the development of new light in schools is the challenge to find funding for switching to intelligent SSL, another the low awareness of possibilities. A starting point to solve this problem can be to focus on children with specific needs (autism, hyperactivity etc.). It can be valuable for a company to market themselves as caring for sensitive individuals (social entrepreneurship). To find sponsorship along this line could be a possibility. When noting changes within this group of individuals the funding approach could spread to bigger group. There needs to be hard evidence that the new solutions give substantial improvement/added value, otherwise the cheapest solution may be favored in the buying process above the option with best value-to-cost ratio.

3.2 Elderly Homes

We are getting older and the aging of the European society progresses more and more. Better lighting can help elderly people to manage on their own longer avoiding premature institutionalisation.

Dynamic user adapted light can improve the quality-of-life for elderly people and thereby also for their relatives. Dynamic user adapted light can provide many benefits e.g. more healthy and uninterrupted sleep, decreased risk of falling (e.g. fractured femur), less problems with sleep disorders and depression and more self-confidence. When elderly people can manage on their own there is a reduced need for health care, nursing homes and home care.

Visibility and color temperature adapted to time of the day and activity are two aspects specifically important for elderly people. The daytime lighting system should provide higher ambient light levels and use light sources with shorter wavelength content (more bluish light), and the evening lighting system should give lower ambient light levels and use light sources with less short-wavelength content. Whereas especially blue light was long thought to be important due to its activating effect

on users, recent research indicates that also the amount of red/orange light can play a role: here we need to come to proven light recipes and concepts as well.

The illumination at night-time is important; to illuminate specific objects/corners/edges when needed is good for the user as well as from an energy saving point of view.

Visual ergonomics is important: elderly people can have problems to change bulbs, poor lighting at the kitchen counter, poor lighting in the hall, difficulty to access light switches because it is crowded, difficulty accessing electrical outlets installed close to the floor etc. Ergonomics and, especially, the user interface are important to consider for this group when changing to a new system.

Here a project to improve life of elderly people in Stavanger is described to show the potential of technical means.

Stavanger has a large amount of elderly and the numbers continue to increase, which is sometimes viewed as a burden. Technical means can enable elderly people can stay longer at home and take care of themselves avoiding institutionalization and immobility resulting in a benefit for the whole community. Stavanger has one of the world's most extensive glass fibre networks with almost unlimited data capacity, enabling Lyse, a Norwegian energy and telecom company, to provide smart home solutions. Its Smartly Welfare product in which different types of sensors communicate wirelessly with each other, including direct contact with the fire department, makes it possible for elderly and care-needing people to live longer and safer in their own home.

3.3 Light as a mediator of information and experience

A guiding, visualizing and atmosphere enhancing intelligent lighting system can make the city (environment) more attractive and provide a variety of guidance tools, for visitors, and naturally also for the inhabitants, making investments attractively. This lighting based functionality can contribute to a feeling of sharing the place, being connected, partly by being able to find the individually most interesting attractions easier and even more by attracting the eyes to the most pleasant parts of various views, as the most beautiful parts of nature and architecture are highlighted.

Such a lighting system is based on the dynamical provision of the right light, at the right place, at the right time, for as many people as possible (and for the people that in various ways are paying for the new service). Such system provides not only the best solution for the user but, from sustainability point of view, does not waste energy.

This vitalization can be significant for the city development, economically and even more basically in a sustainable development perspective, by enabling dematerialization of the basis for quality-of-life experiences. For example, focus on lighting guided tours is a service, and not a physical product that must be possessed to enjoy. To make knowledge based experiences more available, by means of intelligent lighting solutions, is a positive example of an experience- and service-based society.

In contrast, static lighting solutions tend to be ineffective and disturbing. Light pollution impedes the possibility to highlight the things you want people to see and also the lighting ambiance that you want to create. Light pollution tend to disturb the sleep of numerous people that live nearby extensively lighted city attractions and light poles, and thereby negatively affect their health and wellbeing.

An intelligent, dynamic, context-dependent lighting solution can create and improve positive visualization effects and simultaneously also reduce or avoid negative implications. Furthermore, the aspect and feeling of security and safety, and the quality-of-life in a broad sense, can inherently be improved.

Intelligent lighting can be promoted as a way to consciously move towards a more vibrant and positively sustainable developing society, and thereby improving the image of the city externally and

among its citizens, into a sustainable, healthy, beautiful/progressive/caring, and “green” one. This is important to attract people to live in and to visit the intelligently enlightened city.

Citizens feel a sense of proudness and feel at home. The way the light present the city will increase the citizens’ ability and experience of being meaningfully present in their city. Ultimately the city is promoting and mediating, with the help of light, a higher quality of life for its citizens (in a visible way). And healthier societies are also less costly.

3.4 Storytelling

Telling the story can be a tool to clarify the more specific user values with dynamic lighting. The following two short stories, describing the goals of Eindhoven and Stavanger city, are intended to inspire other actors interested in new SSL development.

Eindhoven is focussing In the railway zones on feeling safe and secure through easy way finding. This is achieved with the help of lights in different colours that are controlled by the entering the destination in an app installed on the visitors’ smartphone. The coloured navigation lights are attached to the street lights. The lighting system adapts its intensity to the density of the traffic and the weather. The city also focuses on light for wellbeing employing mood adapted lighting and aesthetically attractive lighting. In the station hall is warm light that quickly makes the visitors feel a lot better, and beautifully illuminated objects with coloured lights that pause and wait for the visitor.

Stavanger is focusing on energy efficiency, on safety and security and the exploration of the recreational area Vannassen. The light intensity is adapted to daily rhythm, season and weather and activity in the park. This creates a low level of light pollution and enables star gazing on clear nights. The lighting does not disturb the animals’ circadian rhythm. At the benches it can be adapted for readability, romantic settings etc. by the user. Overall, the lighting is dynamic and can be adapted to different needs. During workouts lap times are registered and it is possible to add music and to get guided tours about nature and culture along the entire lighted path. If something happens to somebody, the location and need of assistance will be registered and the nearest lights will send out the message. It is a two way connection. Fire ignitions are automatically registered at the fire department. Internet is readily available in the area and there is the possibility to charge electrical bikes.

4 Compilation of smart lighting examples

This chapter presents the potential development opportunities of SSL and LED lighting solutions in a wide range of functional areas and describes how these solutions can ultimately improve quality of life with not only focus on energy saving and cutting costs but also on soft-co-added values. Initially, examples of the state of the art lighting solutions on the market are presented, suggesting in this way what is needed in order to accomplish what the cities desire. The actors in society who could benefit from the opportunities are briefly presented. An extended discussion about the areas believed to have particular societal development potential is undertaken before elaborating upon how to approach the opportunities, the space of freedom of action which a new lighting experience with its added values offers.

4.1 State of the art

This section presents a selection of the state of the art in LED and SSL solutions and their related added value.

Table 1: State of the art examples in the field of lighting

<i>Area</i>	<i>Product</i>	<i>Solution</i>	<i>Type/Status</i>	<i>Link</i>	<i>Value</i>
Health & wellbeing	Wake up alarms	Slowly increases the light intensity to simulate the sun's intensity gradient	Philips	http://www.usa.philips.com/c-p/HF3480_60/wake-up-light	Pleasant wake up experience
	"Light therapy series"	10000 Lux white energy light or light of blue summer sky	Philips	http://www.usa.philips.com/c-m-li/light-therapy/	Decreased winter blues & energy dips, improved sleep habits
	F.lux	Software for computer, tablet or smartphone. Adjust the screen intensity, color temperature after time of the day to minimise the blue light at night	F.lux	https://justgetflux.com/	Better ability to sleep due to minimisation of the blue light
Smart devices	Kangaroo light	Portable light in the shape of a pillow	Kickstarter	https://www.kickstarter.com/projects/ostrich-pillow/kangaroo-light?ref=nav_search	Multiple use, e.g. to find things in bags
	PILED Development system	Programmable RGB, LED light controller	Kickstarter	https://www.kickstarter.com/projects/2113011562/programmable-intelligent-led-development-system-pi?ref=city	User adapted, cost savings, material savings
	Smart Light – Flykly	Bicycle light that the mobile phone can be	Thing M	http://thingm.com/products/blink	Indicator light, provide

Area	Product	Solution	Type/Status	Link	Value
		attached to. The lamp is attached to the pedals & the mobile phone can be charged		-1.html	information
	Blink1	USB stick that blinks & can be connected to different events in the computer			
Home / Office	Portable light task – Adjustable, direct & diffused light	Attractive, adjustable lights connected to app	Student project, Rochester Institute of Technology	http://sustainabilityworkshop.autodesk.com/project-gallery/mate-portable-smart-task-lighting-system	Portable, adjustable light, wayfinding, energy savings
	Goldee	Smart light system that wakes you up in the morning & turns off the light when you leave the house. Adjustable color & intensity	Independently crowd funded	http://getgoldee.com/	Automatic, adjustable home lighting
Energy efficiency & effectiveness	NanoLight	“Most energy efficient light bulb on the planet”	Kickstarter	https://www.kickstarter.com/projects/nanoleaf/nanolight-the-worlds-most-energy-efficient-lightbulb	Energy efficiency
	LiFi	Usage of light instead of radiowaves as data transfer method	NOT YET ON THE MARKET	https://en.wikipedia.org/wiki/Li-Fi Ted talks about LiFi: http://www.ted.com/talks/harald_haas_wireless_data_from_every_light_bulb	Enormous capacity
	Spotter	Sensor measuring sound, light, temp, moist	Quirky	https://www.quirky.com/shop/609	Monitor motion, sound, light, temperature, and humidity all from your mobile device.
	Plum	WiFi enabled LED light bulbs. Control lights at home using iPhone, Android or remote Smart AC outlets controllable by the phone		http://plumlifestore.com/	
Smart system	IFTTT (If This Then That)	Connection of different events e.g. if someone leave the home → put out the light, receive e-mail → send text Compatible with Philips smart light Hue	IFTTT	https://ifttt.com/myrecipes/personal	Information

Area	Product	Solution	Type/Status	Link	Value
Traffic	Indiegogo	Roads filled with LED. Loaded by solar cells during the day	Indiegogo	https://www.indiegogo.com/projects/solar-roadways#home	Function as lines in the street, warning system directly on the street

4.2 Future potential functional areas for smart lighting

Smart lighting solutions could broaden the horizons of what we can achieve in the field of lighting. Societal needs and desires striving towards more vibrant and sustainable development rather than energy savings and cost cutting suggest the solutions and added values presented in Table 2. The data is derived from the application workshops of Task 2.3 and is further processed by the authors of this report.

Various green business opportunities based on smart lighting will appear for different actors, creating synergies beyond the prospective functional area for businesses, as well as, for society and ultimately generate a higher quality of life for citizens. The actors who presumably could benefit from the added value of context dependent lighting are displayed in Figure 1 together with examples of added values for given solutions and received by the actors. Entrepreneurs are understood to be founders of small(er) businesses exploring the green business opportunities. Companies are larger and also conduct innovation within the field.

The actors create synergies from which other type of business could benefit. Social values and external networking effects are generated when private persons benefit from the added value related to context dependent lighting. The cities facilitate, enrich and protect its citizens with context dependent lighting. The values are transferred from business to consumer and between businesses. To be able to compete on the future market it will be important to facilitate open innovation. It is important for companies to build connections to other companies to be able to combine a variety of LED's, sensors, communication devices, hardware and software, "apps", cloud data and user interfaces.

On another level it is important to combine knowledge between people that sell light (e.g. table lamp selling companies), ICT experts, lighting designers and people with knowledge how light affects our health and wellbeing. Regardless of which function a company decides to invest in, the company that has the developed and clear vision as well as the technical competence to assemble the solution, will be the winner.

Table 2: Examples of potential functional areas for smart lighting

Area	Issue	Solution	Value	Societal need
Schools	Stressful situation	Light when someone is using the bathroom	Less stress	Less stressful school environment to improve results & wellbeing
	Glare, Light not adapted to different study needs	Creation of rooms in the room with light	Utilising the whole classroom, possible for students to find their own space focused students who are less tired	Better study results

Area	Issue	Solution	Value	Societal need
	Tired & unfocused students, bad study results	"Color" of light adapted to lectures & leisure time	Enjoyable environment for students that help them decrease stress from school & calm down	Improved results & well-being, high competence
Elderly homes	Dependency, accidents	LED door light stripes	Reduces the risk of falling (fractures)	Better possibility for elderly people to manage on their own
Health & wellbeing	Problems to move	Green light for Parkinson patients	Easier to speed up the steps	Improved health & quality of life
	Stress, tiredness	Warm light (in station hall)	Calm & harmonic traveller	Less stressful & tiring environment
	Long hospital stays, & increased presence of bacteria in hospitals, high healthcare costs	Light for specific purposes in hospitals & at home	More efficient healthcare, faster rehabilitation, less bacterial proliferation	Improved health & quality of life
Guidance & information	Confusion & frustration among citizens & visitors	Pathways driven by different lights in the city	Help visitors to find their way	Improved reachability & accessibility
	Desolate & unsafe environment	Keep track of movement of people in different parts of the city	Create suitable meeting places (human beings need a suitable amount of people to be able to feel safe)	A feeling of safety & comfort in the city
	A city's cultural qualities are overlooked	Highlight places of interest, event venues and cultural paths;	Guidance for visitors	Improved city image
	Frustration & unsafe feeling of being lost	Lights in different colors controlled by entering destination on visitors' smartphone.	Feeling of safety & security through easy way finding	City image of being easily accessible
	Lack of attraction value & tourists	Color navigation attached to street lights Pprovide good information on location, history and tourism facilities	Easy access to explore the cities gems (monuments, nature, etc.)	A good place for tourists
Assessment of risk & emergency	Citizens exposed to risk	Make visible that something has happened. Registration of location & need for assistance.	Support emergency services	A safer place for citizens
	High rate of crimes in relation to properties	Detecting and sensing devices set up	Reduced risk of risk of crime and vandalism around and inside properties.	Improved safety at properties
	Citizens exposed to risk	Fire ignitions registered automatically registered at the fire department	Support emergency services	A safer place for citizens
Food production	Unhealthy & lack of locally produced food	Wavelength specific light for vegetables in wintertime	Organic vegetables in wintertime	Promotion of sustainable food production
Entertainment & leisure	Overlooked cultural qualities	Transparent paints to illuminate monument surfaces	Attractive monumental lighting to valorize the cultural asset	Enhanced cultural identity of the cit
	Unattractive	Beautifully illuminated	Enhance the enjoyment of	More attractive &

Area	Issue	Solution	Value	Societal need
	environment which doesn't invite citizens	objects with colored lights that pause & wait for the visitor	what the city has to offer	beautiful city
	Poorly utilised city space	Special effects to strengthen qualities of a green area	Ability to explore different aspects & activities in the park	More interesting and exciting city
	Inactive citizens	Different moods at the benches in the park, e.g. readability & romantic settings by the user Registration of work out lap times (supplemented with music)	Promote outdoor living & social interaction Encouragement for exercising	Better use of what the city has to offer Healthier citizens
	Lost contact with nature	Guided tours about culture & nature through entire lighted path	Encourage interest in nature	Reconnection with nature as a place to be
Biosphere	Expose animals to damaging light pollution	Light that does not disturb the animals circadian rhythm	Promotion of healthy natural environment	City in harmony with nature

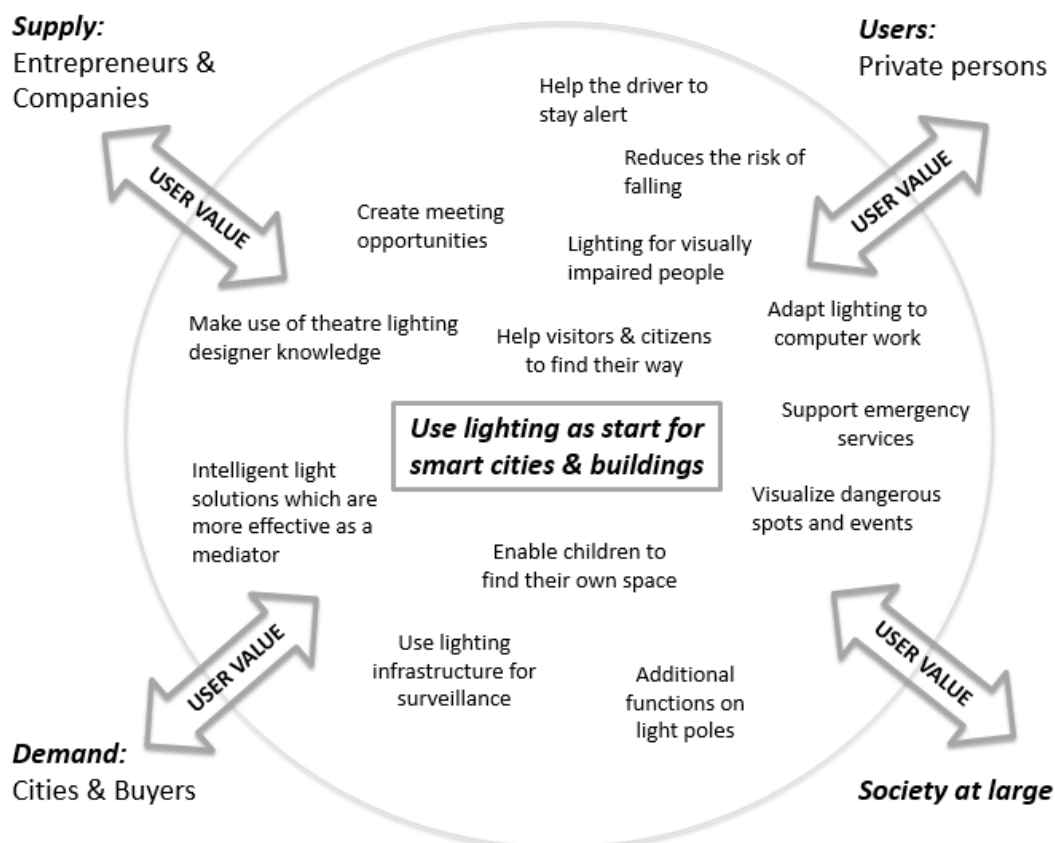


Figure 1: Green business actors and added value examples

5 Difficulties and opportunities with the new freedom of action

As stated in the introduction, the aim of this report is to clarify how big the gap is between what is already on the market and what we want to accomplish. On the one hand, we have described the state of the art on the basis of products and components on the market and, on the other hand, formulated the desires and needs of the customers in an attempt to clarify the meeting point between the two ends.

Another more positive approach is to describe that gap in terms of the technical “freedom of action” it gives, see Figure 2. In contrast to the positive opportunities, the technical freedom of action also provides an opportunity for unreliable business actors to cheat; labelling of products and stating properties related to the new opportunities can result in doubtful marketing. With the existing SSL technology a safer and healthier environment with exciting light experiences can be created.

A high barrier that hinders us from making full use of the technical potential is that we do not know what we want. Every light solution needs to be adapted to each specific situation, which requires exchange between the developers and the users, see Figure 3. In order to sell, the SMEs need to be able to read the situation, understand the need and lay the puzzle in accordance with usability and controllability for the specific situation, in order to make the right SSL product. To provide context dependent and user adapted lighting solutions the companies need to speak with potential clients and customers about their specific needs.

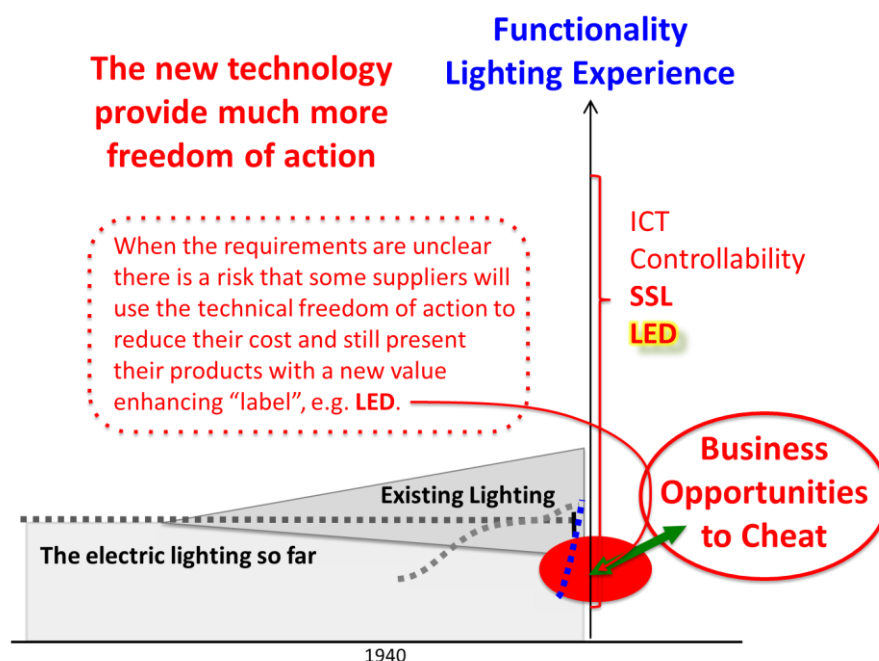


Figure 2: The gap (freedom of action) between what is already on the market and what we want to accomplish.

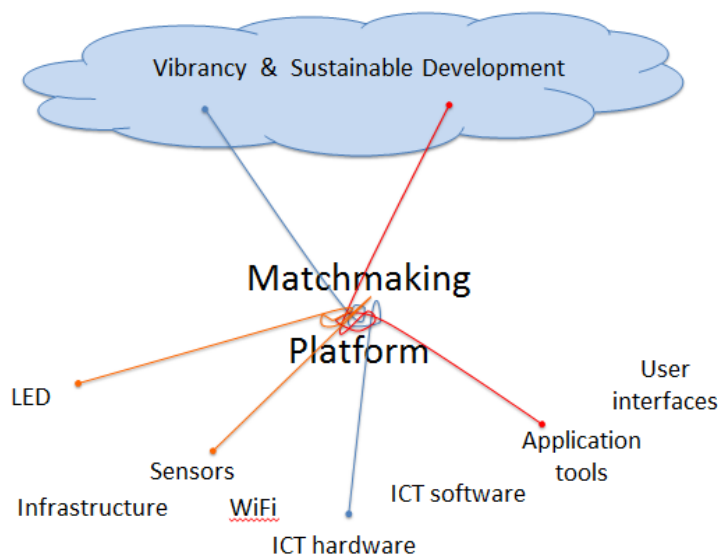


Figure 3: The meeting point between the user needs and the availability of technical components

5.1 Tools to navigate in the new freedom of action

The possibilities to create products/systems with added values for individual users and society are huge with the new technology. Many areas could benefit from the effects of human centric lighting. However to what degree these areas also are interesting business opportunity areas is important to determine. The SMEs will need advice how to evaluate the business opportunity potential. An approach for this must be provided as next step in deliverable D2.5 together with business development tools to navigate within the new freedom of action field that SSL lighting and ICT open up. These tools will support start-up and performance of business experiments and promoting SSL business growth.

Again communication is most important; a list of common words easily understood by both client and lighting designer is crucial. Only when the companies that have to implement the solutions, and the clients speak the same language, successful solutions can result adapting the light environment to the needs of the users.

6 Conclusion

Until now, lighting has been viewed upon as something that makes objects visible. With the new SSL opportunities of SSL it's becoming obvious that light can function as a mediating contact medium between human beings, and with the world around them offering even non-visual beneficial effects to people. This shift of perspective can help us to figure out new ways to create better, interactive lighting, to get away from the traditional thinking about light points. The change to LED in many cases requires an alteration of the whole lighting system, and in the future (with a.o. OLED) we need to move beyond the traditional luminaire boundaries. We need to shift the focus from products to light environments and from illumination/brightness of objects to (perceived) value for people.

Key is to read the situation, understand the need and to lay the puzzle in accordance with usability and controllability for the specific situation, in order to make the right lighting system. We are aiming for smarter solutions, to categorize the proposals regarding their ability to provide user adapted solutions. In order to foster new innovations and widen the opportunities actors should also look beyond the traditional business areas where lighting solutions normally are applied. This will widen the opportunities and develop the field in new directions and application areas.

Other specific issues which needs to be addressed are, in particular, the need for standardization (meaning how to measure soft-co benefits and light output), and how to develop user interfaces and a generic open source platform based on ICT. Another hurdle is the prevailing lack of awareness how light can improve the quality of life in a multitude of areas such as health and wellbeing. Therefore, training and education of installers and procurers is so important.

A business development strategy to confront challenges and embrace opportunities which come with the new freedom of action is key. Tools to support start-up and performance of business experiments and to promote SSL lighting business growth could for example include a communication "tool-box", to mediate the new added user values of human centric lighting, and an approach of how to evaluate the business potential of markets.