LIGHT HOUSE

Expertise in ...

... **Smart Lighting** and **Smart Cities**

RESEARCH ...

Methods
for research into policy, needs, opportunities and effects

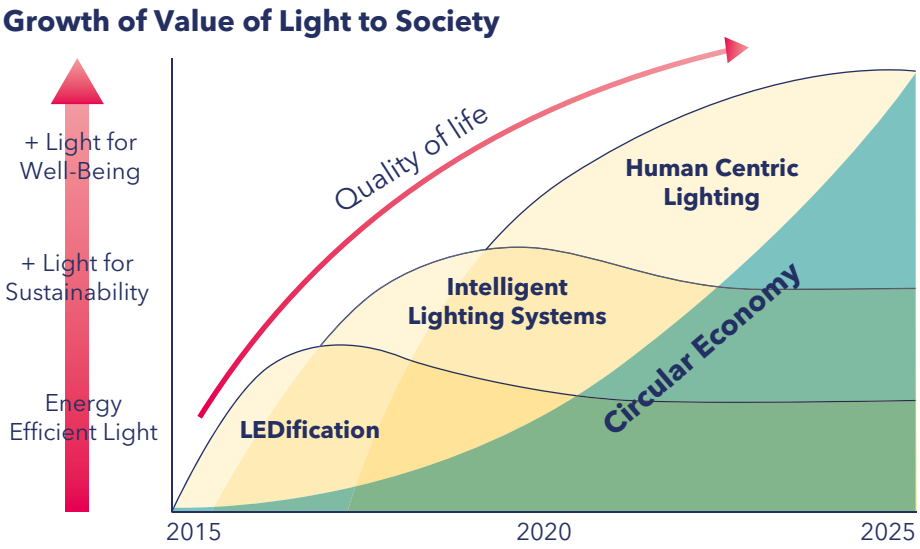
- Area-focused policy research
- Research into needs and opportunities
- Research based on system data
- Perception research

... INTO **LIGHTING INNOVATIONS**

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Developments and new **opportunities**

Much of today's public lighting is due for replacement to prevent rising maintenance and energy costs. LED and smart controls are becoming (almost) the standard choices for both new and replacement public lighting projects and installations.



Smart lighting as added value to energy efficient lighting (Source: Lighting Europe, Strategic Roadmap 2025).

Examples of innovative lighting solutions for use in public spaces: Heijmans Bikescout (upper photo) and Philips Connected Lighting (lower photo).

In addition, lighting masts - partly because of their widespread use - are increasingly being regarded as ideal mounting points for all kinds of smart city systems and the Internet of Things, for example sensors and particulate meters.

Developments in light sources and smart controls offer new opportunities to make public spaces more attractive, safer and more interesting. But how can we avoid just talking about technology? And how can we make sure that smart lighting really does contribute to the quality of life?

Meaningful applications

Developments in infrastructure and systems (e.g. connectivity and sensors) offer new technological opportunities - and they also generate data. This data makes new services possible, and these solutions are still largely unexplored. New applications become significant when they match relevant (societal) needs - human centric lighting (see the above figure). In other words, if we want to conceive, develop and implement significant new applications, we need to start with the needs in the public space, the functions of the area and the people who live and move within it.

A few **challenges**:

Light is intangible

It is difficult to ask people directly about their preferences for public lighting, because they are not usually aware of them. And if you ask them to describe lighting, they will most probably say something about the design of the luminaires. The perception of light needs to be measured using indirect variables.

Lighting solutions are innovative

People are used to certain kinds of lighting, often 'white', 'high lux' or static. Many of the lighting scenarios that we are now designing enable dynamic adjustment, including the use of lower light levels. This can lead to reactions like "we don't want it because it's unfamiliar" or "we don't really need it".

Perception is personal

People's perception and acceptance are built up of a series of subjective variables – for example preferences, emotions and past experiences. This makes it difficult to separate facts from emotions, and to distinguish causes and effects.

It's located in public spaces

Lighting performance must always be tested in real-life situations – on the street, on roads etc. This makes it difficult to manage the context variables, such as the weather, the surrounding environment and the possible presence of people in the area.

No standards

There are (still) no standards for testing the performance of innovative lighting solutions.

Because innovative lighting solutions call for innovative research approaches, LightHouse has developed a range of methods. Depending on the stage of the project and the specific research question to be addressed, these approaches can be applied to increase the chances of successful implementation.

Subdividing **research methods**

(variants of):

1 Area-focused policy research

2 Research into needs and opportunities

3 Research based on system data

4 Perception research

1 Area-focused **policy research**

Deep Dive workshops are structured using posters to enable good interaction and in-depth discussions between all those involved, and to build support for the shared results.

For municipal organisations too, it is often highly innovative to make the switch from 'traditional' public lighting to smart lighting, or even to smart city solutions.
This kind of step needs to have the buy in of different disciplines, as well as of levels from management to people working on-site. There is also a growing wish among municipalities to actively involve residents and other stakeholders in decision-making about public spaces. To make this partnership well structured right from the start, it is important to jointly define the shared ambitions and the outline solutions. LightHouse has developed the 'deep dive' research method to facilitate this process.

In the 'deep dive' process, all the participants brainstorm using jointly defined ambitions, with the ultimate goal of formulating the needs that exist in a specific area and the possible solutions to those needs.

Result

A shared picture of the strategic ambitions for the area. This will then allow the necessary policy to be clearly outlined.

Policy at **municipality level**	
Workshop with policy-makers on the ambitions and interests of the municipality. The present highlights and basic principles of the municipality are identified, and the drivers and strategic ambitions are formulated.	**Workshop with the strategic (project) managers on the overall ambitions and interests at a supra-departmental level.** The present highlights and basic principles of the municipality are identified, and the overall, supra departmental ambitions are formulated.

Policy at **area level**	
Workshop with the internal stakeholders of the area to define the societal needs in the area from the perspective of the different departments within the municipality. The present highlights and basic principles for the area are identified, and the relevant societal needs are formulated.	**Workshop with the external stakeholders of the area to define the societal needs in the area from the perspective of different user groups such as residents, businesses, police and schoolchildren.** The present highlights and basic principles for the area are identified, and the relevant societal needs are formulated.

2 Research into **needs and opportunities**

LightHouse has developed a number of methods to give residents and other stakeholders in an area or neighbourhood the chance to participate in thinking about relevant innovative solutions,.

The methods are used in a range of sessions with residents and stakeholders. These also involve different working approaches: interviews, discussion groups, workshops and interactive sessions.

People are asked about the experiences, stories, needs and wishes that are important to them, using photos of specific locations and situations in their living environment. This is followed by a discussion which seeks to find out what is needed to make a location a good place to spend time. As well as providing an understanding of what people find important in their direct environment, the discussion also provides immediate information about the opportunities for smart lighting applications in the neighbourhood.

Various photos of innovative lighting solutions are used to inspire people and to let them indicate which ones they find relevant for their own environment.

Collecting people's experiences, stories and needs relating to their direct living environment using different working approaches.

Result

A description of the desired services to allow a development wish-list to be defined, based on the needs and opportunities put forward by residents.

N.B.: The interaction tables shown in the lower photo are part of the PhD research entitled '[X] Changing Perspectives' by Philemonne Jaasma of the Industrial Design department at Eindhoven University of Technology (TU/e).

Effect research

There is still little knowledge about the acceptance of smart lighting solutions by the public at large, nor about their effects on the perceived safety and comfort levels. In addition, it is still not clear whether people appreciate a solution to a greater or lesser extent if they understand its ecological and social effects. As well as that, smart lighting solutions in many cases make use of data. This has the advantage of allowing the systems to respond to real time data, but may have an adverse effect on privacy.
In its research into the effect of smart lighting, Lighthouse focuses primarily on the contribution to the quality of life, and looks for methods through which the effect of the selected lighting solutions can be determined, both subjectively and objectively. The advantage of smart lighting solutions is that different lighting scenarios can be created, in many cases through the use of software. This is not only useful during the research; it also means that the results can be used to identify the desired lighting scenarios together with the users.

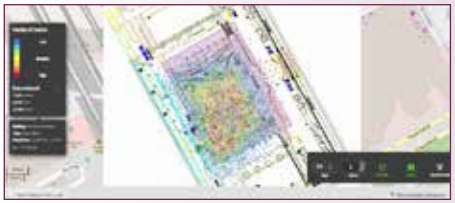
3 Research based on **system data**

Smart lighting solutions make use of ICT, which also allows a certain amount of objective data to be gathered. LightHouse works together with users to decide which data are relevant to achieve the defined goals, and how these can best be analysed. The ethical and privacy-related aspects are also taken into account fully in the research plan.

System data can be used in an increasing number of systems to visualise the real time situation, but primarily to identify correlations between parameters and to allow longer-term effects to be identified.

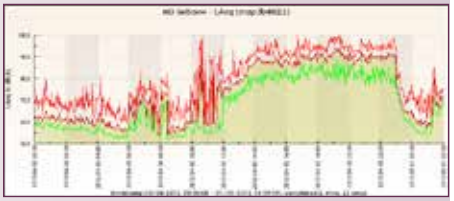
Result

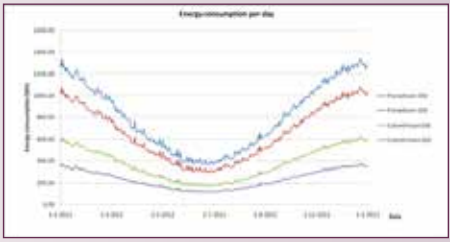
Understanding the effects of lighting scenarios on a range of parameters, such as energy consumption, the time spend by people in the area and the amount of social interaction between people. The results allow the effect to be monitored, and if necessary the scenarios can be modified.



Examples of real-time data visualisation of the numbers of people in the area (Source: Cisco and Philips Design).

Examples of a dashboard with system data (Source: Cisco).





Examples of longer-term measurements to allow patterns to be recognise, in this case of energy usage and sound-level measurements (Source: Philips and Sorama).

4 Perception research

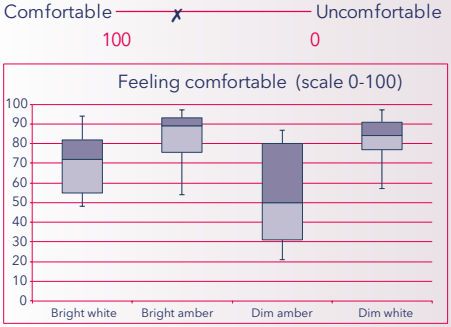
Perception research investigates the effects of lighting scenarios on users. LightHouse uses a combination of research methods to subjectively determine how specific lighting scenarios make people feel. Together with these research methods, a number of measurements are made to provide understanding of possible individual differences between people.

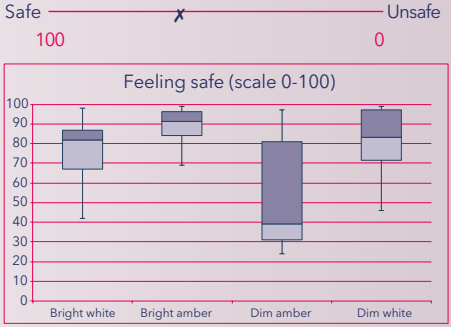
The research is preferably carried out on the spot, if necessary using prototypes or temporary installations.

Result

An understanding of users' appreciation of a range of lighting scenarios. This allows the settings of the system to be determined

Can you say how you feel?





Example of research into the perception of comfort and safety in different lighting scenarios.

Example of research into the effects of different dynamic lighting scenarios with measurement of physiological stress.

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NAVIGATION TO **KNOWLEDGE** ...

Lighthouse was founded to make the knowledge of Eindhoven University of Technology (TU/e) about intelligent lighting and smart cities accessible to society at large.

LightHouse maintains close links to the research programmes into urban lighting and smart cities. LightHouse works closely together with the TU/e strategic areas of Mobility and Energy, and the research programmes of the Intelligent Lighting Institute (ILI), the Data Science Centre Eindhoven (DSC/e) and the Smart City Program Eindhoven (SCP/e). LightHouse operates knowledge-intensive projects based on people's wishes or requests from the community and organisations. This work forms part of the valorisation activities of the TU/e Innovation Lab.

We make use of the knowledge, methods and designs of the various departments of the university in practical applications. In this way we create liveable, sustainable solutions in the areas of public lighting and smart city solutions.

We co-create solutions together with cities, multinationals, SMEs and start-ups. We add value to TU/e by inspiring its new research and teaching programmes with best practices and societal trends.

Projecten

- Jouw licht op 040, Eindhoven.
- Stratumseind, Eindhoven.
- Hoekenrodeplein, Amsterdam.
- Zilverackers, Veldhoven.
- ENIGMA, Bassano del Grappa, Eindhoven, Espoo, Malmø, Stavanger.
- Smart Space: developing, implementing and evaluating a smart lighting system together with Ostend, Middelburg, Sint-Niklaas and Tipperary.

For more information, please visit:
www.tue-lighthouse.nl

DR. IR. ELKE DEN OUDEN
Founder & strategic director
e-mail: e.d.ouden@tue.nl

DR. IR. RIANNE VALKENBURG
Founder & value producer
e-mail: a.c.valkenburg@tue.nl

Graphic Design: www.VissenCom.nl

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY