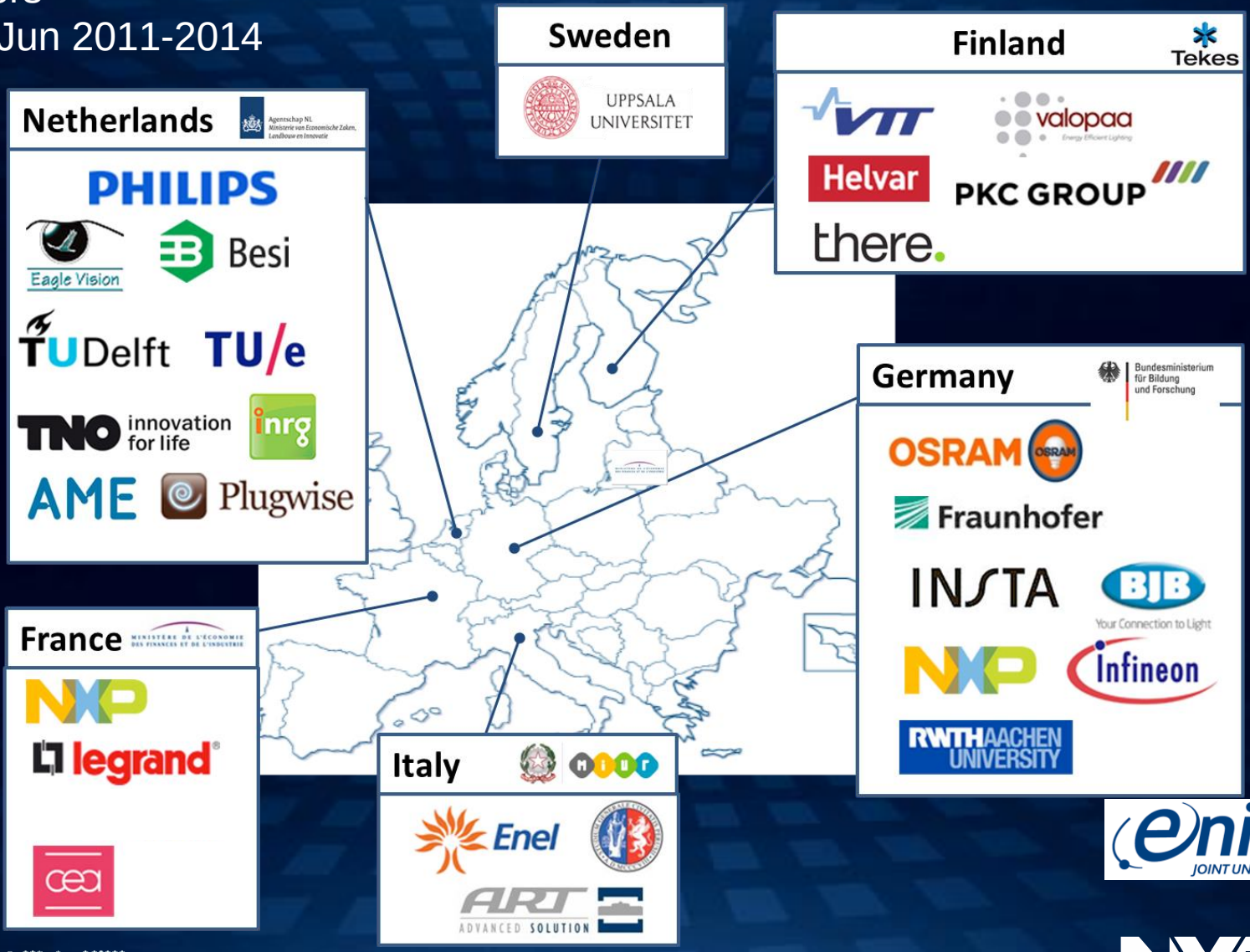
EnLight

Möglichkeiten der Energieeinsparung durch intelligente Beleuchtung

Tim Böttcher

EnLight Consortium

29 Partners
3 Years, Jun 2011-2014

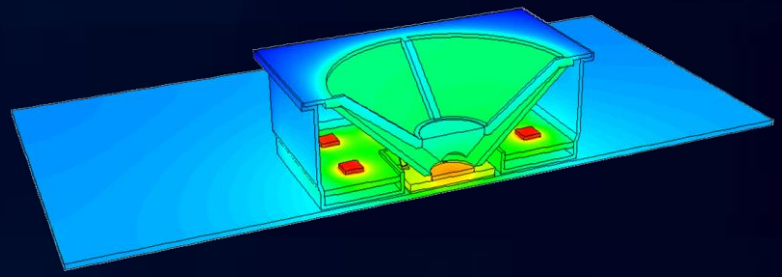


EnLight Project

EnLight is a EU-wide project with 29 partners, funded within the ENIAC framework

To exploit the full potential of solid-state lighting through breakthrough innovations on:

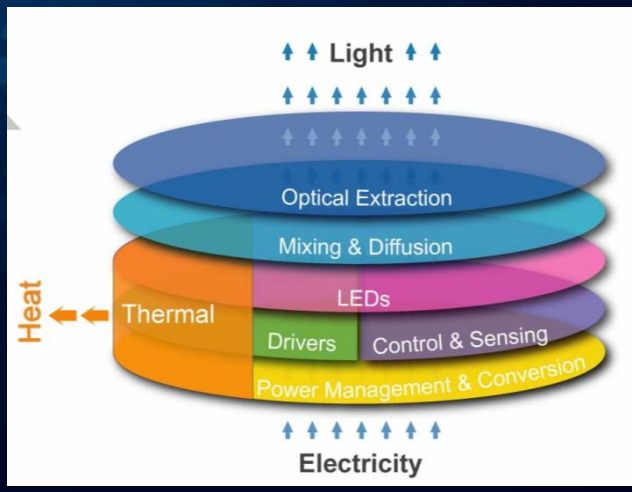
- non-conventional,
- energy efficient,
- intelligent lighting systems,
- beyond LED retrofit applications,



- with the aim of **40%** additional energy reduction compared to LED retrofit systems.

EnLight Project

- **Energy efficient light source -20%**
  - Electrical efficiency – Integrated drivers
    - – Power supply
    - – Control
  - Optical efficiency – Higher LOR
  - Thermal efficiency – Lower T_j



- **Intelligent control: -20%**
  - The right light,
  - at the right amount
  - at the right place
  - at the right time

	Task Tuning	Personal Control	Occupancy Control	Smart Time Scheduling	Daylight Harvesting	Variable Load Shedding
Private Offices (no windows)	•	•	•			•
Private Offices (with windows)	•	•	•		•	•
Open Office (cubicles)	•	•	•	•	•	•
Hallways/Lobbies	•			•		•
Washrooms			•			•
Meeting Rooms	•	•	•	•	•	•
Storage			•	•		•

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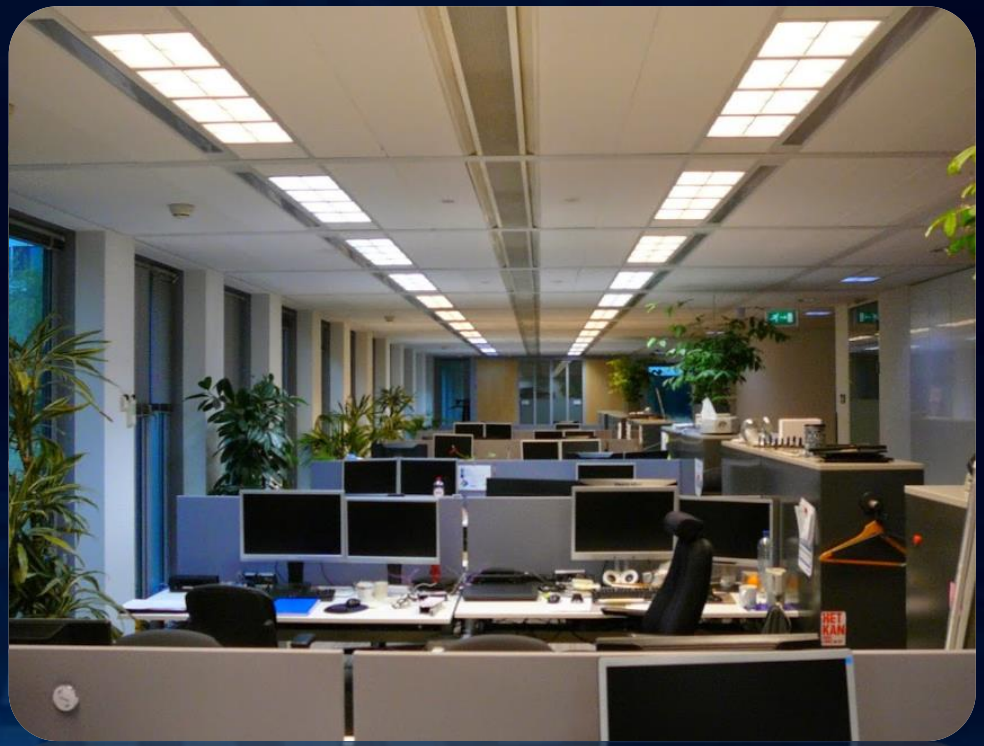
Outline

- System Architecture key concepts
- Bus Architecture
- Driver Electronics
- Results

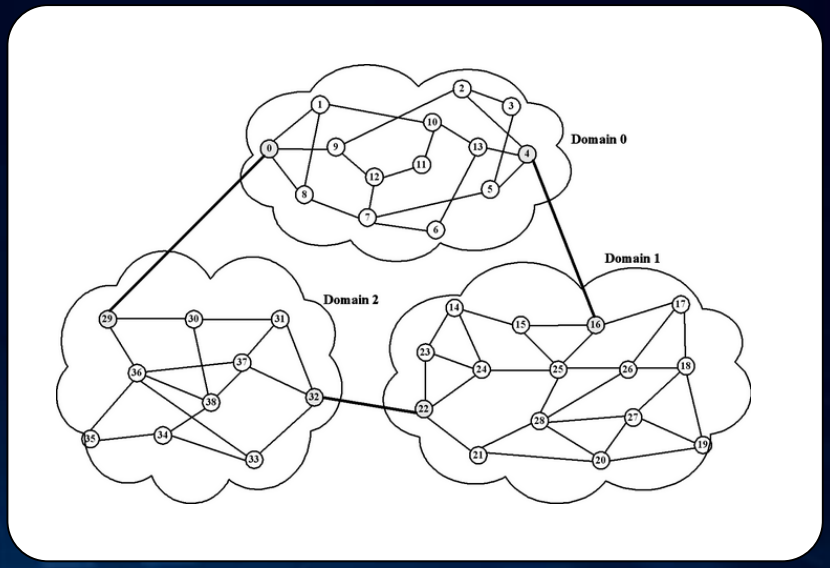


System Architecture

Decentralized intelligence / Lighting Control Network (LCN)

‘Internet of Things’ Architecture

- No central node & no global knowledge of network topology is required
- All decision processes take place locally at each node and no global knowledge of the network is required a priori



System Architecture

Decentralized intelligence / Lighting Control Network (LCN)

Intelligent luminaire is cornerstone building block

- Autonomously controls brightness, CCT, color, beam shape, …
- Reacts to events instead of being instructed by e.g. a central controller
- All nodes in the network can raise events
- Connection to Building Control Network via area controller

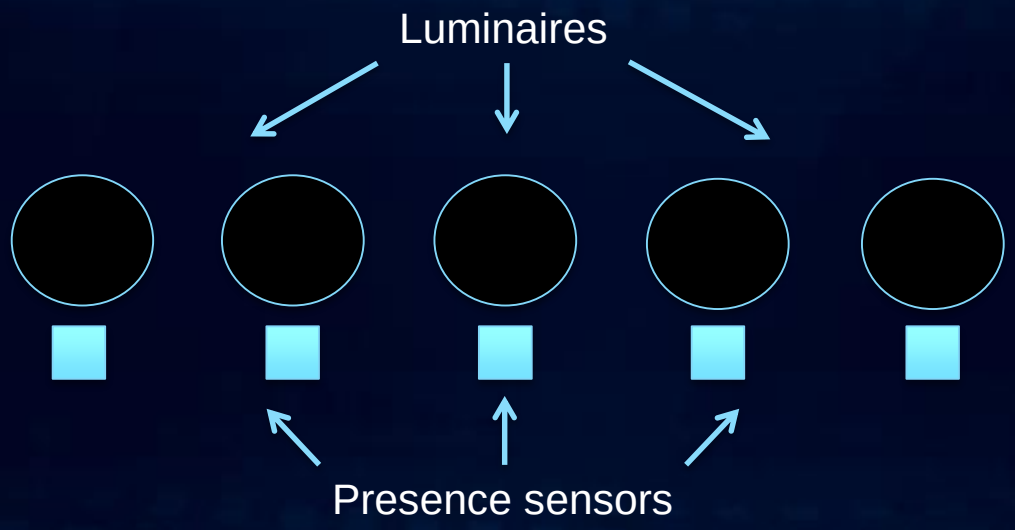
"Intelligence by configuration"

- Rules based behavior: configured during commissioning phase
- Flexible: Ability to adapt/change behavior per node
- Self learning: Ability to adapt behavior as result of global data analysis and data mining

System Architecture
Rules example

Set of rules determines the behavior of each luminaire.

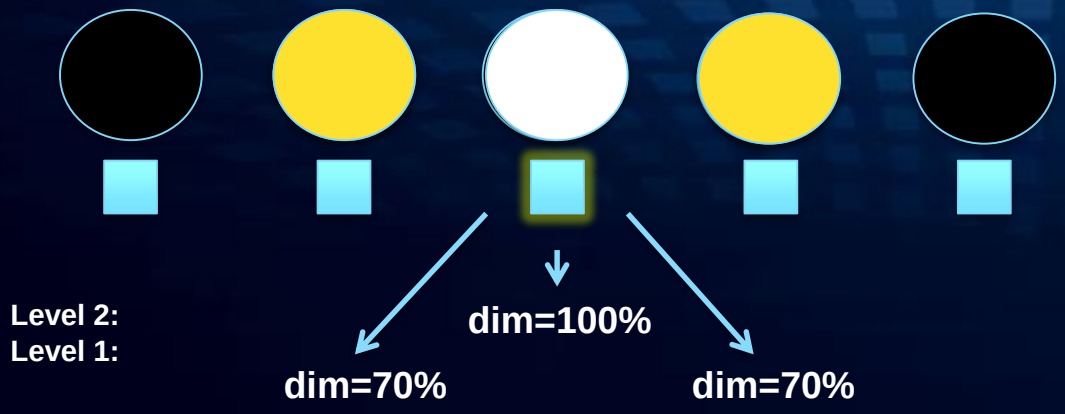
- Rule = event, condition, action

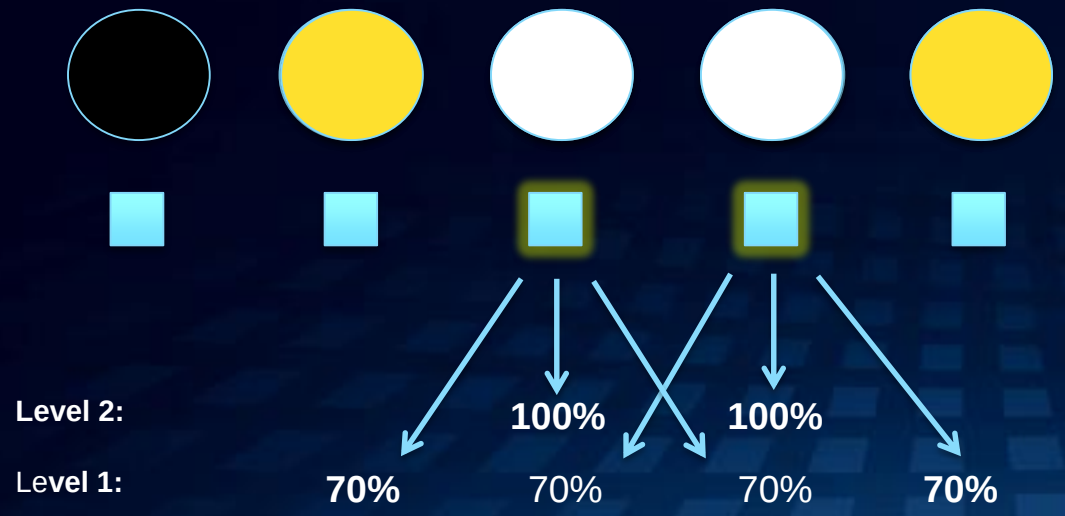


Desired behavior, e.g.

- Each luminaire is switch off in case of absence
- Luminaire is on (100%) in case of presence
- Luminaires are 70% dimmed if a neighboring luminaire is on.

Rules described in XML



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    <Luminaire Name="Power Balance" Address="00:0D:6F:00:02:78:C5:D0">
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            <Action>
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                    <Argument>
                        <Constant_u16>70</Constant_u16>
                    </Argument>
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        </Rule>
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        </Rule>
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                        <Constant_u16>70</Constant_u16>
                    </Argument>
                </LuminaireSetting>
            </Action>
        </Rule>
    </Luminaire>
</AreaLightingSystem>
```

Outline

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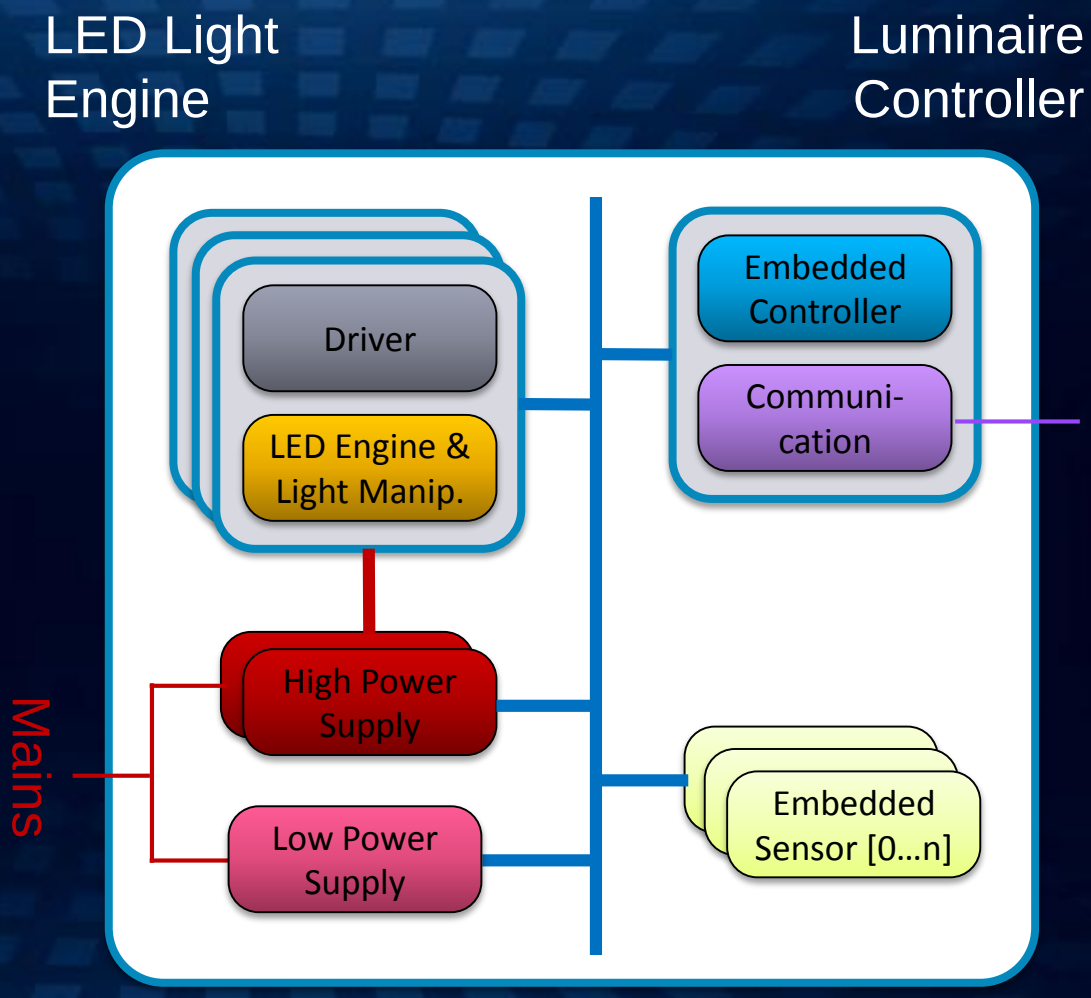
Intelligent Luminaire Architecture

Intra Luminaire Bus (**ILB**)

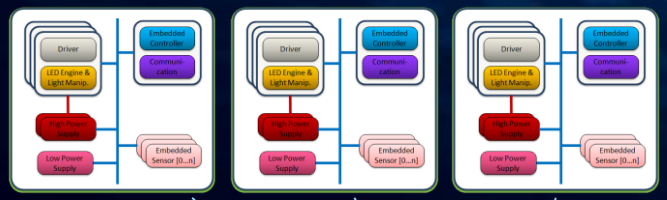
- I²C based
- Plug & Play
- To decouple lifecycles of independent technologies
- Enables market players to contribute, differentiate and compete



Intelligent Lighting Architecture

Area Level

Intelligent Luminaires



Local User Control

Switch, Remote...

External Sensor

Presence, Sound, Temperature...

Area Configurator

PC, Tablet, Phone ... (XML)

Lighting Control Network (Zigbee – UDP / IP)

A2A Gateway

Area Controller

Sensor Fusion

Area Controller

Sensor Fusion

Area Controller

Sensor Fusion

Global Sensor

Operator Interface

Building Control Network (TCP / IP)

System Controller

Internet

E-Monitoring (Plugwise)

Data Mining / Analysis

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Network / Bus Technology

Lighting Control Network:

- Wireless: Zigbee Pro Stack, using a new EnLight Profile
- Wired: UDP / IP

Intra Luminaire Network:

- Wired: I^2C Phy, using ILB message protocol

Power Network

- 24V high power supply for LED driver
- 5V low power supply for standby operation

Easy interfacing to building management over KNX and compatible with DLT (Ledotron), DALI via adapter

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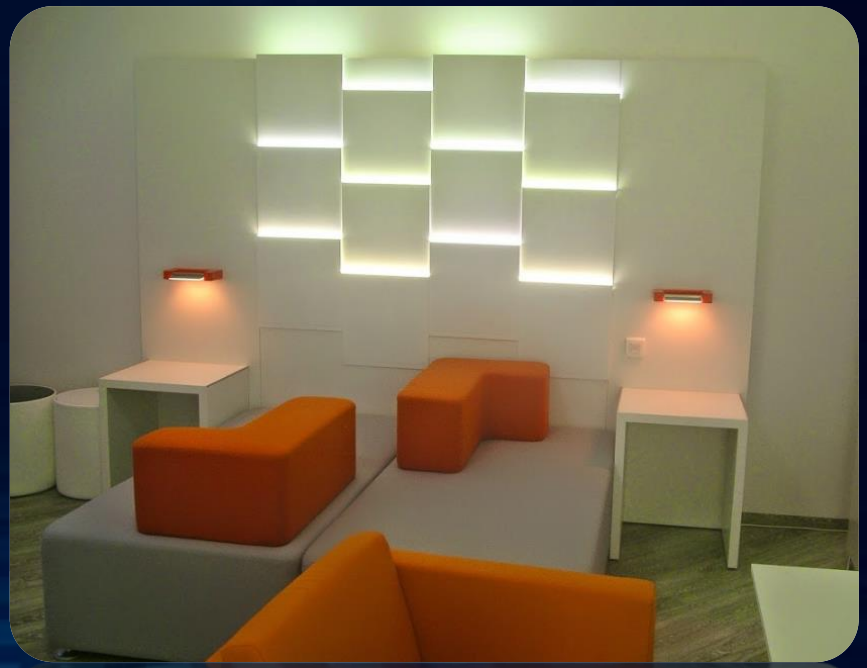

Hardware Implementation

"Luminaire Lego"

- Intelligent Luminaire Modules
  - LED driver
  - ILB and Zigbee
  - Standard interfaces
  - Optional Controller
  - Expandable to form large luminaires
- Three modules which allow to build luminaires from spot size to wall size
  - 350mA Boost driver board (25…70V)
  - 1000mA Buck driver board (7…21V)
  - Control Board
- All modules can be equipped with a Jennic JN5168 as µController and Zigbee module

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Hardware Implementation

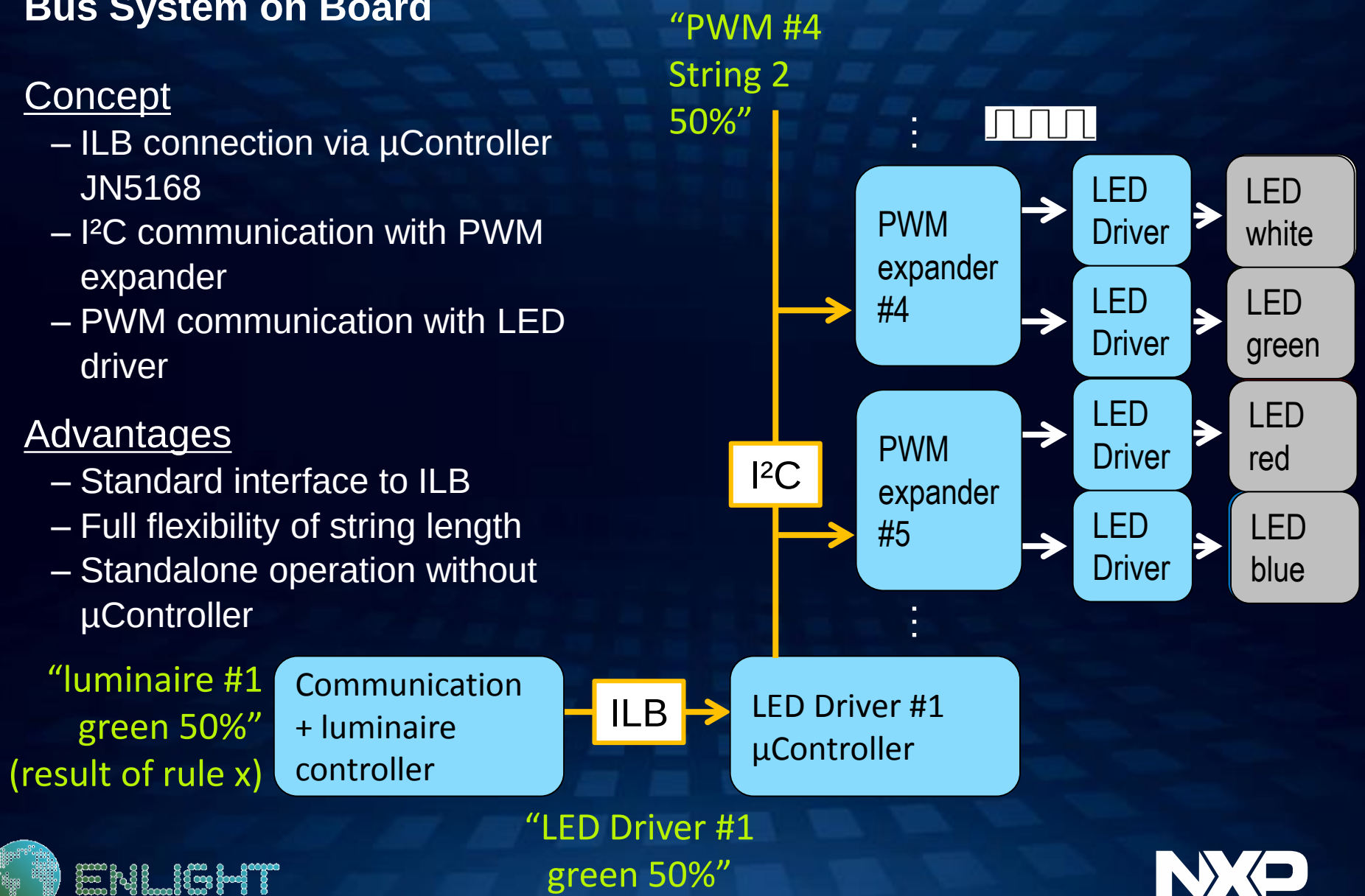
Bus System on Board

<u>Concept</u>

- ILB connection via µController JN5168
- I²C communication with PWM expander
- PWM communication with LED driver

<u>Advantages</u>

- Standard interface to ILB
- Full flexibility of string length
- Standalone operation without µController



Hardware Implementation

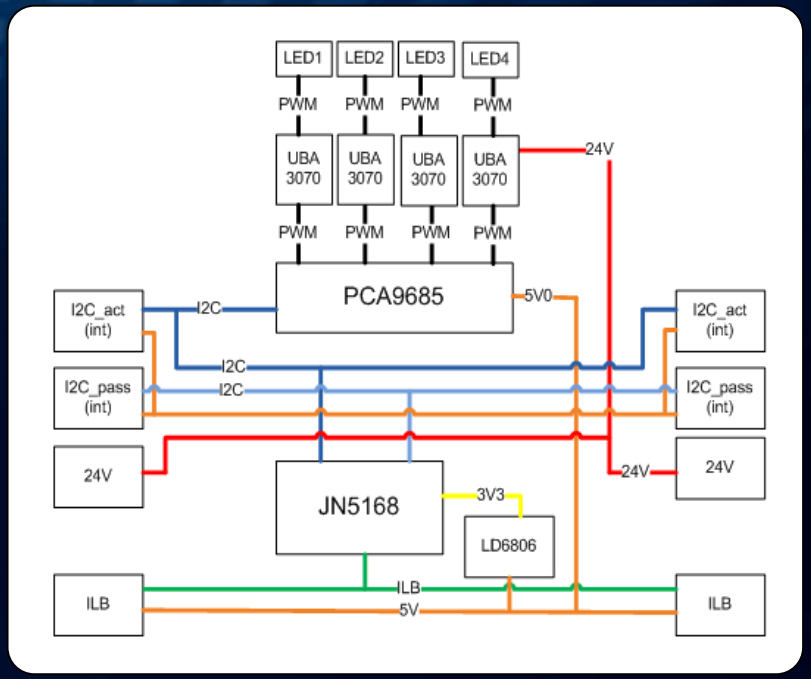
1000mA buck driver board

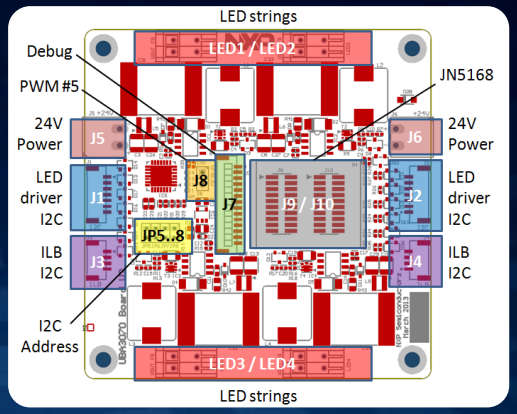
Configuration

- µController / Zigbee JN5168
- PWM expander PCA9685
- LED Driver UBA3070
- Standard interface / daisy chain of all bus systems

Bus Systems

- 24V LED supply
- ILB for intelligent luminaire
- I2C to operate LED driver

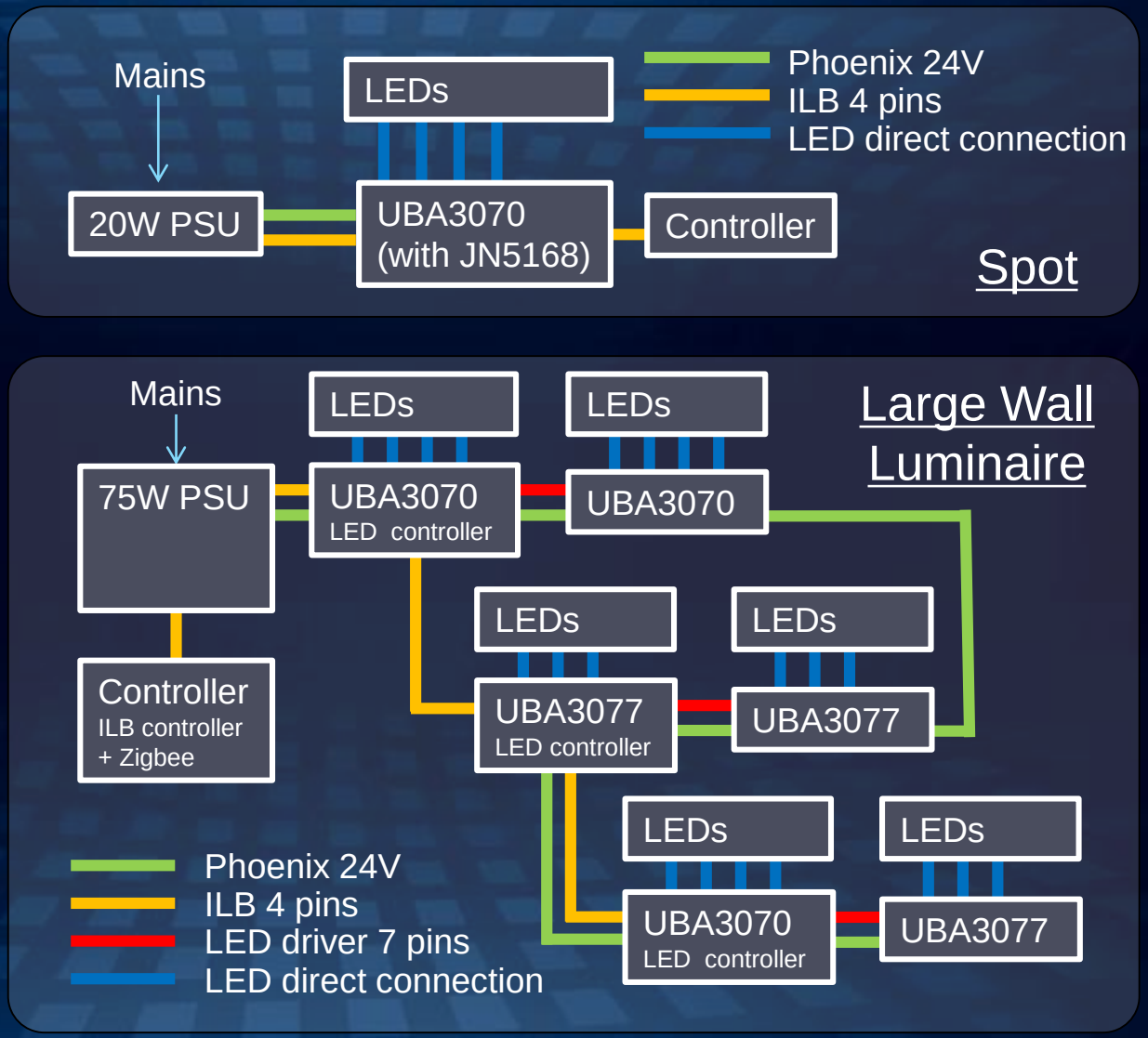




Luminaire Designs

Concept

- Re-use hardware modules
- Connect through bus system
- Create functionality by driver software



Hardware Implementation

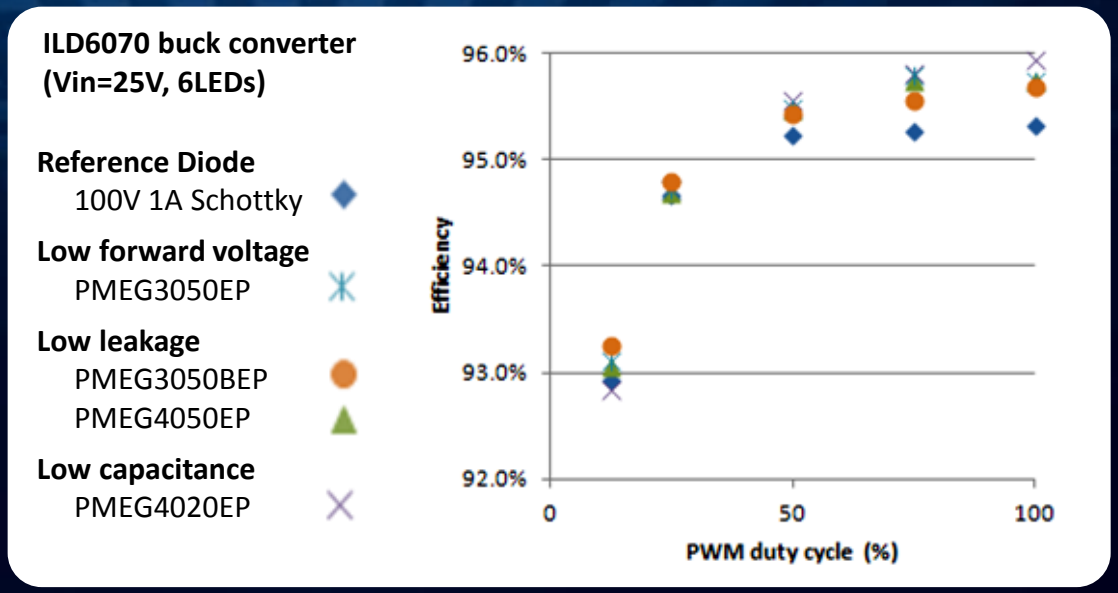
LED Driver / DCDC converter

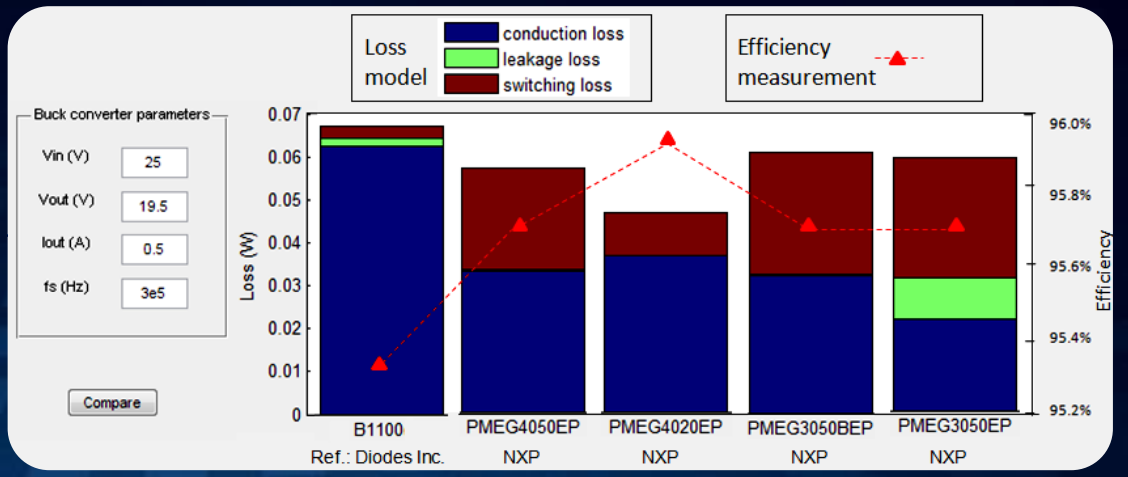
Voltage selection

- LED string voltages 6…70V
- Efficiency scales with voltage ratio
- 24V bus voltage results in a ratio up to 3

LED driver topologies

- Buck converter UBA3070 (NXP) or ILD60150 (Infineon)
- Boost converter UBA3077 (NXP)



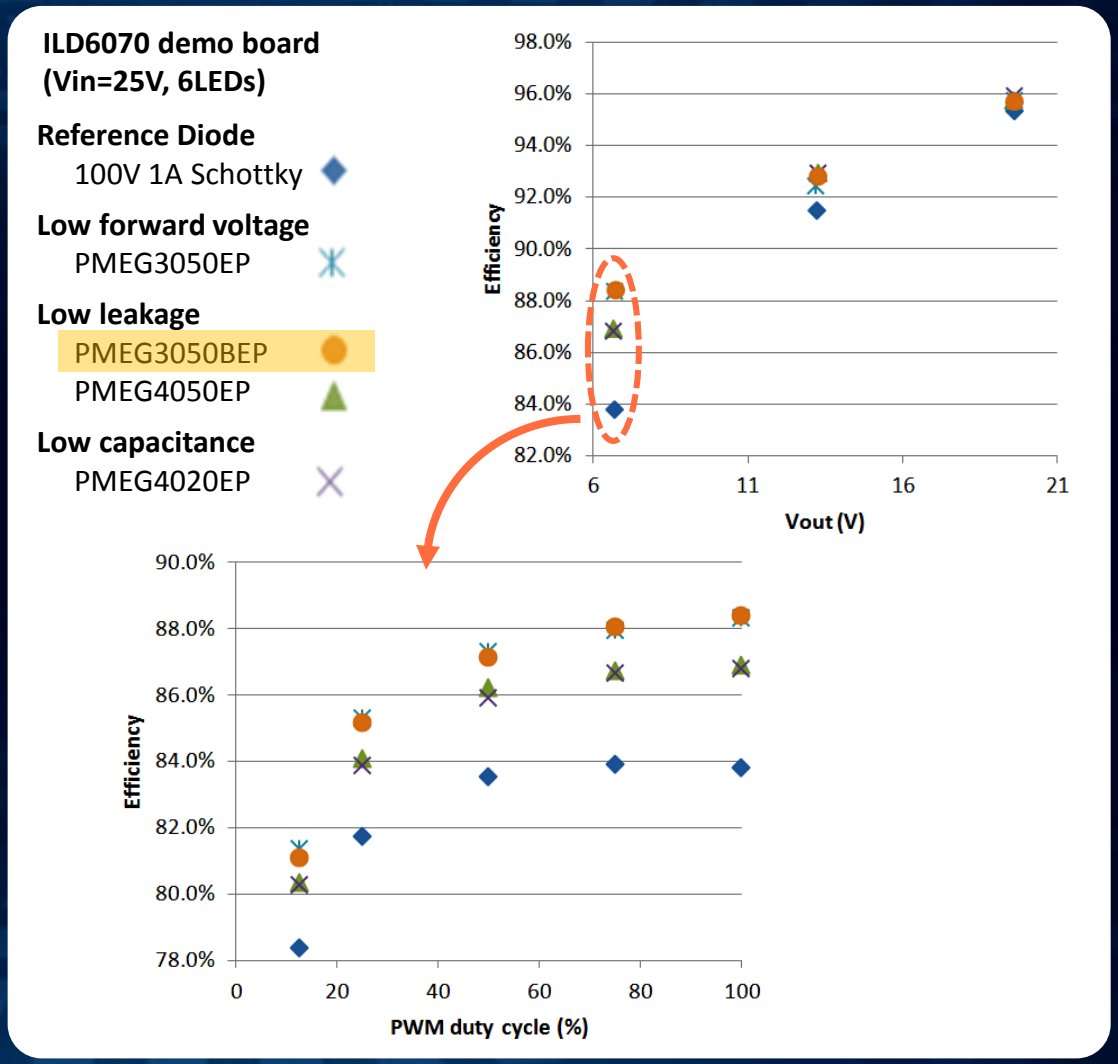


Hardware Implementation

LED Driver / DCDC converter

LED Driver Optimization

- Choice of Flyback Diode strongly affects system efficiency
- PMEG3050BEP offers high efficiency across whole voltage range
- Board operation above 90° C environment temperature possible



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Demonstrator Luminaires
using EnLight Hardware Platform

- Spot “Glow 100tm”

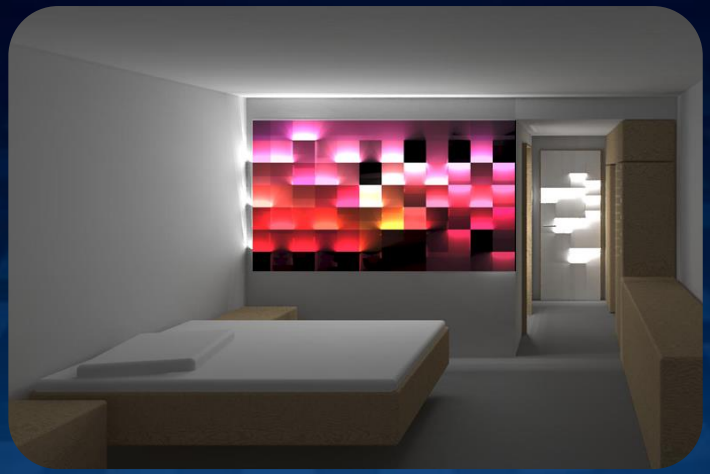
INSTA

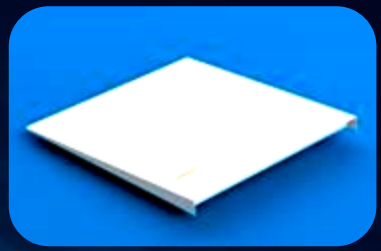
- Ceiling Light “Power Balance “

PHILIPS

- Wall light “Wedge”

OSRAM





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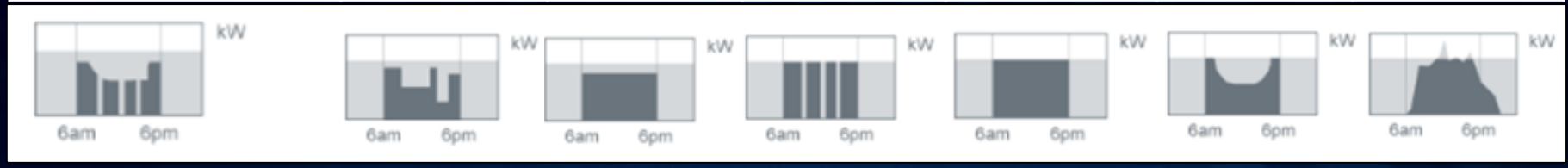
Overall validation methodology

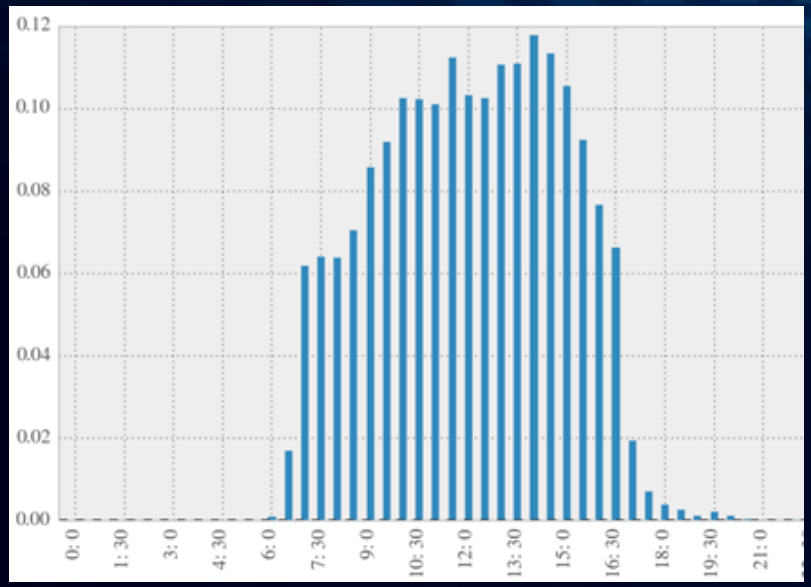
- Office (Philips, VTT) & hospitality (OSRAM) demonstrators
  Comparison between the Baseline and EnLight
  - Energy consumption and illumination measurements
  - → *annual energy consumption of the lighting (LENI)*
  - User acceptance studies for light quality evaluation
  - → *user feedback*

Energy saving strategies

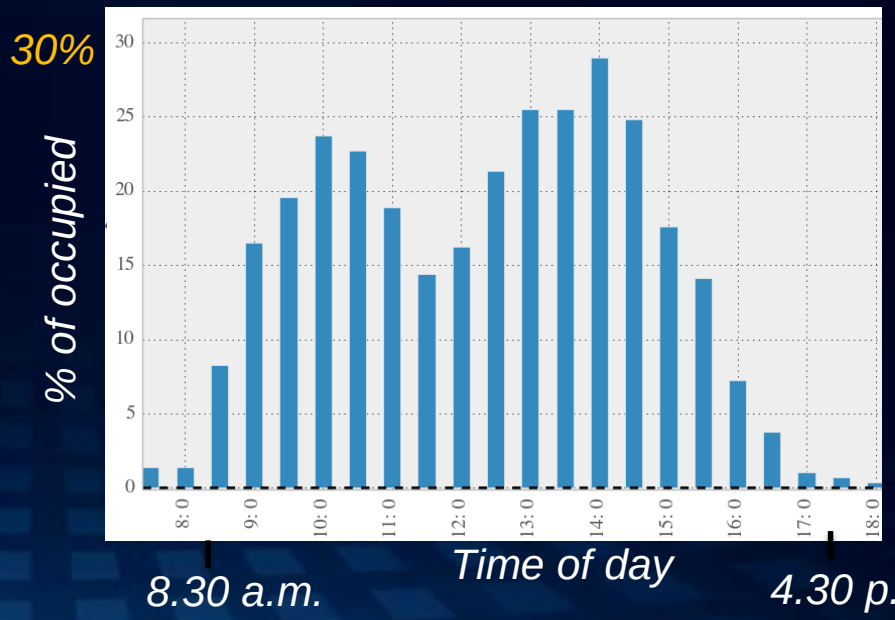
Office	Task tuning	Personal control	Occu-pancy	Time schedule	Daylight harvest	Load shedding
Open office	Ambient / task tuning	Desk light	Local sensing with light bubble	Sunrise rhythm	Local constant lux	√
Meeting room	5 Scenes	Scene selection	Local occupancy sensing			
Corridor			Follow me Room Linking	Office hours		√



Energy consumption in Office VTT
Baseline

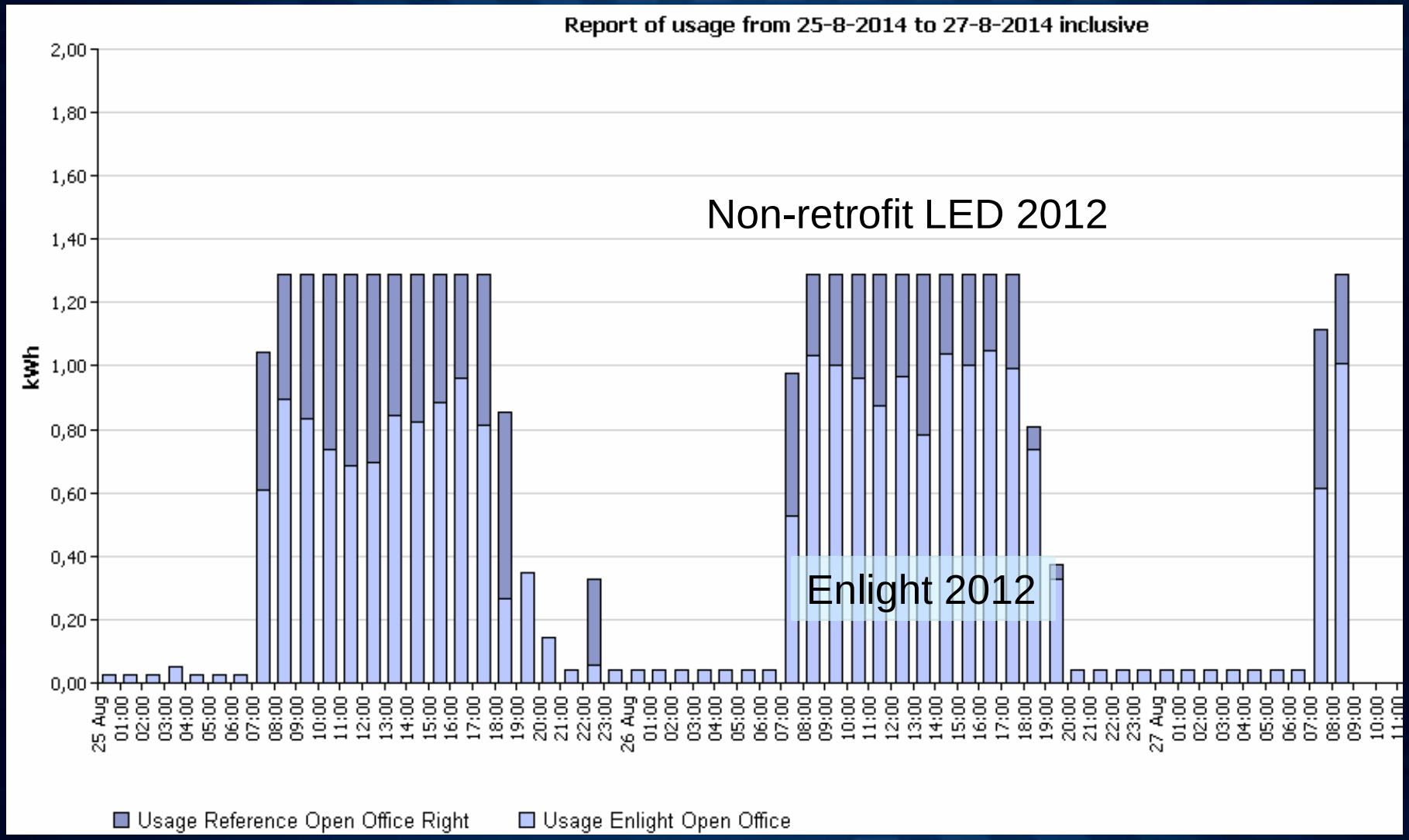


→ A lot of energy is wasted when nobody is there!

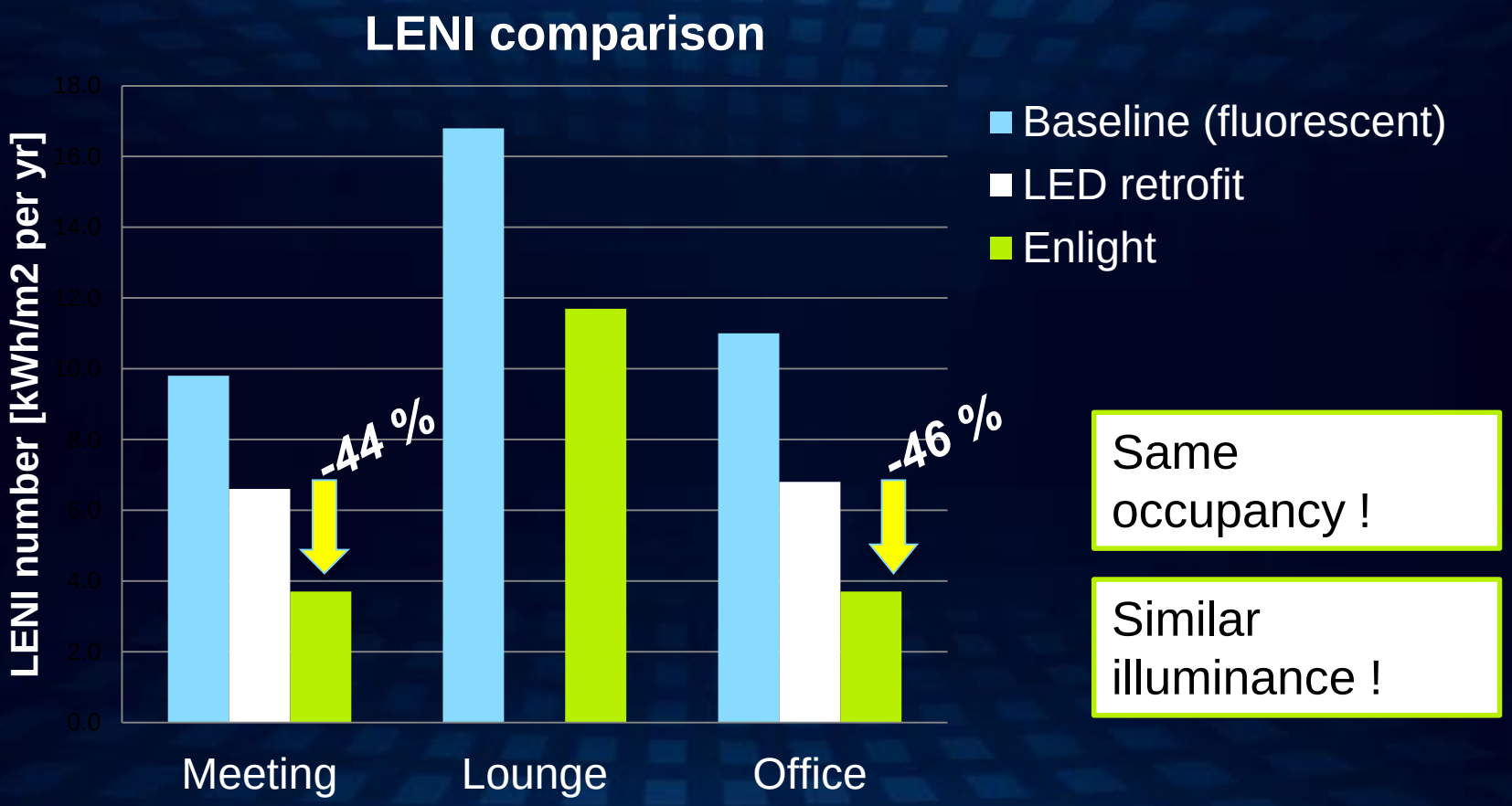


Data from 11.2.2013 - 29.11.2013.

Philips Open Office energy snapshot

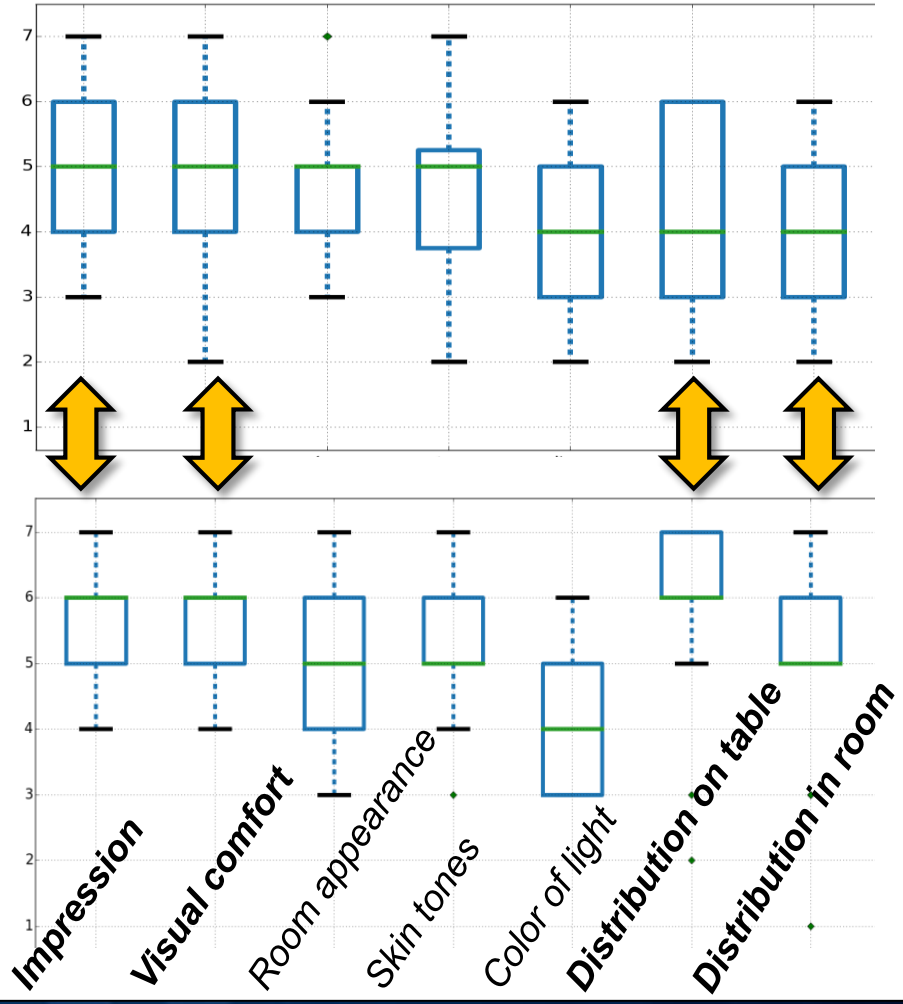


Meeting the Grand Challenge



Enlight light quality: Office VTT

“Overall impression, quality of light, vista and visual comfort”



EnLight

http://www.enlight-project.eu/

Next Generation Lighting System with

- Decentralized intelligence in the luminaire and end nodes, rule-based, communicating via a Zigbee network,
- Modular intra-luminaire architecture with a ILB digital bus interface,
- Software-defined functionality and minimized hardware.

Acknowledgement: The project is sponsored in the framework of the joint undertaking ENIAC (ENIAC Annual Work Program 2010) and on the basis of the national research program “IKT 2020 – Research for Innovation” by the German Federal Ministry of Education and Research (BMBF)

ENLIGHT

eniac JOINT UNDERTAKING

Bundesministerium für Bildung und Forschung

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EnLight

http://www.enlight-project.eu/

Next Generation Lighting System with

- More than 44 % energy savings at similar illumination level and occupancy
- Uniformly distributed illumination with a lighting level according to standards
- End user surveys indicate enhancement in the user comfort

Acknowledgement: The project is sponsored in the framework of the joint undertaking ENIAC (ENIAC Annual Work Program 2010) and on the basis of the national research program “IKT 2020 – Research for Innovation” by the German Federal Ministry of Education and Research (BMBF)


Thank you