Next generation intelligent lighting systems beyond retrofit

Introduction

- **Paradigm shift** in illumination driven by disruptive technology developments in solid-state lighting (SSL).
- First stage (today) is about cost effective retrofit LED lamps.
- Enlight focuses on the next generation intelligent LED systems leveraging the intrinsic qualities of solid-state lighting technology.

Objectives:

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% energy reduction compared to LED retrofit systems.

Approach:

- **Energy efficient light source:**
  - Electrical efficiency: Integrated LED drivers, Power supply, Communication & control
  - Optical efficiency: Higher LOR
  - Thermal efficiency: Lower Tj

- **Intelligent control and energy saving strategies:**
  - The right light,
  - at the right amount,
  - at the right place,
  - at the right time.

Application areas:

- **Hospitality** Developing intelligent energy-saving functionalities to enhance comfort
- **Office** Seamlessly integrating lighting to facilitate the offices of the future, using data on perception, psychology, design, and human factors.
- **Power Grid** Impact of new devices and lighting systems on the distribution grid.

Consortium

Consortium is built on two of the largest global lighting players and leading semiconductor industry players, prominent knowledge institutions, a utility company and innovative medium-sized and small enterprises.

Partners represent the entire lighting value chain

Impact:

- Saving up to 40% energy consumption for lighting. Substantial reduction of global CO2 emission.
- Accelerating market uptake and cost effective mass market lighting solutions that combine:
  - ‘More illumination’: focusing on efficiency, cost, miniaturization and revolution in form and fixture;
  - ‘More than illumination’: added intelligence, interaction management fueling novel applications and solutions.
- Strengthening European technological leadership in next generation intelligent SSL solutions.

Expected results:

- Validated application and demonstration scenarios for hospitality, office and power grid.
- Specification of module and system interfaces for next generation intelligent lighting systems;
- Prototypes of optimal LED lighting modules, accurate and cost effective sensors and controls;
- Contributions to standards and standardisation initiatives such as Zhaga, NEMA, IEC CISPR, IEC 62756 / DLT, Zigbee, IETF.

Project info:

- June 2011 – May 2014
- Coordinator: Philips Lighting
**Energy efficient and intelligent lighting systems**

**Decentralized intelligence architecture based upon modular intelligent luminaire**

**System Architecture (based on use cases):**

1. **Decentralized Intelligence Architecture**
   - Internet of Things design pattern:
     - No central node & no global knowledge of network topology required
     - All decision processes take place locally at each node

2. **Modular Intelligent Luminaire**
   - **LED Light Engine**
   - **Driver (1.0)**
   - **LED Engine & Light Manip.**
   - **Embedded Controller**
   - **Communication**
   - **Embedded Sensor (0.1)**
   - **Intra Luminaire Communication bus (PC based)**

**Intermediate results**

- Validated system architecture mirrored on **Use cases and features** as defined in Requirements and Specifications Work Package;
- Specification of module and system interfaces with Intra-Luminaire Bus (ILB) and Lighting Control Network (LCN);
- Development of EnLight compliant building blocks:

**Level**

1. **System**
   - ![System Components](image)
2. **Fixture**
   - ![Fixture Components](image)
3. **Module**
   - ![Module Components](image)

**Next steps**

- Demonstration and validation in Office and Hotel

**Energy saving perspective**

Benchmark results (IES), average figures:

<table>
<thead>
<tr>
<th>Building type</th>
<th>Occupancy</th>
<th>Daylighting</th>
<th>Personal tuning</th>
<th>Institutional tuning</th>
<th>Multiple types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>23%</td>
<td>38%</td>
<td>38%</td>
<td>38%</td>
<td>42%</td>
</tr>
</tbody>
</table>

... but EnLight enables more advanced energy saving strategies:

- Variable CRI/CCT, adaptive to task (i.e. Circadian rhythm, energy saving mode)
- Adding luminaire embedded sensors and local control strategies
- Enhancing system intelligence by fusion of embedded and area sensor events

**Advantages**

- **Robustness:**
  - No single point of failure but graceful degradation
- **Scalability:**
  - Investments, complexity and intelligence grow linear
  - Low entry level
- **Modularity and extensibility:**
  - Nodes can be added, modified or updated during lifecycle
  - Enables product differentiation in functionality and performance
- **Effectiveness and reduced installation complexity:**
  - Less complex commissioning when using local embedded sensors
  - Embedded presence sensors increase overall energy efficiency compared to centrally placed sensors.
- **Manage luminaire diversity and complexity increase** by decoupling lifecycles of independent technologies.

Contact:
Project Manager: Frank van Tuijl
Philips Lighting
HTC44-1, 5656 AE Eindhoven, the Netherlands
Tel: +31-40-2749545
E-mail: frank.van.tuijl@philips.com
Website: www.enlight-project.eu
**NXP contribution**

**Intelligent Luminaire Modules**

Fully EnLight compatible luminaire modules comprising:
- High & low power supplies, LED Light Engine (LLE), embedded controller, sensors
- Internally connected via Intra-Luminaire Bus (ILB) based on I²C
- Zigbee communication within the Area Network with distributed Intelligence

**NXP provides**

- LED drivers
  - μController with extremely low power consumption and I²C, ZigBee communication
- Power supply Controllers (resonant and flyback) and improved discrete components enabling increased efficiency
- Novel discrete semiconductors (diodes, transistors) for increased power supply and LED driver efficiency
- Embedded Software for LLE and Embedded Controller

Wake up radio concept to reduce standby power to a few μW

**Luminaire modules roadmap**

<table>
<thead>
<tr>
<th>Light Engine</th>
<th>Power Supply</th>
<th>Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>UB3077</td>
<td>+24V – TEA1733 +5V – TEA1721T</td>
<td>PCA9634 I²C to PWM</td>
</tr>
<tr>
<td>V_out &lt; 24VUBA3070</td>
<td>+24V – SSL4120 +5V – TEA1721T</td>
<td>JN5168 for Zigbee Wireless ILB +3V – LD6806</td>
</tr>
<tr>
<td>V_out &gt; 24VUBA3077</td>
<td>Customized circuits and PCB’s for Demo Luminaires</td>
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</tr>
<tr>
<td>M24</td>
<td>M36</td>
<td>Customized circuits and PCB’s for Demo Luminaires</td>
</tr>
</tbody>
</table>

Optimized discrete Components
Optimized LED driver
Wake-up radio concept

**M24 Realization (large luminaire, V_out >24V)**

<table>
<thead>
<tr>
<th>PSU</th>
<th>LLE</th>
<th>Communication / Controller</th>
</tr>
</thead>
<tbody>
<tr>
<td>+24V SSL4120</td>
<td>+5V TEA1721T</td>
<td>LD6806</td>
</tr>
<tr>
<td>24V</td>
<td>5V</td>
<td>3V</td>
</tr>
<tr>
<td>LLE Controller PCA9685</td>
<td>JN5168</td>
<td>ZigBee Comm</td>
</tr>
<tr>
<td>V_in – 70V, 6x350mA 2xUBA3077</td>
<td>LLE SW running on JN5168</td>
<td></td>
</tr>
</tbody>
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**Wake up radio**

Wake up radio to cut standby power to μW regime without external source.

**Discrete Components**

- **Luminaire Power Supply**
  - Flyback Diode (Hybrid and/or trench power diode)
  - Transistor (High Voltage Planar for cost optimization)

- **LED Light Engine (LLE)**
  - Flyback Diode (Hybrid and/or trench surface mount diode)

**Embedded Software**

- **LLE**
  - LED driver, ILB Framework, Color Conversion

- **Embedded Controller**
  - Zigbee stack, ILB Framework