Outdoor LED
in residential areas

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Project team

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Niclas Norlén, Lumen Radio AB
Kjell Berndtsson, Riksbyggen AB
Can LED + wireless lighting control reduce energy use and at the same time keep or improve the qualities of the perceived light environment?
Aim

To compare

- people’s subjective light perception and perceived safety and accessibility
- energy use
- maintenance costs

before and after LED-lighting with wireless lighting control has been installed, in the outdoor environment of multifamily residential areas.
The Human-Environment Interaction Model, Küller, 1991

ACTIVITY
being outdoor after dark

BASIC EMOTIONAL PROCESS

PHYSICAL ENV
subjective lighting perception

INDIVIDUAL RESOURCES
gender, age, disability, values, attitudes

SOCIAL ENV
Sense of community

perceived accessibility danger

Variation over time

Theoretical departure
Multi-place perspective

An environment consists of several interconnected functional units. (Bonnes & Secchiaroli, 1995)

Units of analysis:
- Entrance
- Path
- Yard
Design

Technical problems

Baseline | Intervention | Post 1 | Post 2 | Post 3 | Post 4

Helsingborg
Luleå
Helsingborg

Riksbyggen AB
Built in 1978
Appartments 138
Helsingborg, Feb 2010

High pressure sodium 90w
Entrance 8.5-13.1 lx
Path 6.5-10 lx
Garden 1.2-2.3 lx
Luleå

Riksbyggen AB
Built in 1980s
Appartments 49
Luleå, Feb 2010

Mercury lamps 90w
Entrance 6.3-7.8 lx
Path 0.3 lx
Garden 0.2 lx
## Collected data

<table>
<thead>
<tr>
<th>Description</th>
<th>Time Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert descriptions of residential areas</td>
<td>Baseline</td>
</tr>
<tr>
<td>Residents’ subjective assessments</td>
<td>Baseline + 3 post tests</td>
</tr>
<tr>
<td>On site measurements of light levels</td>
<td>Baseline + 3 post tests</td>
</tr>
<tr>
<td>Up-time of outdoor lighting per month (Riksbyggen)</td>
<td>Feb 2010 – Apr 2011</td>
</tr>
<tr>
<td>Logg of diming function (LumenRadio)</td>
<td>Aug 2010– Apr 2011</td>
</tr>
<tr>
<td>Laboratory measures of all old and new light sources (Fagerhult AB)</td>
<td></td>
</tr>
</tbody>
</table>
Expert: Semantic environmental description

SMB, Küller 1991
**Expert description of outdoor area**

- Planning
- **Design**
- Greenery
- Physical access
- Traffic
- Safety
- **Maintenance**
- Social life
- Commerce
- *Light*

Expert checklist: Küller, 2002; Tucker Cross 2004, * p<.05, ** p<.01, *** p<.001
Subjective assessments: participants

Residents during the study period
N=246, 50% have participated at least once

Perception Before – After
N=62, response rate 25%
Male 40%, Female 60%
Mean age 64 years (20-85 years)

Perception of LED over time
N=50 response rate 20%
Male 37%, Female 63%
Mean age 65 years (20-85 years)
Helsingborg February 2010
Instruments

10-page questionnaire including

Subjective lighting quality for three unit of analysis
After Küller & Wetterberg, 1993; 1996

Perception of how natural the colour of objects are, new items

Perceived accessibility, Johansson, Rosén & Küller, 2011

Perceived danger, Blöbaum et al., 2005; Johansson, Rosén & Küller, 2011

(Lighting concern Kuhn & Maletipwaan Mattsson et al, work in progress)

Background data
Lighting perception at entrance

- *Unpleasant
- *Coloured
- *Concentrated
- *Cold
- *Evenly distr
- *Soft
- Focused
- Unnatural
- Murky
- Monoton
- *Bright
- Dimmed
- Brilliant

Luleå

Hbg
Lighting perception at path

*Light
*Unpleasant
*Coloured
*Concentrated
*Cold
*Evenly distr
*Soft
Focused
Unnatural
*Murky
*Monoton
Bright
Dimmed
*Brilliant

Luleå
Hbg
Lighting perception at yard

Lighting characteristics:
- Unpleasant
- *Coloured
- *Weak
- *Concentrated
- *Cold
- Evenly distr
- *Soft
- Focused
- Unnatural
- Murky
- *Monoton
- *Bright
- Dimmed
- *Brilliant

Graph showing the perception of lighting at yard locations Luleå and Hbg.
Correlations with accessibility

<table>
<thead>
<tr>
<th>LIGHTING QUALITY</th>
<th>ENTRANCE Pearson r</th>
<th>PATH Pearson r</th>
<th>GARDEN Pearson r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>.51**</td>
<td></td>
<td>.51**</td>
</tr>
<tr>
<td>Unpleasant</td>
<td></td>
<td>-.35**</td>
<td>-.46**</td>
</tr>
<tr>
<td>Coloured</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weak</td>
<td>-.28*</td>
<td></td>
<td>-.34**</td>
</tr>
<tr>
<td>Concentrated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cold</td>
<td></td>
<td>-.37**</td>
<td>-.31**</td>
</tr>
<tr>
<td>Evenly distributed</td>
<td>.31**</td>
<td></td>
<td>.32**</td>
</tr>
<tr>
<td>Soft</td>
<td></td>
<td></td>
<td>.23*</td>
</tr>
<tr>
<td>Focused</td>
<td>.29**</td>
<td>.34**</td>
<td></td>
</tr>
<tr>
<td>Unnatural</td>
<td>-.29**</td>
<td>-.35**</td>
<td></td>
</tr>
<tr>
<td>Murky</td>
<td>-.33**</td>
<td></td>
<td>-.53**</td>
</tr>
<tr>
<td>Monotonous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bright</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimmed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brilliant</td>
<td>.30**</td>
<td>.23*</td>
<td>.32*</td>
</tr>
</tbody>
</table>

* p<.05, ** p<.01
Intervention – installation of LED

LED 1000lm, 4000K

+ wireless light control from Lumen Radio AB

LED 2000lm, 4000K

Fagerhult AB
Intervention in Helsingborg
After intervention
Bef. glödljus som behålles

Luleå
Regulation: time of day and presence

<table>
<thead>
<tr>
<th>Time span</th>
<th>Percentage</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>-23</td>
<td>100%</td>
<td>Level 1</td>
</tr>
<tr>
<td>23-02</td>
<td>70%</td>
<td>Level 2</td>
</tr>
<tr>
<td>02-05</td>
<td>30%</td>
<td>Level 3</td>
</tr>
</tbody>
</table>
Energy use Helsingborg

**Helsingborg pole mounted fixture**
Average energy consumption per fixture per day (23.00 - 05.00):
High pressure sodium: 2.850 kWh
LED: 0.813 kWh

**Wall mounted fixture**
Average energy consumption per fixture per day (23.00 - 05.00):
Old: 0.467 kWh
New: 0.318 kWh

**Percentage of dimming level per day**
Level 1: 80 %
Level 2: 5 %
Level 3: 15 %
Energy use Luleå

Pole mounted fixture
Average energy consumption per fixture per day (23.00 - 05.00):
Mercury: 2.850 kWh
LED: 0.834 kWh

Wall mounted fixture
Average energy consumption per fixture per day (23.00 - 05.00):
Mercury: 0.467 kWh
LED: 0.321 kWh

Percentage of dimming level per day
Level 1: 82 %
Level 2: 7 %
Level 3: 8 %
What outdoor lighting would you prefer in your residential area? March 2011

89% the present lighting (LED)
6% the previous lighting (high pressure sodium in Helsingborg)

Response rate 25%

We do not know the preference of the non-respondents (75%)!
What will the data be able to tell?

- Differences in energy use of the conventional outdoor lighting and the LED lighting.

- Differences in the perception of conventional outdoor lighting and LED lighting.

- Differences in the perception of outdoor LED lighting over time.

- Correlations between photometric measures and subjective assessments.

- The "psychological complexity" of subjective lighting perception for outdoor (LED) lighting and the associations with perceived accessibility and danger.
Developments

International informal network environmental psychology and street lighting

Instrument development "Lighting concern" in co-operation with G. Tonello
Universidad Nacional de Tucumán, Tucumán, Argentina

Subjective lighting quality of LED light sources, Malmö.

Input to interdisciplinary research “Urban walking”

Input to technology development for street lighting (wireless lighting control)
Dissemination

Conference presentations
Kuhn, L. (2010). Outdoor LED- the effects on perceived safety, accessibility and subjective quality of light. Area group meeting in Environmental Psychology, Lund

Popular science
Thank you for your attention!

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