

BLISS FINAL GUIDE

Volume 2

Better Lighting in Sustainable Streets

TECHNICAL CASE STUDIES
Interleuven

April 2014



BLISS FINAL GUIDE

Volume 2

The Better Lighting in Sustainable Streets (BLISS) project was conceived in better understand how to reduce energy consumption in public lighting in ways that are acceptable to both local people and to the local environment. The BLISS partners are St. Helens, Eindhoven, Interleuven and Kaiserslautern. The partners are grateful to INTERREG IVB North-West Europe (NWE) programme for co-funding the project.

Many European projects have tried to understand how to reduce energy consumption in public lighting. BLISS has been different; it has tried to look forward, to understand the future role of public lighting, to test and trial the public acceptability of existing innovations and technologies, and to start to prototype new lighting technologies, innovations and solutions.

The BLISS partners have each made significant investments in their pursuit of finding energy saving solutions that are acceptable to stakeholders; pedestrians, cyclists, drivers, residents and businesses. Each of the ninety or so investments has been designed to gain a better understanding of the benefits of using different combinations of materials, equipment, design and technologies. The investments have been in Belgium, United Kingdom, Germany and the Netherlands. In different spaces and places; both existing and new residential streets, as part of the redevelopment of the former Philips manufacturing area at Strijp-S, on major highways, in shopping and commercial areas, for car parks and bridges, and in heritage parks and car parks close to wildlife sites.

The energy saving and technical benefits arising from each investment have been carefully assessed. In parallel, stakeholders, from business and drivers to professional lighting engineers and resident's investments have been involved. This has helped partners better understand their dislikes, likes, preferences, opinions and views, both before and after the investments. In looking to the future, installing prototypes for future lighting solutions has given BLISS a unique opportunity to explore the responses of local stakeholders, manufacturers and professionals to these innovations.

The BLISS partners have carefully chosen a representative sample of their investments. For each they have prepared "Technical Case Studies" (TCS). These bring together in a similar format the essential aspects of each investment; the technical specifications, challenges faced, learning gained, and the outcomes and achievements of the investments. Some of the outcomes of the investments can be compared – energy saving, reduction in accidents, total cost of ownership etc. But each investment is unique in terms of the lighting being replaced or installed, the place, the politics, the responsibilities, the priorities and the stakeholders.

The TCS demonstrate that involving stakeholders in the decision making is time consuming, often gives surprising outcomes and needs special skills. But they demonstrate that involving a wide range of stakeholders, add credibility to the design process, is innovative, endorses the technological solutions and can provide political justification for further investments.

This Volume 2 of the BLISS final guide is the partners' selection of Technical Case Studies. Further information and download versions are available from the partners;

Eindhoven:

<http://www.light-s.nl/website/light-s>

St Helens;

<http://www.sthelens.gov.uk/what-we-do/traffic-travel-and-parking/highways/street-lighting/BLISS-case-studies>

Interleuven;

<http://www.interleuven.be/bliss>

Kaiserslautern:

<http://www3.kaiserslautern.de/wb>

The BLISS project provides assistance to municipalities wishing to reduce energy in public lighting and gain the support of citizens. We would like to thank you for your interest in this guide.

The BLISS partners,

St. Helens, Eindhoven, Interleuven and Kaiserslautern.

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Better Lighting in Sustainable Streets

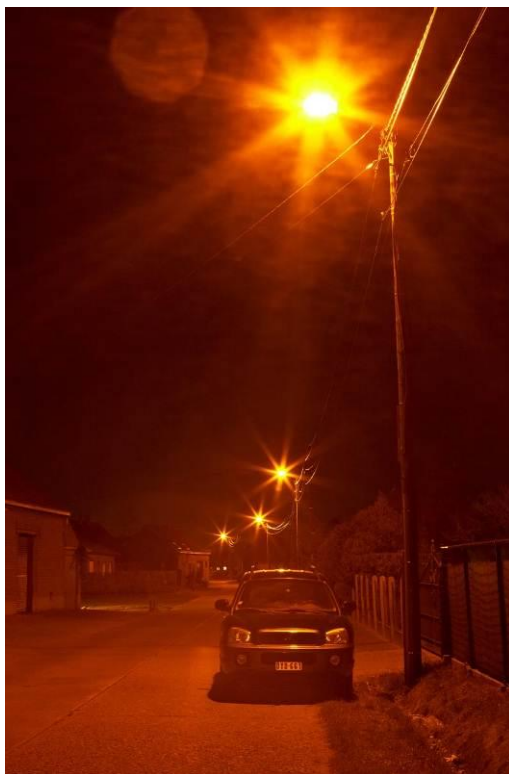
Technical Case Study

Werchter, Rotselaar, B

Residential area

21.02.2014

BLISS/IL/7.1/2013/TCS01



St. Helens Council



gemeente Eindhoven



INTERLEUVEN

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Better Lighting in Sustainable Streets

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Key information

Year	2010-2011
Theme	People
Scheme type	Residential
Scheme location	Werchter, Rotselaar, B
Property type	Semi-detached and detached bungalows
Number of roads	1
Speed limit	18.6mph (30 kph)
Crime rate	Low
Existing installation	70W HPS light source in the surrounding residential areas
Main consideration	New development
New installation	60W CPO
Distribution Network Operator	EANDIS



1.0 Background

This investment concerns a new residential development using white light technology in preference to High Pressure Sodium (HPS) which is the preferred norm in accordance with local policy. The new development is situated within an established residential area which will be used as a reference point. The installation of modern street lighting luminaires will offer improved efficiency with a minimal energy usage and costs.

The scheme includes the installation of 15 new street lighting units in total, which are a white light Cosmopolis 60W lamp which provides high-quality colour rendition and illumination. The lighting in the surrounding residential areas is a SON light source and the improvement in colour temperature and colour rendition on the new estate should be clear. The new lighting provides a safe and welcoming atmosphere helping to attract new residents to the estate.

1.1 Site description



The new site is situated in Werchter, a small village of the municipality of Rotselaar, north-east of Leuven. Rotselaar has a population of 15,200 people. The new development comprises of two roads, named Jef Scherensstraat and Frans Van Leemputtenstraat, situated between two existing roads: Grotestraat and Kleinstraat.

The two roads in this new residential area, subject to a 18.64 mph (30 kph) speed limit, have an overall width of 5 metres and around the central place 3 metres, with a mix of 38 semi-detached and detached properties. The distance to the centre of Werchter is 0.62 miles (1 km). The centre of Rotselaar is 1.7 miles (2.8 km) away. In this area are a number of key services including schools, medical centres, leisure centres, a supermarket and places of worship.



Image 1: Werchter, new residential development.



Image 2: Werchter, new lighting scheme.



Image 3: aerial view (Middenschalige orthofotomozaïek, Vlaanderen, winteropnames (wordt jaarlijks vernieuwd), geldig op datum van vandaag 22/11/2013, AGIV en Provincie Vlaams-Brabant

1.2 Crime considerations



Before (4 years): **low**
After (2 years): **0 facts**

Only those facts of crime in which the illumination of the street is relevant, are retained in these considerations: burglaries, car-thefts, car break-ins, bike thefts, vandalism, drug offenses, sexual offenses and arson; were also deter illegal dumping and graffiti.

In certain cases, we can't say if certain facts are street related or not. These facts were considered as possibly street related and are not included in the figures.¹

For this new road, a reference area was used to get the figures '2006-2009'.

Rotselaar - Werchter	crime - street related								
	2006	2007	2008	2009	before	2010	2011	2012	after
DARK	0	0	0	2	2		0	0	0
DUSK	1	0	0	0	1		0	0	0
SEMI-DUSK	0	0	0	0	0		0	0	0
	1	0	0	2	3		0	0	0

Table 1: Crime – street related - figures

1.3 Accident considerations



Before (4 years): **low**
After (2 years): **0 accidents**

The accident statistics are based on all reported accidents: with fatalities, with bodily harm and material damage.

For this new road, a reference area was used to get the figures '2006-2009'.

Rotselaar - Werchter	Accidents								
	2006	2007	2008	2009	before	2010	2011	2012	after
DARK	0	3	1	1	5		0	0	0
DUSK	0	0	0	0	0		0	0	0
SEMI-DUSK	0	0	0	1	1		0	0	0
	0	3	1	2	6		0	0	0

Table 2: Accidents – street related - figures

Remark: in traffic accidents with fatalities and/or injuries you are obliged to call the police. So we assume that these figures are correct and complete. The accidents with material damage, the police is not always informed. So these figures are just a minimum of the actual figures.²

¹Projectzone: ANG periode 2007-2012, extractie 9 sep 2013

² FedPol/CGOP/B, periode 2007-2012 (PV-gegevens).

1.4 Social demographic considerations



The information below shows key social economic and demographic data covering the area which helps to develop a representation of the potential activity in the hours of darkness.

Gender and age – Information obtained from the National Register – Rijksregister, verwerking door Steunpunt Sociale Planning (01.01.2013) - shows that the gender are fairly evenly divided. The age profiles show a majority of people in the age ranges of 18-29, 30-44 and 45-64 years.

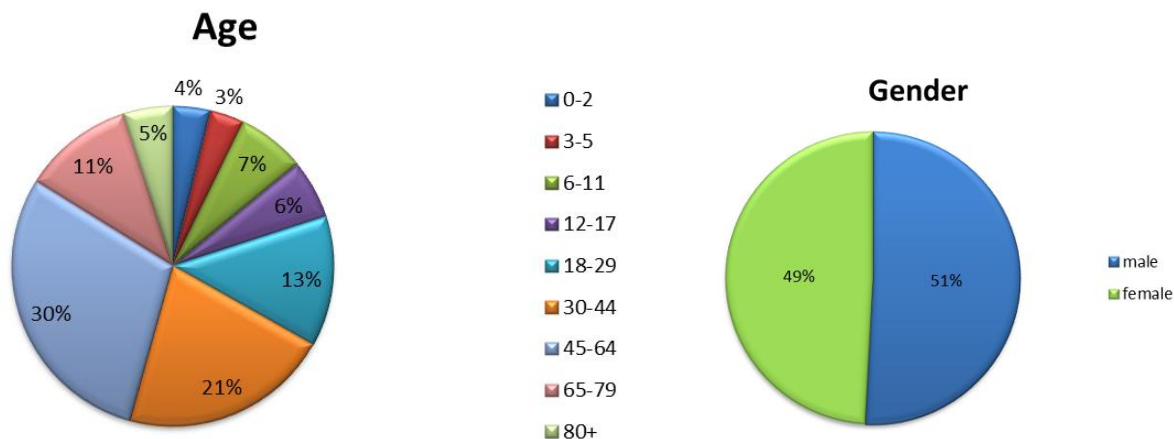


Chart 1: Age

Chart 2: Gender

Social economic – Information obtained from “Kruispuntbank van de sociale zekerheid” (31.12.2010) shows that the group ‘salaried employees’ and ‘children’ is the most common group in the region of this investment. 18% of the inhabitants are retired.

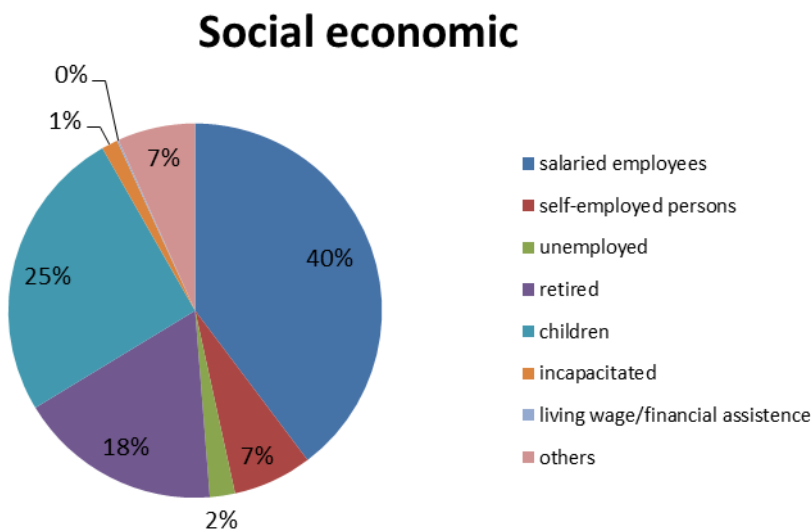


Chart 3: Social economic data

2.0 Existing installation

This investment includes a new housing project and the construction of a new road. Therefore, a comparison with an existing installation can't be made.

The existing inefficient luminaires (70W HPS) in the surrounding streets have deteriorated: poor colour rendering properties, deteriorating lumen output, increased number of reactive maintenance visits and high energy consumption.

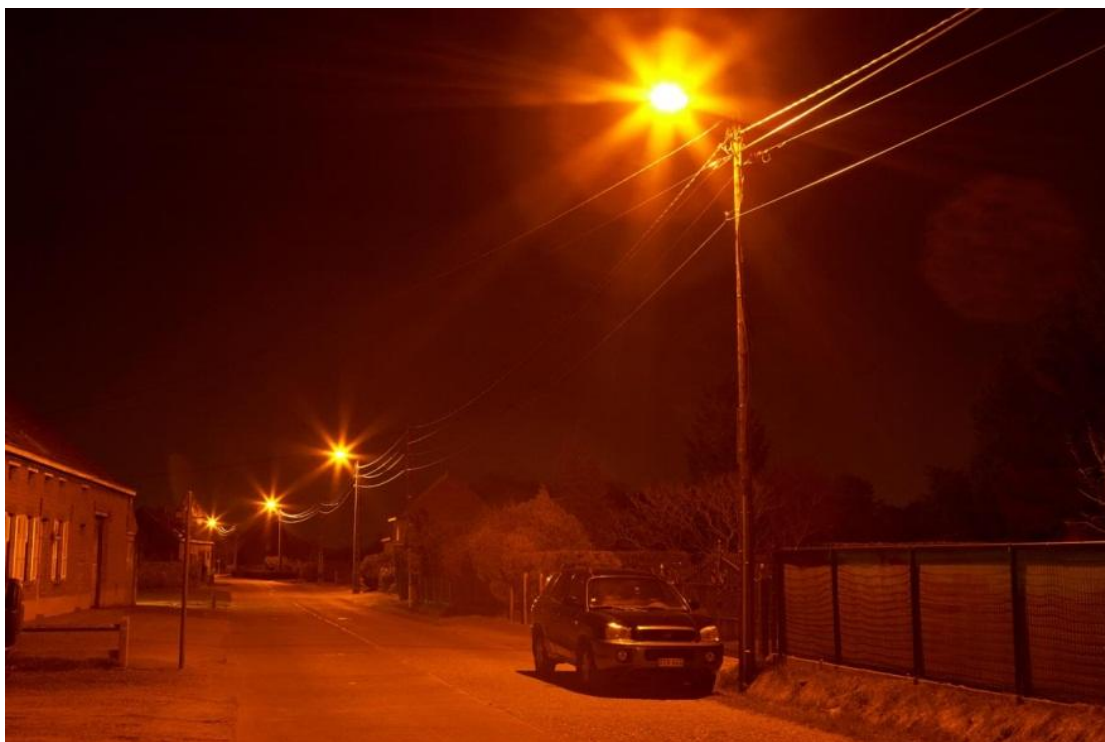






Image 4: Werchter existing scheme (image of the Kleinestraat)

3.0 Design development

Selection of the appropriate lighting classification;

Criteria	Description	Notes
 Road type	Residential street	Residential road. Limited number of conflict areas. No inter linking pathways present.
 Traffic flow	Low	18,6 mph (30 kph) speed limit. Majority of properties have off road parking for up to 2 vehicles. No traffic calming or signage present. The estate is not a bus route.
 Crime rate	Low	Low identified for the estate prior to scheme installation. No monitoring by any local authority CCTV surveillance equipment present.
 Colour rendition	Ra ≥ 60	Ra ≥ 60 chosen as appropriate for facial recognition (bicycle path), CPO white light sources in the new scheme.






	Environmental zone	E2	Countryside, residential street in a rural environment. Low surrounding brightness. Further details regarding sustainability can be found in section 6.0.
	Safe ease of passage	Generally good	Pedestrian ease of passage good. Slow traffic zone. No separate footpath, no overgrown vegetation, general visibility good, public transport links in surrounding area.
	Design uniformity	Uo - Me4b	Overall uniformity of illuminance (Uo) in accordance to the Me4b-class (*).
	Control method	50% lumen output 22:00 – 06:00	The new lighting installation is equipped with dimming. But is not yet in use. A separate technical investment in a high voltage cabinet is necessary. This is planned for the near future.
	Electricity supply	Distribution Network Operator	DNO low voltage system supply for public lighting use only (230V) continuous throughout the site.

Table 3: Primary and secondary design factors

(*) The following design standard was utilised within the design process in 2010/2011:

- ★ NBN EN 13201: A Belgian standard as result of the translation of a European standard.

With consideration to the criteria above, an Me4b lighting classification of 0,75 cd/m² average was chosen to provide an appropriate level of illumination.

	<i>Me4b</i>
L avg (cd/m ²)	0.75
U0	0.40
UI	0.50
TI max (%)	15.00

Table 4: The Me4b standard

Why CPO was an option and not LED?

During the design period in 2010, LED was not yet catalogued as an efficient lighting solution. Distribution Network Operator Eandis did a lot of tests with that light source. In 2010 LED was not yet ready to use as a good and efficient lighting system for public lighting. Nowadays, after a lot of testing cases, the LED lighting system evolved to a very good and energy efficient solution for certain Eandis investments.

The distribution network operators use the manual 'Typebestek 005' to design the public lighting on local roads (see 10.0). Every supplier of lighting systems has to follow the guidelines of this manual. In 2010, LED was not yet in the manual. At that moment, CPO was the most efficient and standardized public lighting solution.

4.0 Total Cost of Ownership

To support the lighting design process a Total Cost of Ownership evaluation has to be. Due to the BLISS project, project partner Interleuven proposed the CPO 60W luminaire to place on this new residential development. This instead of the traditional used lighting systems (like the surrounding streets). Finally, the Distribution Network Operator Eandis has proposed a dimming system. The municipality of Rotselaar agreed with this proposal. So, the new lighting installation is equipped with dimming, but is not yet in use. A separate technical investment in a high voltage cabinet is necessary. The old lighting circuit in the neighbourhood and the new lighting circuit must be separated (on this moment it is still one circuit) because the existing lighting luminaires are not equipped with electronic control devices for dimming. This is planned for the nearest future.

4.1 Initial capital expenditure

Three elements were considered:

- Site clearance costs of the existing installation (in the surrounding streets)
- Supply and installation of the equipment (luminaire, lamp, column and control)
- Electrical works (Distribution Network Operator)

Option	No.	Capital cost
CPO60W	25	€89,065
Final design CPO 60W	25	€89,065

Table 5: Initial capital expenditure

Remark: The capital cost includes a dimming option. Eandis demands of the suppliers that each luminaire has a dimming system. Luminaires without a dimming option are refused.

4.2 Energy provision

The energy provision was calculated using a cost per kWh based on Estimated Actual Consumption at commission year, excluding inflation and taxation:

- Energy cost per kWh = € 0.20
- Burning hours = 4,200 per year
- Dimmed hours = 2,100 (7 days per day)
- Carbon = 0.23 Kgs per kWh
 - www.synerggrid.be – Impact of efficient public lighting on CO₂emissions – CE4-N35N-13.05.2009
- 50% reduced lumen output between 22:00 – 06:00

Option	No.	Energy	% saving	Annual cost
HPS70W	25	7,000 kWh 1,470 Kgs		€ 1,400
CPO 60W	25	6,000 kWh 1,260 Kgs	15%	€ 1,200
CPO 60W with dimming	25	2,250 kWh 472 Kgs	68 %	€ 450
Final design CPO 60W with dimming	25	2,250 kWh 472 Kgs	68 %	€ 450

Table 6: Energy provision

4.3 Maintenance strategy

Planned maintenance regimes were considered: cyclic activities (lamp replacement, luminaire cleaning and structural inspection), electrical testing and inspection regimes.

A four year cyclic maintenance programme is applied to the HPS and CPO options.

Option	No.	Cost per luminaire	Cost per scheme
CPO 60W	25	€250	€6,250
CPO 60Wwith dimming	25	€250	€6,250
Final design CPO 60W with dimming	25	€250	€6,250

Table 7: Maintenance operations

4.4 Total Cost of Ownership 25-year expenditure

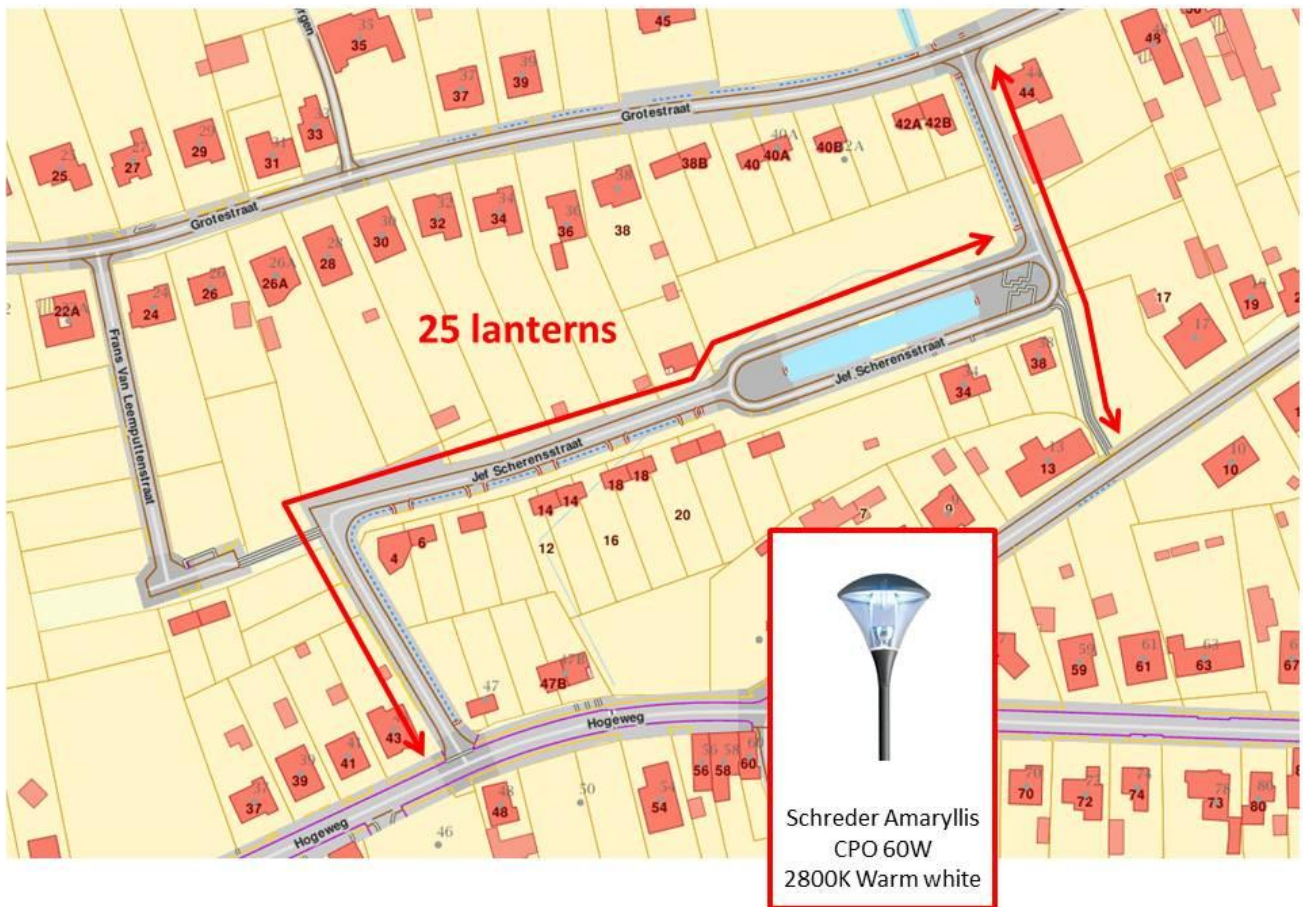
Table 8 outlines the total predicted expenditure over a 25-year life cycle.

Option	Initial capital costs	Energy costs	Maintenance costs	Whole life cost
CPO 60W	€89,065	€ 30,000	€6,250	€ 125,315
CPO 60Wwith dimming	€89,065	€ 11,250	€6,250	€ 106,565
Final design CPO 60W with dimming	€89,065	€ 11,250	€6,250	€ 106,565

Table 8: TCO 25-year expenditure

The results indicate that a CPO scheme with dimming is the most cost effective solution. The scheme performs well in terms of reduced energy and maintenance costs.

5.0 Designspecification



Plan 1: Detailed design specification



Image 5: Schreder Amaryllis CPO 60W, 2800K Warm White

6.0 Sustainability



6.1 Energy

Predicted energy calculations were produced based on manufacturers’ technical specifications to ensure that the new installation achieved a significant energy reduction, in accordance with the BLISS project aims.

Installed power (Watts)	
Before (*)	1,750 W
After (with dimming)	1,125 W
Savings (%)	625 W (36%)

Table 9: Installed power

(*) If the same luminaires are used as in the surrounding streets.

Energy consumption, CO ₂ emissions and savings per year (kWh, Kg CO ₂)		
Before	7,000 kWh	1,470 Kgs
After	2,250 kWh	472 Kgs
Savings (%)	4,750 kWh (68%)	998 Kgs (68%)

Table 10: Energy consumption

As identified in table 10, the use of more efficient light sources and control gear will reduce the energy consumption of street lighting, thereby reducing CO₂ emissions to generate the electricity whilst reducing the life cycle of the fuel and maintenance requirements.

6.2 Materials



The luminaire housings are made from aluminium (powder coated aluminium) with glass bowl protectors (slightly curved glass), which are both highly recyclable. The distribution network operator Eandis, responsible for this BLISS-investment, has a strict environmental policy. The manufacturers of lighting equipment are required to strictly follow the rules concerning recycling and the environment.



DNO Eandis also imposes requirements regarding light pollution and sky glow. These rules are based on the standard ‘Typebestek 005 – Equipment for public lighting’ (see 10.0). The manufacturer of the luminaires has to produce a very directional light source and produce minimal upward light, reducing the contribution to obtrusive light and sky glow. These kind of luminaires have no adverse effects on the local ecology.

6.3 Obtrusive light considerations



The environmental zone E2 'Countryside, rural environment', was selected for this road. Specific criteria from the manual CIE 150:2003 (*) relating to obtrusive light considerations were utilised during the equipment selection process.

(*) The manual CIE 150:2003 'Guide on the limitation of the effects of obtrusive light from outdoor lighting installations' contains guidelines for designers and governments to limit the sky glow (see 10.0).

7.0 Interleuven stakeholder research

Interleuven invited the inhabitants of the new street and the surrounding streets to comment the pre and post installations. The inhabitants of the surrounding streets are best placed to compare the pre and post situation.

Interleuven invited 125 properties to comment regarding the pre and post installations. 27% responded to the pre survey and 12% to the post survey. The main results are summarised below.



Pre works survey

- ★ 82% of the residents felt safe walking alone during the night
- ★ 82% felt that the old installation was 'comfortable on the eye'
- ★ 42% stated the old installation shows up the whole street well
- ★ 32% can see people at a distance clearly and 61% has no problem to see obstacles on the ground
- ★ 55% of the residents stated that the old lighting installation was too dark
- ★ 45% says that the old installation doesn't show the colours properly

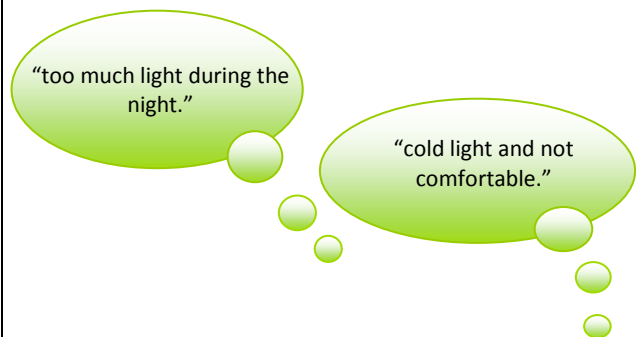
Additional residents' comments:



Post works survey

- ★ 85% of the residents felt safe walking alone during the night
- ★ 95% felt that the new installation is 'comfortable on the eye'
- ★ 79% stated the new installation shows up the whole street well
- ★ 79% can see people at a distance clearly and also 79% has no problem to see obstacles on the ground
- ★ 21% of the residents stated that the new lighting installation is still too dark
- ★ 15% says that the new installation doesn't show the colours properly

Additional residents' comments:



'How does the new street lighting compare with the previous street lighting?'

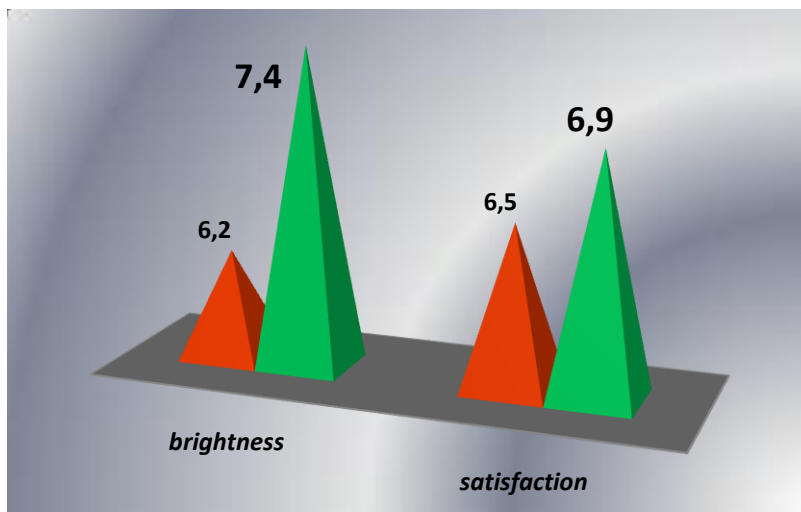
For only 36% of the respondents the new lighting installation is an improvement.



... and using a scale of 1 to 10 ...

... how bright is the street lighting

... how satisfied you are with the lighting



■ pre ■ post

8.0 Results









		Before(*)	After	Outcome
	Calculated energy	7,000 kWh 1,470 Kgs of CO ₂	2,250 kWh 472 Kgs of CO ₂	68% energy saving
	Number of luminaires	New development Surroundingstreets:70W HPS	25no. Cosmopolis	/
	Calculated colour rendition	/	Ra ≥ 60	/
	Calculated colour temperature	/	2800K Warm white	/
	Control regime	None	50% 22:00 – 06:00	Improved functionality
	Interleuven research	<ul style="list-style-type: none"> ★ 82% felt safe alone at night ★ 58% poor visibility ★ 45% colour rendition ★ 82% 'comfortable on the eye' ★ 55% say it's too dark ★ Satisfaction 6.5 	<ul style="list-style-type: none"> ★ 85% felt safe alone at night ★ 21% poor visibility ★ 15% colour rendition ★ 95% 'comfortable on the eye' ★ 21% say it's still too dark ★ Satisfaction 6.9 	Improved perception
	Measured crime	Low	Low	Low crime
	Measured accidents	6	0	Reduced accidents

Table 11: Results

(*) surrounding streets

9.0 Conclusion

This investment concerns a new residential development using white light technology in preference to High Pressure Sodium (HPS) which is the preferred norm in accordance with local policy. The new development is situated within an established residential area which will be used as a reference point.

The crime rate for the municipality Werchter, part of Rotselaar, is low. Only those facts of crime in which the illumination of the street is relevant, are retained in the considerations. The figures for 2011 and 2012 give no crime facts. On this moment, the evaluation time is too short to get a view of any positive impact of the new street lighting. The change to a white light source, producing an improved night environment, may be a contributory factor in the reduction of reported criminal incidents.

The accident rate is also very low. No reported accidents in 2011 and 2012. Important remark: The site is currently still a major construction site with the construction of several private houses. Accident figures on a later moment will give a view of the possible effect of the new lighting scheme.

The recorded demographics give an indication of the social profile of this area. The majority of people are in the age range of 45 – 64 and 40% of the residents are salaried employees. Most of the households are privately owned. This may mean that residents are more aware of their neighbourhood in terms of aesthetics and crime prevention.

To support the lighting design process a Total Cost of Ownership evaluation has to be made. This would determine which solution offered the most effective whole life cost. A CPO 60W lamp was chosen as most cost effective solution. Additionally the Distribution Network Operator Eandis has proposed a dimming system: the lumen output will be reduced with 50% between 22:00 and 06:00. The calculated energy saving is 68%.

Lighting can only be evaluated by stakeholder opinions and technical evaluation, there is no practical way to evaluate if the new lighting increases social activity, encouraging residents to make use of their local amenities during the hours of darkness. The post survey results in a 9 for the new lighting scheme, against the 6.7 for the previous scheme.

No negative comments or results have been obtained in relation to the reduction in lumen output to 50% between 22:00 and 06:00, following evaluation of the postal survey. Respondents generally appeared to be more concerned about the appearance and safety of where they live.

In conclusion, the change to white light appears to have had a positive impact on respondents' perceptions of their environment during the hours of darkness. Careful consideration should be made based on a number of detailed location criteria before changing to white light, including financial and environmental considerations. White light provides improved colour rendition with a predominantly warm white colour temperature, which may help to discourage night crime issues.

10.0 Standards

For several types of spaces, several European and Belgian standards are applicable. This chapter provides a brief overview of legislation and standards used in the development of lighting projects in Flanders/Belgium.

EN 13201 standard for public lighting.

Part 2 of this European standard, the performance requirements, has been translated into a Belgian standard NBN EN 13201-2. Part 1 of the European standard concerning the 'selection of the lighting classifications' is not yet translated into a Belgian standard. The 'Belgisch Instituut voor Verlichting BIV' is investigating this part of the European standard.

This standard establishes minimum levels of illumination that are necessary when a road is illuminated. Go below this minimum (eg dimming) is possible, but it happens, just like the whole of the public lighting on the responsibility of the road authority.

In the selection of lighting classes a distinction is made between:

- The (regional) roads/primary roads and secondary roads both with a specified minimum value for luminance or illuminance,
- The (public or private) local connection or access roads (each inside and outside the village) for which minimum luminance values are indicated
- and a series of other (including bicycle paths, 30 kph zones, pedestrian areas, squares, ...) for which minimum illuminance values are specified.

Regional roads.

Categorie	Functie	Subcategorie	CEN Klasse	L _{gem} [cd/m ²]	U ₁	U ₀	TI max [%] (2)	SR	E _h gem [lux]	U ₀ [E]	E _h min [lux]	E _v gem [lux]	E _v min [lux]	E _{sc} min [lux]
Hoofdweg / Primaire weg	Verbinden op internationaal en gewestelijk niveau	Conflictzones (ring, toelindingswegen...)	(1)	1,5	0,60	0,40	15	-	-	-	-	-	-	-
		Doorgaande wegsecties	ME3b	1,0	0,60	0,40	15	0,50	-	-	-	-	-	-
	Verzamelen op gewestelijk niveau	Rotondes	CE1	-	-	-	-	-	30	0,40	-	-	-	-
		Kruispunt primaire wegen	CE2	-	-	-	-	-	20	0,40	-	-	-	-
Secundaire weg	Verbinden (I) of verzamelen (II) op lokaal en bovenlokaal niveau	Conflictzones (ring, toelindingswegen...)	ME3b	1,0	0,60	0,40	15	0,50	-	-	-	-	-	-
		Rotondes	CE1	-	-	-	-	-	30	0,40	-	-	-	-
		Kruispunt primaire wegen	CE3	-	-	-	-	-	15	0,40	-	-	-	-

(1) Klasse ME3b met L >= 1,5 cd/m²

(2) Een verhoging van 5% van de TI is aanvaardbaar in geval van gebruik van lichtbronnen met lage luminatie (Natrium Lage Druk en Fluorescentie buis), zijnde TI max = 20%

Table 12: Lighting classifications for regional roads

Regional roads, local connections or private roads.

Categorie	Functie	Subcategorie	Situatie (4)	CEN Klasse	L _{gem} [cd/m ²]	U _i	U _o	TI max [%] (2)	SR	E _h gem [lux]	U _o [E]	E _s min [lux]	E _v gem [lux]	E _v min [lux]	E _{sc} min [lux]			
Lokale verbindingsweg	Verbinden op lokaal niveau	Algemeen	Buiten bebouwde kom	ME4a	0,75	0,60	0,40	15	0,50	-	-	-	-	-	-			
			Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	-			
Lokale gebiedsontsluitingsweg	Ontsluiten (verzamenen en verdelen) op lokaal niveau	Algemeen	Buiten bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-	-			
			Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	-			
Erftoegangs weg	Veel bebouwing	Verblijven en toegang verlenen tot de aanpalende percelen	Woonstraat/Ventweg	Buiten bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-			
			Woonstraat/Winkelstraat	Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-			
	Woonstraat/Ventweg		Buiten bebouwde kom	ME5	0,50	0,40	0,35	15	0,50	-	-	-	-	-				
	Woonstraat/Winkelstraat		Binnen bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-				
Landelijke weg	Algemeen	Algemeen	Buiten bebouwde kom	(3)	0,30	0,40	0,35	20	-	-	-	-	-	-	-			
			Aanliggend fietspad	-	(3)	CE Klasse van aanliggende rijweg -1												
Andere	-	-	Vrijliggend fietspad Voetpad (naast weg) Wandelweg Voetgangers- en fietsbrug	-	(3)	S4	-	-	-	-	5	-	1	-	-	-		
			Zone 30	-	(3)	CE4	-	-	-	-	10	0,40	-	-	-	-		
			Voetgangerszone, voetgangersweg en woonef	-	(3)	CE4 [ES5]	-	-	-	-	10	0,40	-	-	-	-	[2]	
			Plein	-	(3)	S4 [ES7]	-	-	-	-	5	-	1	-	-	-	[1]	
			Handels- en historische centra	-	(3)	CE3 [ES4]	-	-	-	-	15	0,40	-	-	-	-	[3]	
			Onderdoorgangen voetgangers en fietsers	Nacht	-	-	-	-	-	-	100	-	-	-	-	-	-	10
				Dag	(3)	-	-	-	-	-	200	-	-	-	-	-	-	20
Oversteekplaats	-	(3)	-	-	-	-	-	80	0,30	-	40	-	-	-				

(2) Een verhoging van 5% van de TI is aanvaardbaar in geval van gebruik van lichtbronnen met lage luminantie (Natrium Lage Druk en Fluorescentie buis), zijnde TI max = 20%

(3) ME6 Klas met TI <= 20%

(4) Binnen bebouwde kom: <= 50 km/h - Buiten bebouwde kom >= 50 km/h

Table 13: Lighting classifications for regional roads, local connections and private roads

For regional roads the performance requirements of NBN EN13201-2 are also translated into the 'Standard Specification240' in which four categories of roads and spaces are distinguished. This standard defines the following accents: smooth and safe traffic (A), mixed use (B), visual comfort and safety (C) and the need of mood lighting (D).

Synergrid, the Federation of Distribution Network Operators, translated these performance requirements into the 'Typebestek 005 – Equipment for public lighting'. The distribution network operators use this 'Typebestek 005' to design the public lighting on local roads.

In the design of public lighting next standards and manuals are important:

- Vlare II, the Flemish environmental legislation with rules to prevent light pollution.
- CIE-documents. In accordance with the standard 'EN13201-3 Road lighting-Part 3: Performance Calculation' these CIE documents give technical guidelines for designers:
 - Report CIE 126-1997 'Guidelines for minimizing sky glow'.
 - The manual CIE 150:2003 'Guide on the limitation of the effects of obtrusive light from outdoor lighting installations' contains guidelines for designers and governments to limit the sky glow. In this guide techniques are described for lighting systems in relation to the requirements for astronomical observations. The upward flux of luminaires should be avoided in natural areas (environmental zone E1) (0%) and in rural areas (environment zone E2) it must be limited to max 5%.

<u>Environmental zone</u>	<u>Area</u>	<u>Brightness of the environment</u>	<u>Examples</u>
E1	Nature	Dark	Conservation area
E2	Rural	Low artificial brightness in the environment	Industrial, residential and rural areas
E3	Cities	Moderate artificial brightness in the environment	Urban residential areas with potential industry
E4	City centers	High artificial brightness in the environment	City center with a mix of residential and commercial functions

Table 14: Classification in areas for outdoor lighting design

- Evaluation and approval of lighting equipment. With 'Typebestek 005' as guide, Synergrid has made a list of approved luminaires. The distribution network operators preferably use these approved devices.

11.0 Images



Image 6: Werchter new scheme



Image 7: Werchter new scheme



Image 8: Werchter new scheme

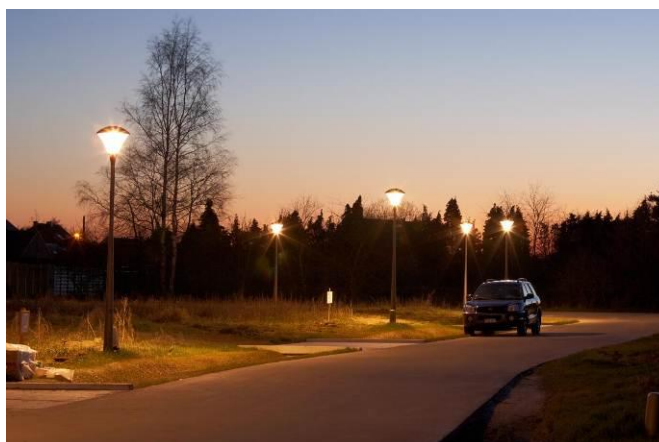


Image 9: Werchter new scheme



Image 10: Werchter new scheme



Image 11: BLISS-publicity panel in Werchter



Image 12: The new housing project in Werchter, information evening 27.02.2012



Image 13: BLISS-banners on the information evening 27.02.2012



Image 14: New lighting scheme

For additional information contact:

BLISS International website: www.bliss-streetlab.eu

INTERLEUVEN
+32 16 235836
milieu@interleuven.be
www.interleuven.be

Composer report: Stefan Kempeneers
stefan.kempeneers@interleuven.be, +32 16 284 221

Eandis
+32 78 35 35 34
www.eandis.be

Technical support: Marc Lemmens
marc.lemmens@eandis.be

BLISS Better Lighting in Sustainable Streets

Technical Case Study

Kumtich, Tienen, B

Residential area

21.02.2014
BLISS/IL/7.2/2013/TCS02



St. Helens Council



gemeente Eindhoven



INTERLEUVEN
ONDERNEMEND EN ONDERSTEUNEND



Better Lighting in Sustainable Streets

BLISS

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Key information

Year	2010-2011
Theme	People
Scheme type	Residential
Scheme location	Kumtich, Tienen, B
Property type	Semi-detached and detached bungalows
Number of roads	2
Speed limit	31mph (50 kph)
Crime rate	Low
Existing installation	Existing part of the residential area: 70W SON lamps
Main consideration	New development – expansion of a residential area
New installation	60W CPO
Distribution Network Operator	EANDIS



1.0 Background

This investment concerns the expansion of a residential area. The existing part of the residential area is of similar size and has lighting columns with 70W SON lamps. This site is the reference site for the new development, subject of this case study. In the new development, the same lantern and column height is used, but has another light source, a 60W Cosmopolis lamp. The installation of these luminaires will offer improved efficiency with a minimal energy usage and costs.

The scheme includes the installation of 16 new street lighting units in total, which are a white light Cosmopolis 60W lamp which provides high-quality colour rendition and illumination. The lighting in the surrounding residential areas is a 70W SON light source and the improvement in colour temperature and colour rendition on the new estate should be clear. The new lighting provides a safe and welcoming atmosphere helping to attract new residents to the estate.

1.1 Site description



Kumtich is a small suburb of the city of Tienen, a city with a population of 32,100 people, 25 km east of Leuven. This expansion of a residential area comprises of two roads, named the Lisstraat and the Duikers-Ontmijnersstraat.

The two roads in this new residential area, subject to a 31 mph (50 kph) speed limit, have an overall width of 5 metres, with a mix of 4 semi-detached and 35 detached properties. The distance to the centre of Tienen is 3.10 miles (5 km). In this area are a number of key services including schools, medical centres, leisure centres, a supermarket and places of worship.



Image 1& 2: Kumtich, expansion of a residential development.



Image 3: Kumtich, new lighting scheme



Image 4: Kumtich, a BLISS-investment



Image 5: aerial view (Middenschalige orthofotomozaïek, Vlaanderen, winteropnames (wordt jaarlijks vernieuwd), geldig op datum van vandaag 22/11/2013, AGIV en Provincie Vlaams-Brabant

1.2 Crime considerations



Before (4 years): **low**
 After (2 years): **low**

Only those facts of crime in which the illumination of the street is relevant, are retained in these considerations: burglaries, car-thefts, car break-ins, bike thefts, vandalism, drug offenses, sexual offenses and arson; were also deter illegal dumping and graffiti.

In certain cases, we can't say if certain facts are street related or not. These facts were considered as possibly street related and are not included in the figures.³

For this new road, a reference area was used to get the figures '2006-2009'.

Tienen - Kuntich	crime - street related								
	2006	2007	2008	2009	before	2010	2011	2012	after
DARK	0	0	0	2	2		0	0	0
DUSK	1	0	0	0	1		0	0	0
SEMI-DUSK	0	0	0	0	0		0	0	0
	1	0	0	2	3		0	0	0

Table 1: Crime – street related - figures

³Projectzone: ANG periode 2007-2012, extractie 9 sep 2013

1.3 Accident considerations



Before (4 years): **low**
 After (2 years): **low**

The accident statistics are based on all reported accidents: with fatalities, with bodily harm and material damage.

For this new road, a reference area was used to get the figures '2006-2009'.

Tienen - Kuntich	Accidents								
	2006	2007	2008	2009	before	2010	2011	2012	after
DARK	0	0	1	0	1		0	0	0
DUSK	0	0	0	0	0		0	0	0
SEMI-DUSK	0	0	0	1	1		0	0	0
	0	0	1	1	2		0	0	0

Table 2: Accidents – street related - figures

Remark: in traffic accidents with fatalities and/or injuries you are obliged to call the police. So we assume that these figures are correct and complete. The accidents with material damage, the police is not always informed. So these figures are just a minimum of the actual figures.⁴

1.4 Social demographic considerations



The information below shows key social economic data covering the area which helps to develop a representation of the potential activity in the hours of darkness.

Gender and age – Information obtained from the National Register – Rijksregister, verwerking door Steunpunt Sociale Planning (01.01.2013) - shows that the gender are fairly evenly divided. The age profiles show a majority of people in the age range of 30-44 and 45-64 years.

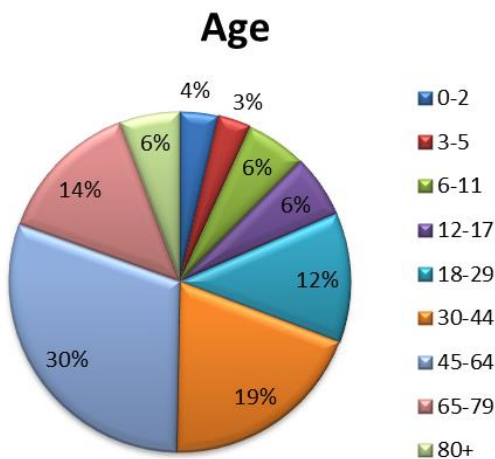


Chart 1: Age

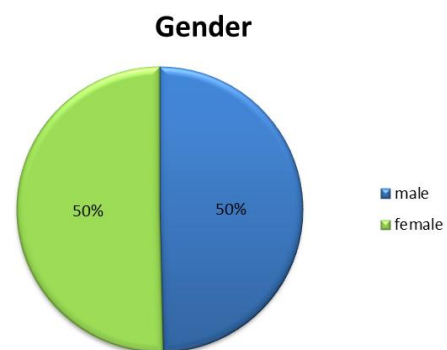


Chart 2: Gender

⁴ FedPol/CGOP/B, periode 2007-2012 (PV-gegevens).

Social economic – Information obtained from “Kruispuntbank van de sociale zekerheid”(31.12.2010) shows that the group ‘salaried employees’, ‘retired’ and ‘children’ are the most common groups in the region of this investment.

Social economic

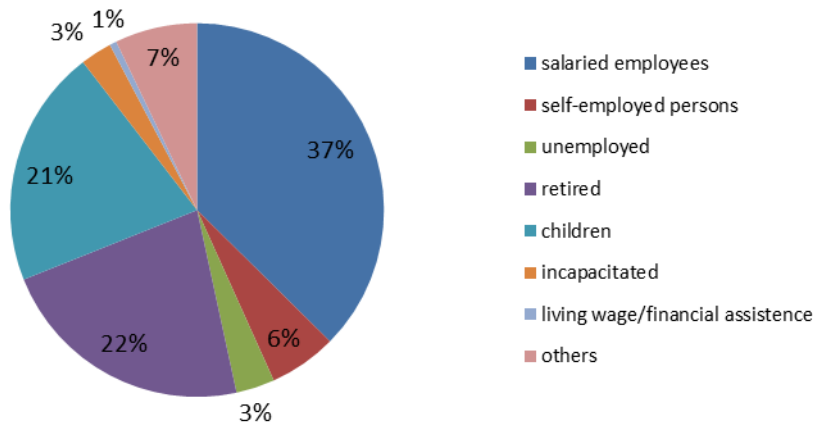


Chart 3: Social economic data

2.0 Existing installation

This investment includes a new housing project and the construction of a new road. Therefore, a comparison with an existing installation can't be made. The existing inefficient luminaires in the neighbourhood have deteriorated: poor colour rendering properties, deteriorating lumen output, increased number of reactive maintenance visits and high energy consumption.

The designers had also to look at the vision of the city government of Tienen: they want uniformity with the rest of the existing residential area. So, they wanted the same poles and luminaires. Due to the BLISS project, DNO Eandis proposed another lamp, a more energy efficient lamp.

Also important to mention: the safety considerations and the safety feeling of the visitors in this area.










Image 6 and 7: Kuntich existing scheme



Image 8: Kuntich existing scheme

3.0 Design development

Selection of the appropriate lighting classification;

Criteria	Description	Notes
 Road type	Residential street	Residential road. Limited number of conflict areas. No inter linking pathways present.
 Traffic flow	Low	31 mph (50 kph) speed limit. Majority of properties have off road parking for up to 2 vehicles. No traffic calming or signage present. The estate is not a bus route.
 Crime rate	Low	Low identified for the estate prior to scheme installation. No monitoring by any local authority CCTV surveillance equipment present.
 Colour rendition	Ra \geq 60	Ra \geq 60 chosen as appropriate for facial recognition (bicycle path), CPO white light sources in the new scheme.
 Environmental zone	E2	Countryside, residential street in a rural environment. Low surrounding brightness. Further details regarding sustainability can be found in section 6.0.
 Safe ease of passage	Generally good	Pedestrian ease of passage good. Slow traffic zone. No separate footpath, no overgrown vegetation, general visibility good, public transport links in surrounding area.
 Design uniformity	Uo - Me4b	Overall uniformity of illuminance (Uo) in accordance to the Me4b-class (*).



 50%	Control method	50% lumen output 22:00 – 06:00	The new lighting installation is equipped with dimming. But is not yet in use. A separate technical investment on the old lighting installation in the near areas is necessary (same circuit). This is planned for the near future.
	Electricity supply	Distribution Network Operator	DNO low voltage system supply for public lighting use only (230V) continuous throughout the site.

Table 3: Primary and secondary design factors

(*) The following design standard was utilised within the design process in 2010/2011:

- ★ NBN EN 13201: A Belgian standard as result of the translation of a European standard.

With consideration to the criteria above, an Me4b lighting classification of 0,75 cd/m² average was chosen to provide an appropriate level of illumination.

Me4b	
L avg (cd/m ²)	0.75
U0	0.40
UI	0.50
TI max (%)	15.00

Table 4: The Me4b standard

4.0 Total Cost of Ownership

To support the lighting design process a Total Cost of Ownership evaluation was made. The designers compared the traditional 70W HPS with the 60W CPO luminaires. Due to the BLISS project, the designers have proposed this CPO 60W lamp. This instead of the traditional used lighting systems (like the surrounding streets). Finally, the Distribution Network Operator Eandis has proposed a dimming system. The municipality of Tienen agreed with this proposal.

So, the new lighting installation is equipped with dimming, but could not be used immediately. The new lighting scheme is connected with the same electrical circuit of the traditional scheme in the nearest streets. However, the old luminaires have no dimming option and dimming the whole circuit is not possible. A separate technical investment was necessary: some technical actions in the high voltage cabinet and separating the two lighting circuits was the solution.

4.1 Initial capital expenditure

Three elements were considered:

- Site clearance costs of the existing installation (in the surrounding streets)
- Supply and installation of the equipment (luminaire, lamp, column and control)
- Electrical works (Distribution Network Operator)

Option	No.	Capital cost
CPO 60W	16	€30,534
Final design CPO 60W	16	€30,534

Table 5: Initial capital expenditure

Remark: The capital cost includes a dimming option. Eandis demands of the suppliers that each luminaire has a dimming system. Luminaires without a dimming option are refused.

4.2 Energy provision

The energy provision was calculated using a cost per kWh based on Estimated Actual Consumption at commission year, excluding inflation and taxation:

- Energy cost per kWh = € 0.20
- Burning hours = 4,200 per year
- Dimmed hours = 2,100 (7 days per day)
- Carbon = 0.23 Kgs per kWh
 - www.synergrid.be – Impact of efficient public lighting on CO₂emissions – CE4-N35N-13.05.2009
- 50% reduced lumen output between 22:00 – 06:00

Option	No.	Energy	% saving	Annual cost
HPS 70W	16	4,480 kWh 940 Kgs		
CPO 60W	16	3,840 kWh 806 Kgs	15 %	€ 768
CPO 60Wwith dimming	16	2,880 kWh 604Kgs	36 %	€ 456
Final design CPO 60W with dimming	16	2,280 kWh 604 Kgs	36 %	€ 456

Table 6: Energy provision

4.3 Maintenance strategy

Planned maintenance regimes were considered: cyclic activities (lamp replacement, luminaire cleaning and structural inspection), electrical testing and inspection regimes.

A four year cyclic maintenance programme is applied to the HPS and CPO options.

Option	No.	Cost per luminaire	Cost per scheme
CPO 60W	16	€250	€ 4,000
CPO 60Wwith dimming	16	€250	€ 4,000
Final design CPO 60W with dimming	16	€250	€ 4,000

Table 7: Maintenance operations

4.4 Total Cost of Ownership 25-year expenditure

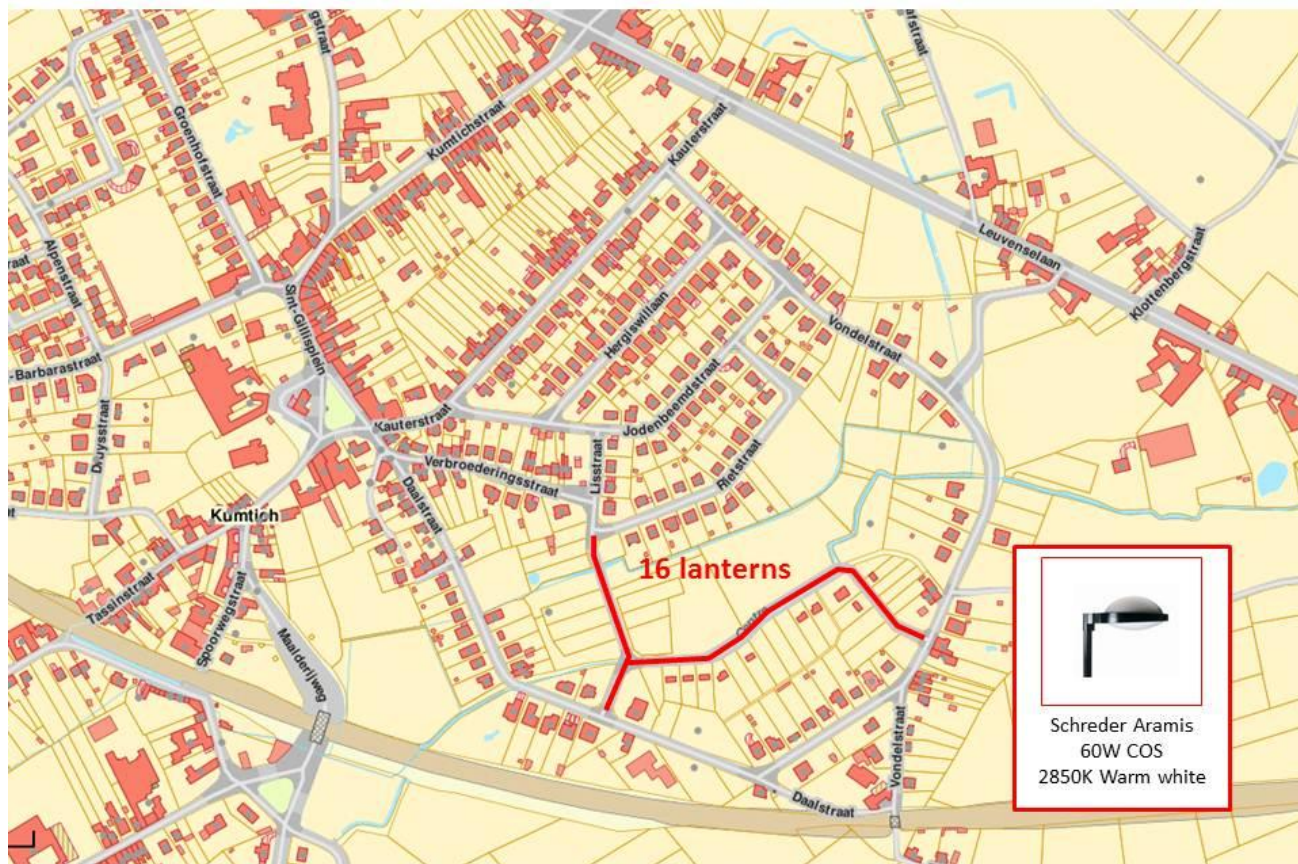
Table 8 outlines the total predicted expenditure over a 25-year life cycle.

Option	Initial capital costs	Energy costs	Maintenance costs	Whole life cost
CPO 60W	€30,534	€ 19,200	€ 4,000	€ 53,734
CPO 60Wwith dimming	€30,534	€ 11,400	€ 4,000	€ 45,934
Final design CPO 60W with dimming	€30,534	€ 11,400	€ 4,000	€ 45,934

Table 8: TCO 25-year expenditure

The results indicate that an CPO scheme with dimming is the most cost effective solution. The scheme performs well in terms of reduced energy and maintenance costs.

5.0 Design specification



Plan 1: Detailed design specification



Image 9: Schreder Aramis 60W Cosmopolis lamp



Image 10: Kuntich new scheme

6.0 Sustainability



6.1 Energy

Predicted energy calculations were produced based on manufacturers’ technical specifications to ensure that the new installation achieved a significant energy reduction, in accordance with the BLISS project aims.

Installed power (Watts)	
Before (*)	1,120 W
After (with dimming)	720 W
Savings (%)	400 W (36%)

Table 9: Installed power

(*) If the same luminaires are used as in the surrounding streets.

Energy consumption, CO ₂ emissions and savings per year (kWh, Kg CO ₂)		
Before	4,480 kWh	940 Kgs
After	2,880 kWh	604 Kgs
Savings (%)	1,600 kWh (36%)	336 Kgs (36%)

Table 10: Energy consumption

As identified in table 10, the use of more efficient light sources and control gear will reduce the energy consumption of street lighting, thereby reducing CO₂ emissions to generate the electricity whilst reducing the life cycle of the fuel and maintenance requirements.

6.2 Materials



The luminaire housings are made from aluminium (powder coated aluminum) with glass bowl protectors (slightly curved glass), which are both highly recyclable. The distribution network operator Eandis, responsible for this BLISS-investment, has a strict environmental policy. The manufacturers of lighting equipment are required to strictly follow the rules concerning recycling and the environment.



DNO Eandis also imposes requirements regarding light pollution and sky glow. These rules are based on the standard 'Typebestek 005 – Equipment for public lighting' (see 10.0). The manufacturer of the luminaires has to produce a very directional light source and produce minimal upward light, reducing the contribution to obtrusive light and sky glow. These kind of luminaires have no adverse effects on the local ecology.

6.3 Obtrusive light considerations



The environmental zone E2 'Countryside, rural environment', was selected for this road. Specific criteria from the manual CIE 150:2003 (*) relating to obtrusive light considerations were utilised during the equipment selection process.

(*) The manual CIE 150:2003 'Guide on the limitation of the effects of obtrusive light from outdoor lighting installations' contains guidelines for designers and governments to limit the sky glow (see 10.0).

7.0 Interleuven stakeholder research

Interleuven invited the inhabitants of the new street and the surrounding streets to comment the pre and post installations. The inhabitants of the surrounding streets are best placed to compare the pre and post situation.

Interleuven invited 130 properties to comment regarding the pre and post installations. 46% responded to the pre survey and only 16% to the post survey. The main results are summarised below.



Pre works survey

- ★ 71% of the residents felt safe walking alone during the night
- ★ 91% felt that the old installation was 'comfortable on the eye'
- ★ 63% stated the old installation shows up the whole street well
- ★ 61% can see people at a distance clearly and 71% has no problem to see obstacles on the ground
- ★ 37% of the residents stated that the old lighting installation was too dark
- ★ 53% says that the old installation doesn't show the colours properly



Post works survey

- ★ 95% of the residents felt safe walking alone during the night
- ★ 89% felt that the new installation is 'comfortable on the eye'
- ★ 79% stated the new installation shows up the whole street well
- ★ 74% can see people at a distance clearly and also 74% has no problem to see obstacles on the ground
- ★ 16% of the residents stated that the new lighting installation is still too dark
- ★ 21% says that the new installation doesn't show the colours properly

‘How does the new street lighting compare with the previous street lighting?’

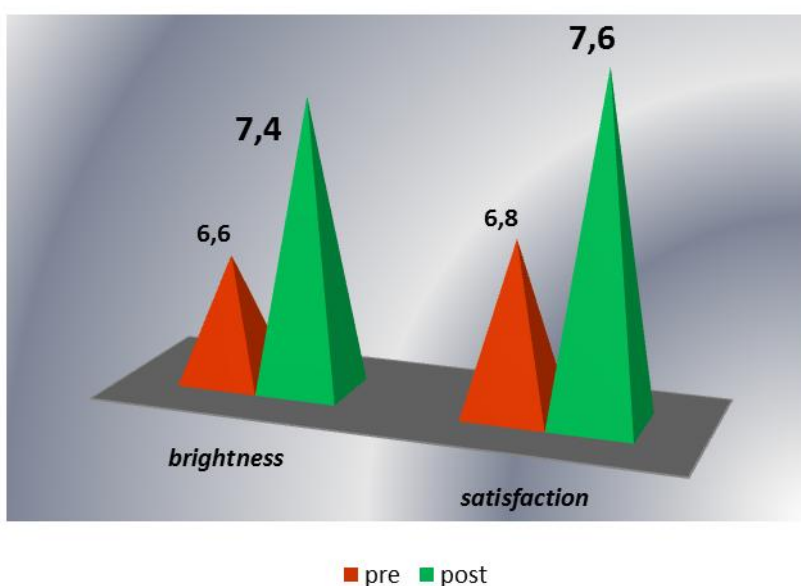
For 84% of the respondents the new lighting installation is an improvement.



... and using a scale of 1 to 10 ...

... how bright is the street lighting

... how satisfied you are with the lighting



8.0 Results

A summary of the results:

	Before(*)	After	Outcome
Calculated energy	4,480 kWh 940 Kgs of CO ₂	2,880 kWh 604 Kgs of CO ₂	36% energy saving
Number of luminaires	New development Surroundingstreets:70W SON	16no. Cosmopolis	/
Calculated colour rendition	/	Ra ≥ 60	/
Calculated colour temperature	/	2850K Warm white	/
Control regime	None	50% 22:00 – 06:00	Improved functionality




 Interleuven research		<ul style="list-style-type: none"> ★ 71% felt safe alone at night ★ 37% poor visibility ★ 53% colour rendition ★ 91% 'comfortable on the eye' ★ 37% say it's too dark ★ Satisfaction 6.8 	<ul style="list-style-type: none"> ★ 95% felt safe alone at night ★ 21% poor visibility ★ 21% colour rendition ★ 89% 'comfortable on the eye' ★ 16% say it's still too dark ★ Satisfaction 7.6 	Improved perception
 Measured crime		Low	Low	Low crime
 Measured accidents		2	0	Reduced accidents

Table 11: Results

(*) surrounding streets

9.0 Conclusion

This investment concerns the expansion of a residential area. The existing part of the residential area is of similar size and has lighting columns with 70W SON lamps. This site is the reference site for the new development, subject of this case study. In the new development, the same lantern and column height is used, but has another light source, a 60W Cosmopolis lamp.

The crime rate for the municipality Kuntich, part of the city of Tienen, is low. Only those facts of crime in which the illumination of the street is relevant, are retained in the considerations. The figures for 2011 and 2012 give no crime facts. On this moment, the evaluation time is too short to get a view of any positive impact of the new street lighting. The change to a white light source, producing an improved night environment, may be a contributory factor in the reduction of reported criminal incidents.

The accident rate is also very low. No reported accidents in 2011 and 2012. Important remark: The site is currently still a major construction site with the construction of several private houses. Accident figures on a later moment will give a view of the possible effect of the new lighting scheme.

The recorded demographics give an indication of the social profile of this area. The majority of people are in the age range of 45 – 64 and 37% of the residents are salaried employees. Most of the households are privately owned. This may mean that residents are more aware of their neighbourhood in terms of aesthetics and crime prevention.

To support the lighting design process a Total Cost of Ownership evaluation has to be made. This would determine which solution offered the most effective whole life cost. A CPO 60W lamp was chosen as most cost effective solution. Additionally the Distribution Network Operator Eandis has proposed a dimming system: the lumen output will be reduced with 50% between 22:00 and 06:00. The calculated energy saving is 36%.

Lighting can only be evaluated by stakeholder opinions and technical evaluation, there is no practical way to evaluate if the new lighting increases social activity, encouraging residents to make use of their local amenities during the hours of darkness. The post survey results in a 7.6 for the new lighting scheme, against the 6.8 for the previous scheme.

No negative comments or results have been obtained in relation to the reduction in lumen output to 50% between 22:00 and 06:00, following evaluation of the postal survey. Respondents generally appeared to be more concerned about the appearance and safety of where they live.

In conclusion, the change to white light appears to have had a positive impact on respondents' perceptions of their environment during the hours of darkness. Careful consideration should be made based on a number of detailed location criteria before changing to white light, including financial and environmental considerations. White light provides improved colour rendition with a predominantly warm white colour temperature, which may help to discourage night crime issues.

10.0 Standards

For several types of spaces, several European and Belgian standards are applicable. This chapter provides a brief overview of legislation and standards used in the development of lighting projects in Flanders/Belgium.

EN 13201 standard for public lighting.

Part 2 of this European standard, the performance requirements, has been translated into a Belgian standard NBN EN 13201-2. Part 1 of the European standard concerning the 'selection of the lighting classifications' is not yet translated into a Belgian standard. The 'Belgisch Instituut voor Verlichting BIV' is investigating this part of the European standard.

This standard establishes minimum levels of illumination that are necessary when a road is illuminated. Go below this minimum (eg dimming) is possible, but it happens, just like the whole of the public lighting on the responsibility of the road authority.

In the selection of lighting classes a distinction is made between:

- The (regional) roads/primary roads and secondary roads both with a specified minimum value for luminance or illuminance,
- the (public or private) local connection or access roads (each inside and outside the village) for which minimum luminance values are indicated
- and a series of other (including bicycle paths, 30 kph zones, pedestrian areas, squares, ...) for which minimum illuminance values are specified.

Regional roads.

Categorie	Functie	Subcategorie	CEN Klasse	L _{gem} [cd/m ²]	U ₁	U ₀	TI max [%] (2)	SR	E _h gem [lux]	U ₀ [E]	E _h min [lux]	E _v gem [lux]	E _v min [lux]	E _{sc} min [lux]
Hoofdweg / Primaire weg	Verbinden op internationaal en gewestelijk niveau	Conflictzones (ring, toelindingswegen...)	(1)	1,5	0,60	0,40	15	-	-	-	-	-	-	-
		Doorgaande wegsecties	ME3b	1,0	0,60	0,40	15	0,50	-	-	-	-	-	-
	Verzamelen op gewestelijk niveau	Rotondes	CE1	-	-	-	-	-	30	0,40	-	-	-	-
		Kruispunt primaire wegen	CE2	-	-	-	-	-	20	0,40	-	-	-	-
Secundaire weg	Verbinden (I) of verzamelen (II) op lokaal en bovenlokaal niveau	Conflictzones (ring, toelindingswegen...)	ME3b	1,0	0,60	0,40	15	0,50	-	-	-	-	-	-
		Rotondes	CE1	-	-	-	-	-	30	0,40	-	-	-	-
		Kruispunt primaire wegen	CE3	-	-	-	-	-	15	0,40	-	-	-	-

(1) Klasse ME3b met L \geq 1,5 cd/m²

(2) Een verhoging van 5% van de TI is aanvaardbaar in geval van gebruik van lichtbronnen met lage luminantie (Natrium Lage Druk en Fluorescentie buis), zijnde TI max = 20%

Table 12: Lighting classifications for regional roads

For regional roads the performance requirements of NBN EN13201-2 are also translated into the 'Standard Specification 240' in which four categories of roads and spaces are distinguished. This standard defines the following accents: smooth and safe traffic (A), mixed use (B), visual comfort and safety (C) and the need of mood lighting (D).

Synergrid, the Federation of Distribution Network Operators, translated these performance requirements into the 'Typebestek 005 – Equipment for public lighting'. The distribution network operators use this 'Typebestek 005' to design the public lighting on local roads.

Regional roads, local connections or private roads.

Categorie	Functie	Subcategorie	Situatie (4)	CEN Klasse	L _{gem} [cd/m ²]	U _i	U _o	TI max [%] (2)	SR	E _h gem [lux]	U _o [E]	E _h min [lux]	E _v gem [lux]	E _v min [lux]	E _{sc} min [lux]			
Lokale verbindingsweg	Verbinden op lokaal niveau	Algemeen	Buiten bebouwde kom	ME4a	0,75	0,60	0,40	15	0,50	-	-	-	-	-	-			
			Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	-			
Lokale gebiedsontsluitingsweg	Ontsluiten (verzamen en verdelen) op lokaal niveau	Algemeen	Buiten bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-	-			
			Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	-			
Erfgoedwagweg	Veel bebouwing	Verblijven en toegang verlenen tot de aanpalende percelen	Woonstraat/Ventweg	Buiten bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-			
			Woonstraat/Winkelstraat	Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-			
	Woonstraat/Ventweg		Buiten bebouwde kom	ME5	0,50	0,40	0,35	15	0,50	-	-	-	-	-	-			
	Woonstraat/Winkelstraat		Binnen bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-	-			
Landelijke weg	Algemeen	Algemeen	Buiten bebouwde kom	(3)	0,30	0,40	0,35	20	-	-	-	-	-	-	-			
			Aanliggend fietspad	-	(3)	CE Klasse van aanliggende rijweg -1												
Andere	-	-	Vrijliggend fietspad Voetpad (naast weg) Wandelweg Voetgangers- en fietsbrug	-	(3)	S4	-	-	-	-	5	-	1	-	-	-		
			Zone 30	-	(3)	CE4	-	-	-	-	10	0,40	-	-	-	-		
			Voetgangerszone, voetgangersweg en woonerf	-	(3)	CE4 [ES5]	-	-	-	-	10	0,40	-	-	-	-	[2]	
			Plein	-	(3)	S4 [ES7]	-	-	-	-	5	-	1	-	-	-	[1]	
			Handels- en historische centra	-	(3)	CE3 [ES4]	-	-	-	-	15	0,40	-	-	-	-	[3]	
			Onderdoorgangen voetgangers en fietsers	Nacht	-	-	-	-	-	-	100	-	-	-	-	-	-	10
				Dag	(3)	-	-	-	-	-	200	-	-	-	-	-	-	20
Oversteekplaats	-	(3)	-	-	-	-	-	80	0,30	-	-	40	-	-				

(2) Een verhoging van 5% van de TI is aanvaardbaar in geval van gebruik van lichtbronnen met lage luminantie (Natrium Lage Druk en Fluorescentie buis), zijnde TI max = 20%

(3) ME6 Klas met TI <= 20%

(4) Binnen bebouwde kom: <= 50 km/h - Buiten bebouwde kom >= 50 km/h

Table 13: Lighting classifications for regional roads, local connections and private roads

In the design of public lighting next standards and manuals are important:

- Vlare II, the Flemish environmental legislation with rules to prevent light pollution.
- CIE-documents. In accordance with the standard 'EN13201-3Road lighting-Part 3: Performance Calculation' these CIE documents give technical guidelines for designers:
 - Report CIE 126-1997 'Guidelines for minimizing sky glow'.
 - The manual CIE 150:2003 'Guide on the limitation of the effects of obstrusive light from outdoor lighting installations' contains guidelines for designers and governments to limit the sky glow. In this guide techniques are described for lighting systems in relation to the requirements for astronomical observations. The upward flux of luminaires should be avoided in natural areas (environmental zone E1) (0%) and in rural areas (environmental zone E2) it must be limited to max 5%.

Environmental zone	Area	Brightness of the environment	Examples
E1	Nature	Dark	Conservation area
E2	Rural	Low artificial brightness in the environment	Industrial, residential and rural areas
E3	Cities	Moderate artificial brightness in the environment	Urban residential areas with potential industry
E4	City centers	High artificial brightness in the environment	City center with a mix of residential and commercial functions

Table 14: Classification in areas for outdoor lighting design

- Evaluation and approval of lighting equipment. With 'Typebestek 005' as guide, Synergrid has made a list of approved luminaires. The distribution network operators preferably use these approved devices.

11.0 Images



Image 11: Kuntichnew scheme



Image 12: Kuntichnew scheme



Image 13: BLISS-publicity panel in Kuntich



Image 14: The new housing project in Kuntich: publicity panel

For additional information contact:

BLISS International website: www.bliss-streetlab.eu

INTERLEUVEN
 +32 16 235836
 milieu@interleuven.be
 www.interleuven.be

Eandis
 +32 78 35 35 34
 www.eandis.be

Composer report: Stefan Kempeneers
stefan.kempeneers@interleuven.be, +32 16 284 221

Technical support: Marc Lemmens
marc.lemmens@eandis.be

BLISS Better Lighting in Sustainable Streets

Investing in Opportunities

This project has received European Regional Development Funding through INTERREG IV B.

INTERREG IV B



Better Lighting in Sustainable Streets

BLISS

Technical Case Study

Tiensestraat, Leuven, B

Residential area

21.02.2014

BLISS/IL/7.6/2013/TCS03



St. Helens Council



gemeente Eindhoven



INTERLEUVEN
ONDERNEMEND EN ONDERSTEUNEND



Better Lighting in Sustainable Streets

BLISS

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Key information

Year	2011-2012
Theme	People
Scheme type	Residential
Scheme location	Leuven, B
Property type	Townhouses in city centre
Number of roads	1
Speed limit	18.64mph (30 kph)
Crime rate	Medium
Existing installation	250W LPS
Main consideration	Renovation of a residential street, downtown
New installation	60W CPO

Distribution Network Operator EANDIS



1.0 Background

The principal aim of this investment was to replace the existing street lighting as part of the renovation of an existing residential street in the city centre of Leuven (downtown) (part of the street from Rector De Somerplein to Herbert Hooverplein). This investment is part of the reorganization of this central city road to a traffic free shopping road. The existing 250W LPS street lighting has become obsolete and inefficient. The replacement with modern street lighting luminaires will offer improved efficiency, light characteristics and control (dimming) with a minimal energy usage and costs.

This investment includes the installation of new lighting scheme incorporating 60W CPO (white light source) within a conventional side entry luminaire with a 8 meter mounting height to replace the existing installation.

1.1 Site description



This investment is situated in the city centre of Leuven, a town with 98,000 inhabitants, capital of the Flemish province Vlaams-Brabant. Leuven has a big university, so during the academic year, there are a lot of students living in studios in the city centre.

Upgrading the lighting quality was part of the renovation of the Tienestraat. This part of the city centre street changed from traffic road to a traffic free shopping road. Due to the vision of the city government, the uniformity in the city centre is very important. The old high pressure lamps and the poles were also in a bad condition.

The Tienestraat connect the Rector De Somerplein (city centre) with the inner ring road of Leuven. This ring road has good connections to the highways E40 and E314. The Tienestraat, with a speed limit of 18.64 mph (30 kph), has an overall width of approx.10 metres, with pedestrian footways on both sides of the street. On one side are also parking places for cars. The part of the street, subject of this case study, is a traffic free shopping road. There is just traffic in the morning for deliveries in the shops. In the city of Leuven are a number of key services including schools, medical centres, leisure centres, supermarkets, shops, restaurants,



Image 1: Tienestraat Leuven, renovation to a car-free pedestrian shopping street.



Image 2: aerial view (Middenschalige orthofotomozaïek, Vlaanderen, winteropnames (wordt jaarlijks vernieuwd), geldig op datum van vandaag 22/11/2013, AGIV en Provincie Vlaams-Brabant

1.2 Crime considerations



Before (3 years): **high (89 facts)**
 After (2 years): **notavailable**

Only those facts of crime in which the illumination of the street is relevant, are retained in these considerations: burglaries, car-thefts, car break-ins, bike thefts, vandalism, drug offenses, sexual offenses and arson; were also deter illegal dumping and graffiti.

In certain cases, we can't say if certain facts are street related or not. These facts were considered as possibly street related and are not included in the figures.⁵

In Tienestraat there are also many other factors which have an influence on the crime figures, such as the presence of the student population and their behaviour when going out in that specific area. On some days during the night hours, there are a lot of students in the street, and therefore more possible victims or in some cases more potential offenders.

Leuven - Tienestr.	crime - street related							
	2010	2011	2012	before	2013	2014	2015	after
DARK	28	26	13	67				
DUSK	5	6	4	15				
SEMI-DUSK	4	2	1	7				
	37	34	18	89				

Table 1: Crime – street related - figures

This investment was realized in 2013. Because of this late time investment the time is too short to become the crime and accident data for the Tienestraat in Leuven. These data are expected mid-2014.

⁵Projectzone: ANG periode 2007-2012, extractie 9 sep 2013

1.3 Accident considerations



Before (3 years): **medium (9 accidents)**
 After (2 years): **not available**

The accident statistics are based on all reported accidents: with fatalities, with bodily harm and material damage.

Due to the renovation of this part of the street, the traffic situation is changed from a car city road to a car free shopping street. That will have an effect on the accident figures in future.

Leuven - Tienestr.	Accidents							
	2010	2011	2012	before	2013	2014	2015	after
DARK	2	3	1	6				
DUSK	2	1	0	3				
SEMI-DUSK	0	0	0	0				
	4	4	1	9				

Table 2: Accidents – street related - figures

Remark: in traffic accidents with fatalities and/or injuries you are obliged to call the police. So we assume that these figures are correct and complete. The accidents with material damage, the police is not always informed. So these figures are just a minimum of the actual figures.⁶

This investment was realized in 2013. Because of this late time investment the time is too short to become the crime and accident data for the Tienestraat in Leuven. These data are expected mid-2014.

1.4 Social demographic considerations



The information below shows key social economic data covering the area which helps to develop a representation of the potential activity in the hours of darkness.

Gender and age – Information obtained from the National Register – Rijksregister, verwerking door Steunpunt Sociale Planning (01.01.2013) - shows that the gender are fairly evenly divided. The age profiles show a majority of people in the age range of 18-29 (students) and 30-44 years.

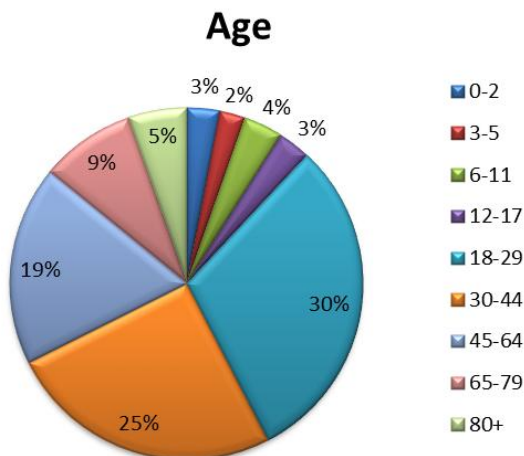


Chart 1: Age

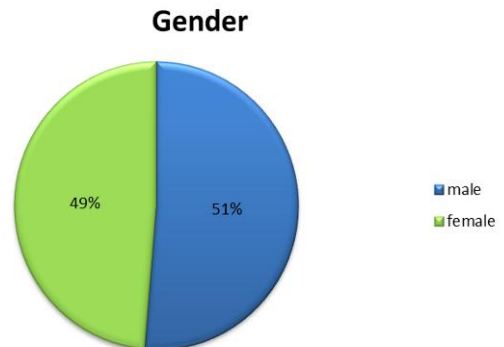


Chart 2: Gender

⁶ FedPol/CGOP/B, periode 2007-2012 (PV-gegevens).

Social economic – Information obtained from “Kruispuntbank van de sociale zekerheid”(31.12.2010) shows that the group ‘salaried employees’ and ‘children’ is the most common group in the region of this investment.

Social economic

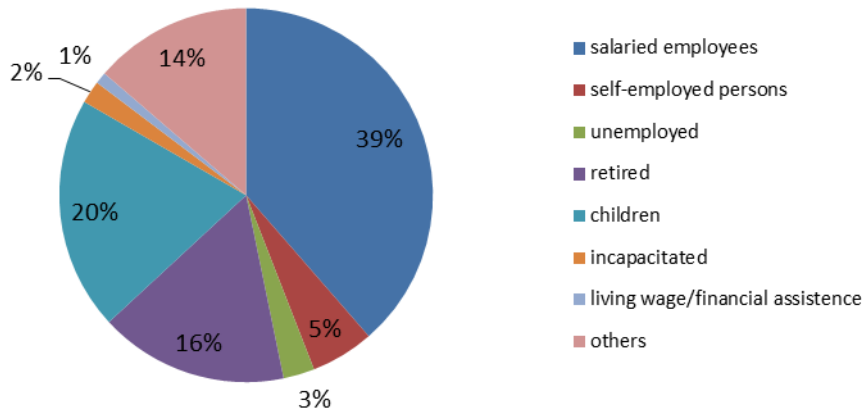


Chart 3: Social economic data

2.0 Existing installation

No.	Age	Column type	Luminaire	Arrangement	Light source & wattage	Colour temperature (K)	CRI (Ra)	Efficacy (lm/w)	Energy consumption
9	30 years	8m wall connection	Conventional	Staggered, rear of footway	9 no. 250W LPS	1800K Warm white	N/A	N/A	9,000 kWh, 2,070 Kgs

Table 3: Existing installation information

The principal aim of this investment was to replace the existing street lighting as part of the renovation of an existing residential street in the city centre of Leuven (downtown). The new luminaires are installed in a part of the Tienestraat: from Rector De Somerplein to Herbert Hooverplein. This investment is part of the reorganization of this central city road to a traffic free shopping road. The existing street lighting has become obsolete and inefficient. The maintenance costs were very high. The old high pressure lamps and the poles were also in a very bad condition.

The designers had also to look at:

- the vision of the city government and the uniformity in the city centre.
- the safety considerations and the safety feeling of the visitors in this part of the city.

The rate of deterioration had continued and the installation was identified as being inefficient with respect to:

- ★ Poor colour rendering properties of the LPS lamps
- ★ Deteriorating lumen output
- ★ Increased number of reactive maintenance visits
- ★ High energy consumption
- ★ Safety precautions



Image 3: Tienestraat Leuven existing scheme

3.0 Design development

Selection of the appropriate lighting classification;










Criteria	Description	Notes
 Road type	City centerstreet	Traffic free shopping street. Limited number of conflict areas.
 Traffic flow	Low	18.6 mph (30 kph) speed limit. Traffic free street: no cars, only pedestrians and cyclists. The street is not a bus route.
 Crime rate	High	High identified for this street prior to scheme installation. No monitoring by any local authority CCTV surveillance equipment present.
 Colour rendition	Ra ≥ 60	Ra ≥ 60 chosen as appropriate for facial recognition, CPO white light sources in the new scheme.
 Environmental zone	E4	High artificial brightness in the environment. City center with a mix of residential and commercial functions. Further details regarding sustainability can be found in section 6.0.
 Safe ease of passage	Generally good	Pedestrian ease of passage good; Pedestrian footfall low, adequate footpaths, no overgrown vegetation, general visibility good, public transport links in surrounding area.
 Design uniformity	Not specified in standards	In the downtown area an overall uniformity of illuminance (U _o) is preferred (*).
 Control method	50% lumen output 22:00 – 06:00	Autonomous variable light control method with CPO luminaires. During the hours of darkness, good light is still necessary: nightlife, student area, safety precautions, ...
 Electricity supply	Distribution Network Operator	DNO low voltage system supply for public lighting use only (230V) continuous throughout site.

Table 4: Primary and secondary design factors

(*) The following design standard was utilised within the design process in 2011/2012:

- ★ NBN EN 13201: A Belgian standard as result of the translation of a European standard.

For this type of area, a commercial and historical center, and with consideration to the criteria above, a Me6 lighting classification was chosen to provide an appropriate level of illumination (see table 13 on page 16). The designers focussed on next characteristics: $T_i \leq 20\%$ and an average of 0.75 cd/m^2 .

Due to the vision of the city government, the uniformity in the city centre is very important. One of the criteria in this part of the city is the use of CPO lighting luminaires. Therefore, the city government has chosen the CPO 60W lamp, one of the standards in their policy of urban development.

4.0 Total Cost of Ownership

To support the lighting design process a Total Cost of Ownership evaluation has to be made. This would determine which solution offered the most effective whole life cost. However, due to the vision of the city government, the uniformity in the city centre is very important. Therefore, the city government has chosen a CPO 60W lamp as one of the standards in their policy of urban development.

Finally, the Distribution Network Operator Eandis has proposed a dimming system. The city government has agreed with this solution.

The number of units required was calculated during an initial desktop evaluation based on the luminaires utilised in the final scheme.

4.1 Initial capital expenditure

Three elements were considered:

- Site clearance costs of the existing installation
- Supply and installation of the equipment (luminaire, lamp, column and control)
- Electrical works (Distribution Network Operator, Private Network Cable)

Option	No.	Capital cost
CPO60W	12	€ 40,169
Final design CPO 60 W	12	€ 40,169

Table 5: Initial capital expenditure

4.2 Energy provision

The energy provision was calculated using a cost per kWh based on Estimated Actual Consumption at commission year, excluding inflation and taxation:

- Energy cost per kWh = € 0.20
- Burning hours = 4,200 per year
- Dimmed hours = 2,100 (7 days per day)
- Carbon = 0.23 Kgs per kWh
 - www.synergrid.be – Impact of efficient public lighting on CO₂emissions – CE4-N35N-13.05.2009
- 50% reduced lumen output between 22:00 – 06:00

Option	No.	Energy	% saving	Annual cost
CPO 60 W	12	2,880 kWh 662 Kgs		€ 576
CPO60W with dimming	12	1,584 kWh 364 Kgs	45 %	€ 317
Final design CPOwithdimming	12	1,584 kWh 364 Kgs	45 %	€ 317

Table 6: Energy provision

4.3 Maintenance strategy

Planned maintenance regimes were considered: cyclic activities (lamp replacement, luminaire cleaning and structural inspection), electrical testing and inspection regimes.

A four year cyclic maintenance programme is applied to the CPO scheme.

Option	No.	Cost per luminaire	Cost per scheme
CPO 60 W	12	€ 250	€ 3,000
CPO 60 W with dimming	12	€ 250	€ 3,000
Final design CPO with dimming	12	€ 250	€ 3,000

Table 7: Maintenance operations

4.4 Total Cost of Ownership 25-year expenditure

Table 8 outlines the total predicted expenditure over a 25-year life cycle.

Option	Initial capital costs	Energy costs	Maintenance costs	Whole life cost
CPO 60 W	€ 40,169	€ 14,400	€ 3,000	€ 57,569
CPO 60 W with dimming	€ 40,169	€ 7,925	€ 3,000	€ 51,094
Final design CPO with dimming	€ 40,169	€ 7,925	€ 3,000	€ 51,094

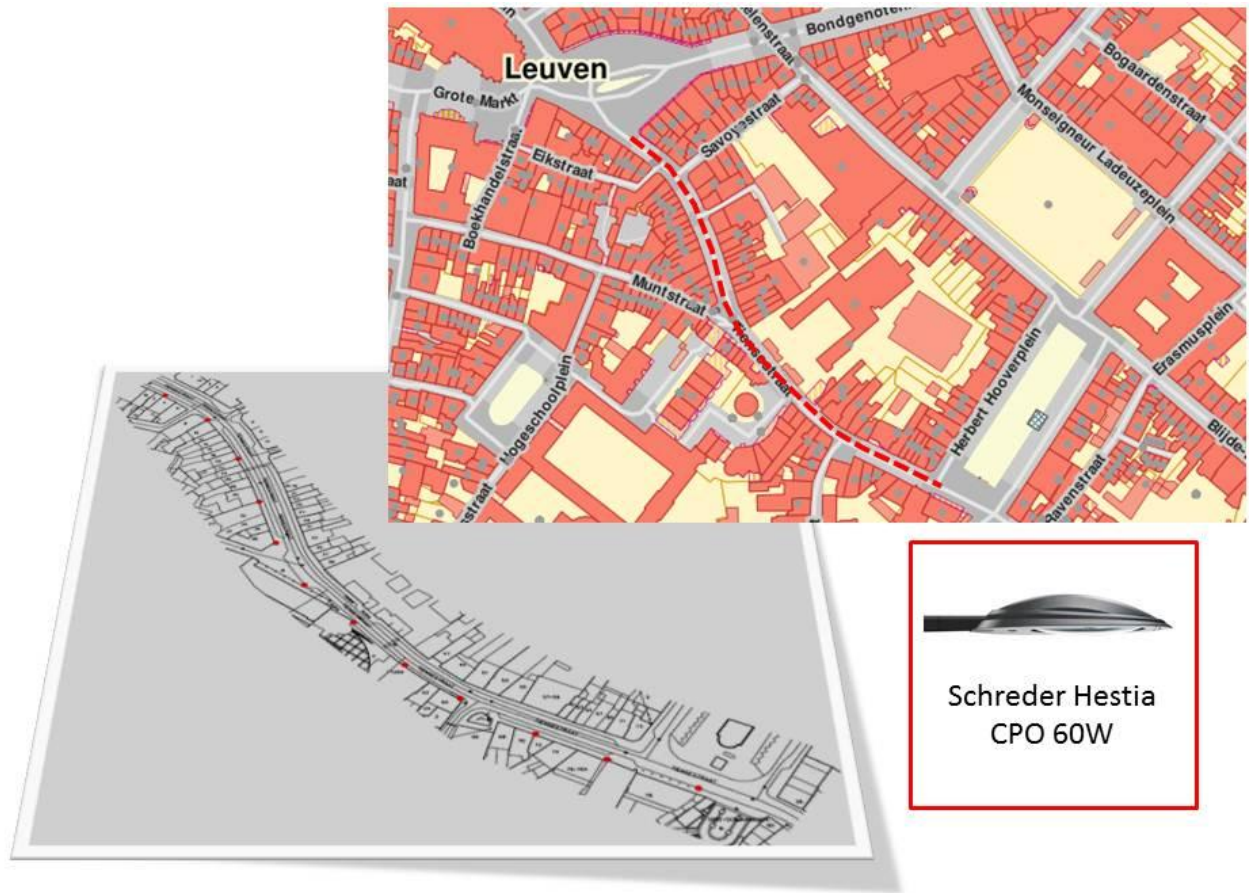
Table 8: TCO 25-year expenditure

The results indicate that a CPO scheme with dimming is the most cost effective solution. The scheme performs well in terms of reduced energy and maintenance costs. The designers had also to take into account the requirements of the city government.



Image 4: Schröder Hestia CPO 60W

5.0 Designspecification



Plan 1: Detailed design specification

All lamps reduce their lumen output by 50% between 22:00 – 06:00.



Image 5: Tienestraat Leuven new scheme and luminaires

6.0 Sustainability



6.1 Energy

Predicted energy calculations were produced based on manufacturers’ technical specifications to ensure that the new installation achieved a significant energy reduction, in accordance with the BLISS project aims.

Installed power (Watts)	
Before	2,250 W
After (with dimming)	720 W
Savings (%)	1,530 W (68%)

Table 9: Installed power

Energy consumption, CO ₂ emissions and savings per year (kWh, Kg CO ₂)		
Before	9,000 kWh	2,070 Kgs
After (with dimming)	1,584 kWh	364 Kgs
Savings (%)	7,416 kWh (82%)	1,706 Kgs (82%)

Table 10: Energy consumption

As identified in table 10, the use of more efficient light sources and control gear will reduce the energy consumption of street lighting, thereby reducing CO₂ emissions to generate the electricity whilst reducing the life cycle of the fuel and maintenance requirements.

6.2 Materials



The luminaire housings are made from aluminium (powder coated aluminum) with glass bowl protectors (slightly curved glass), which are both highly recyclable. The distribution network operator Eandis, responsible for this BLISS-investment, has a strict environmental policy. The manufacturers of lighting equipment are required to strictly follow the rules concerning recycling and the environment.



DNO Eandis also imposes requirements regarding light pollution and sky glow. These rules are based on the standard ‘Typebestek 005 – Equipment for public lighting’ (see 10.0). The manufacturer of the luminaires has to produce a very directional light source and produce minimal upward light, reducing the contribution to obtrusive light and sky glow. These kind of luminaires have no adverse effects on the local ecology.

6.3 Obtrusive light considerations



The environmental zone E4 'City center' (**), was selected for this road. Specific criteria from the manual CIE 150:2003 (*) relating to obtrusive light considerations were utilised during the equipment selection process.

(*) The manual CIE 150:2003 'Guide on the limitation of the effects of obtrusive light from outdoor lighting installations' contains guidelines for designers and governments to limit the sky glow (see 10.0).

(**) E4, city center: High artificial brightness in the environment, city center with a mix of residential and commercial functions.

7.0 Stakeholder research

Interleuven invited the inhabitants of this part of the renewed street to comment the new lighting installations. 35 people responded to the post survey. Originally this investment was not included in the BLISS- project. That's the reason why no pre survey was organised. The main results are summarised below.



Post works survey

- ★ 94% of the residents felt safe walking alone during the night
- ★ 97% felt that the new installation is 'comfortable on the eye'
- ★ All respondents stated the new installation shows up the whole street well
- ★ 94% can see people at a distance clearly and has no problem to see obstacles on the ground
- ★ 6% of the residents stated that the new lighting installation is still too dark (dimming)
- ★ 14% says that the new installation doesn't show the colours properly

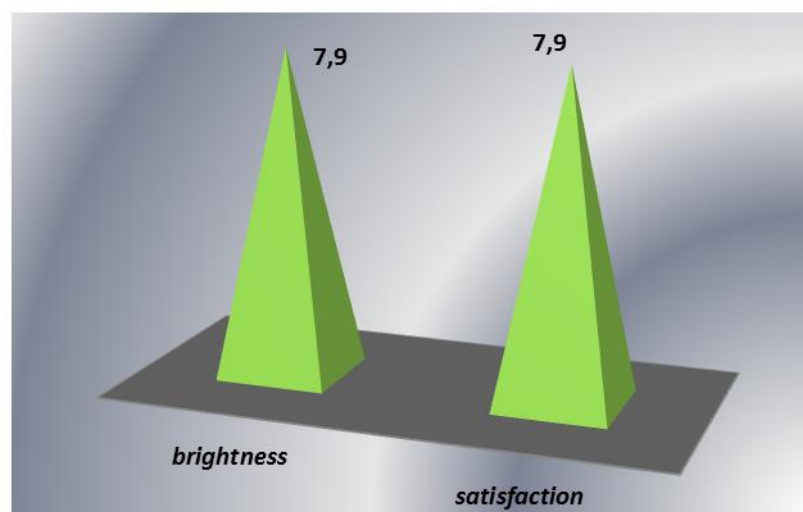
'How does the new street lighting compare with the previous street lighting?'

All of the respondents find the new lighting installation an improvement.

... and using a scale of 1 to 10 ...

... how bright is the street lighting

... how satisfied you are with the lighting



■ post survey

8.0 Results

A summary of the results:









	Before	After	Outcome
 Calculated energy	9,000 kWh 2,070 Kgs of CO ₂	1,584 kWh 364 Kgs of CO ₂	82% energy saving
 Number of luminaires	9no. 250W LPS	9no. 60W Cosmopolis	Same number of units
 Calculated colour rendition	Ra ≤ 20	Ra ≥ 60	Improved colour rendition
 Calculated colour temperature	1800K Warm white	2800K Warm white	Improved appearance
 Control regime	None	50% 22:00 – 06:00	Improved functionality
 Interleuven research	/	<ul style="list-style-type: none"> ★ 94% felt safe alone at night ★ 0% poor visibility ★ 14% colour rendition ★ 97% 'comfortable on the eye' ★ 6% say it's still too dark ★ Satisfaction 7.9 	/
 Measured crime	High	N/A	/
 Measured accidents	9	N/A	/

Table 11: Results

9.0 Conclusion

The principal aim of this investment was to replace the existing street lighting as part of the renovation of an residential street in the city centre of Leuven. This part of the street changed from traffic road to a traffic free shopping road. Due to the vision of the city government, the uniformity in the city centre is very important. So, the existing 250W LPS street lighting was replaced by a new lighting scheme incorporating 60W CPO (white light source).

The crime rate for this part of the city centre is high. Only those facts of crime in which the illumination of the street is relevant, are retained in the considerations. The presence of the student population and their behaviour when going out in that specific area has a high influence on the records. On some days during the night hours, there are a lot of students in the street, and therefore more possible victims or in some cases more potential offenders.

This investment was realized in 2013. Because of this late time investment the time is too short to become the crime and accident data for the Tiensestraat in Leuven. These data are expected mid-2014. On this moment there are no figures yet to see if there is any positive impact of the new street lighting. The change to a white light source, producing an improved night environment, may be a contributory factor in the reduction of reported criminal incidents.

Due to the renovation of this part of the street, the traffic situation is changed from a car city road to a car free shopping street. That will have an effect on the accident figures in future.

The recorded demographics give an indication of the social profile of this area. The majority of people are in the age range of 18 – 29. Most of them are students. The student night life has an impact on the crime records. A survey later on will prove if the new street lighting has an impact on these figures.

To support the lighting design process a Total Cost of Ownership evaluation has to be made. This would determine which solution offered the most effective whole life cost. However, due to the vision of the city government, the

uniformity in the city centre is very important. Therefore, a CPO 60W lamp was chosen as one of the standards in their policy of urban development. Additionally the Distribution Network Operator Eandis has proposed a dimming system: the lumen output will be reduced with 50% between 22:00 and 06:00. The calculated energy saving is 82%.

Lighting can only be evaluated by stakeholder opinions and technical evaluation, there is no practical way to evaluate if the new lighting increases social activity, encouraging residents to make use of their local amenities during the hours of darkness. However respondents' comments suggest that some may feel more confident to use local facilities during the hours of darkness.

No negative comments or results have been obtained in relation to the reduction in lumen output to 50% between 22:00 and 06:00, following evaluation of the postal survey. Respondents generally appeared to be more concerned about the appearance and safety of where they live.

In conclusion, the change to white light appears to have had a positive impact on respondents' perceptions of their environment during the hours of darkness. Careful consideration should be made based on a number of detailed location criteria before changing to white light, including financial and environmental considerations. White light provides improved colour rendition with a predominantly warm white colour temperature, which may help to discourage night crime issues.

10.0 Standards

For several types of spaces, several European and Belgian standards are applicable. This chapter provides a brief overview of legislation and standards used in the development of lighting projects in Flanders/Belgium.

EN 13201 standard for public lighting.

Part 2 of this European standard, the performance requirements, has been translated into a Belgian standard NBN EN 13201-2. Part 1 of the European standard concerning the 'selection of the lighting classifications' is not yet translated into a Belgian standard. The 'Belgisch Instituut voor Verlichting BIV' is investigating this part of the European standard.

This standard establishes minimum levels of illumination that are necessary when a road is illuminated. Go below this minimum (eg dimming) is possible, but it happens, just like the whole of the public lighting on the responsibility of the road authority.

In the selection of lighting classes a distinction is made between:

- The (regional) roads/primary roads and secondary roads both with a specified minimum value for luminance or illuminance,
- the (public or private) local connection or access roads (each inside and outside the village) for which minimum luminance values are indicated
- and a series of other (including bicycle paths, 30 kph zones, pedestrian areas, squares, ...) for which minimum illuminance values are specified.

Regional roads.

Categorie	Functie	Subcategorie	CEN Klasse	L gem [cd/m ²]	U ₁	U ₀	TI max [%] (2)	SR	E _n gem [lux]	U ₀ [E]	E _n min [lux]	E _v gem [lux]	E _v min [lux]	E _{sc} min [lux]
Hoofdweg / Primaire weg	Verbinden op internationaal en gewestelijk niveau	Conflictzones (ring, toelindingswegen...)	(1)	1,5	0,60	0,40	15	-	-	-	-	-	-	-
		Doorgaande wegsecties	ME3b	1,0	0,60	0,40	15	0,50	-	-	-	-	-	-
	Verzamelen op gewestelijk niveau	Rotondes	CE1	-	-	-	-	-	30	0,40	-	-	-	-
		Kruispunt primaire wegen	CE2	-	-	-	-	-	20	0,40	-	-	-	-
Secundaire weg	Verbinden (I) of verzamelen (II) op lokaal en bovenlokaal niveau	Conflictzones (ring, toelindingswegen...)	ME3b	1,0	0,60	0,40	15	0,50	-	-	-	-	-	-
		Rotondes	CE1	-	-	-	-	-	30	0,40	-	-	-	-
		Kruispunt primaire wegen	CE3	-	-	-	-	-	15	0,40	-	-	-	-

(1) Klasse ME3b met $L \geq 1,5 \text{ cd/m}^2$

(2) Een verhoging van 5% van de TI is aanvaardbaar in geval van gebruik van lichtbronnen met lage luminantie (Natrium Lage Druk en Fluorescentie buis), zijnde TI max = 20%

Table 12: Lighting classifications for regional roads

Regional roads, local connections or private roads.

Categorie	Functie	Subcategorie	Situatie (4)	CEN Klasse	L _{gem} [cd/m ²]	U ₁	U ₀	TI max [%] (2)	SR	E _{b, gem} [lux]	U ₀ [E]	E _{b, min} [lux]	E _{v, gem} [lux]	E _{v, min} [lux]	E _{sc, min} [lux]		
Lokale verbindingsweg	Verbinden op lokaal niveau	Algemeen	Buiten bebouwde kom	ME4a	0,75	0,60	0,40	15	0,50	-	-	-	-	-	-		
			Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	-		
Lokale gebiedsontsluitingsweg	Ontsluiten (verzamelen en verdelen) op lokaal niveau	Algemeen	Buiten bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-	-		
			Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	-		
Erftoegangs weg	Veel bebouwing	Verblijven en toegang verlenen tot de aanpalende percelen	Woonstraat/Ventweg	Buiten bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-		
			Woonstraat/Winkelstraat	Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-		
	Woonstraat/Ventweg		Buiten bebouwde kom	ME5	0,50	0,40	0,35	15	0,50	-	-	-	-	-	-		
	Woonstraat/Winkelstraat		Binnen bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-	-		
Landelijke weg	Algemeen	Algemeen	Buiten bebouwde kom	(3)	0,30	0,40	0,35	20	-	-	-	-	-	-	-		
Andere	-	Aanliggend fietspad	-	(3)	CE Klasse van aanliggende rijweg - 1												
		Vrijliggend fietspad Voetpad (naast weg) Wandelweg Voetgangers- en fietsbrug	-	(3)	S4	-	-	-	-	5	-	1	-	-	-	-	
		Zone 30	-	(3)	CE4	-	-	-	-	10	0,40	-	-	-	-	-	
		Voetgangerszone, voetgangersweg en woonerf	-	(3)	CE4 [ES5]	-	-	-	-	10	0,40	-	-	-	-	[2]	
		Plein	-	(3)	S4 [ES7]	-	-	-	-	5	-	1	-	-	-	[1]	
		Handels- en historische centra	-	(3)	CE3 [ES4]	-	-	-	-	15	0,40	-	-	-	-	[3]	
		Onderdoorgangen voetgangers en fietsers	Nacht	-	-	-	-	-	-	100	-	-	-	-	-	-	10
			Dag	(3)	-	-	-	-	-	200	-	-	-	-	-	-	20
Oversteekplaats	-	(3)	-	-	-	-	-	80	0,30	-	40	-	-	-			

(2) Een verhoging van 5% van de TI is aanvaardbaar in geval van gebruik van lichtbronnen met lage luminantie (Natrium Lage Druk en Fluorescentie buis), zijnde TI max = 20%

(3) ME6 Klas met TI <= 20%

(4) Binnen bebouwde kom: <= 50 km/h - Buiten bebouwde kom >= 50 km/h

Table 13: Lighting classifications for regional roads, local connections and private roads

For regional roads the performance requirements of NBN EN13201-2 are also translated into the 'StandardSpecification240' in which four categories of roads and spaces are distinguished. This standard defines the following accents: smooth and safe traffic (A), mixed use (B), visual comfort and safety (C) and the need of mood lighting (D).

Synergrid, the Federation of Distribution Network Operators, translated these performance requirements into the 'Typebestek 005 – Equipment for public lighting'. The distribution network operators use this 'Typebestek 005' to design the public lighting on local roads.

In the design of public lighting next standards and manuals are important:

- Vlare II, the Flemish environmental legislation with rules to prevent light pollution.
- CIE-documents. In accordance with the standard 'EN13201-3Road lighting-Part 3: Performance Calculation' these CIE documents give technical guidelines for designers:
 - Report CIE 126-1997 'Guidelines for minimizing sky glow'.
 - The manual CIE 150:2003 'Guide on the limitation of the effects of obstrusive light from outdoor lighting installations' contains guidelines for designers and governments to limit the sky glow. In this guide techniques are described for lighting systems in relation to the requirements for astronomical observations. The upward flux of luminaires should be avoided in natural areas (environmentalzoneE1) (0%) and in rural areas (environment zoneE2) it must be limited to max 5%.

Environmental zone	Area	Brightness of the environment	Examples
E1	Nature	Dark	Conservation area
E2	Rural	Low artificial brightness in the environment	Industrial, residential and rural areas
E3	Cities	Moderate artificial brightness in the environment	Urban residential areas with potential industry
E4	City centers	High artificial brightness in the environment	City center with a mix of residential and commercial functions

Table 14: Classification in areas for outdoor lighting design

- Evaluation and approval of lighting equipment. With 'Typebestek 005' as guide, Synergrid has made a list of approved luminaires. The distribution network operators preferably use these approved devices.

11.0 Images



Image 6 and 7: Tiensestraat Leuven new luminaires



Image 8 and 9: Tiensestraat Leuven, a renewed car free shopping street



Image 10: Tiensestraat Leuven new luminaires



Image 11: Tiensestraat Leuven, a BLISS investment

For additional information contact:

BLISS International website: www.bliss-streetlab.eu

INTERLEUVEN
+32 16 235836
milieu@interleuven.be
www.interleuven.be

Composer report: Stefan Kempeneers
stefan.kempeneers@interleuven.be, +32 16 284 221

Eandis
+32 78 35 35 34
www.eandis.be

Technical support: Marc Lemmens
marc.lemmens@eandis.be

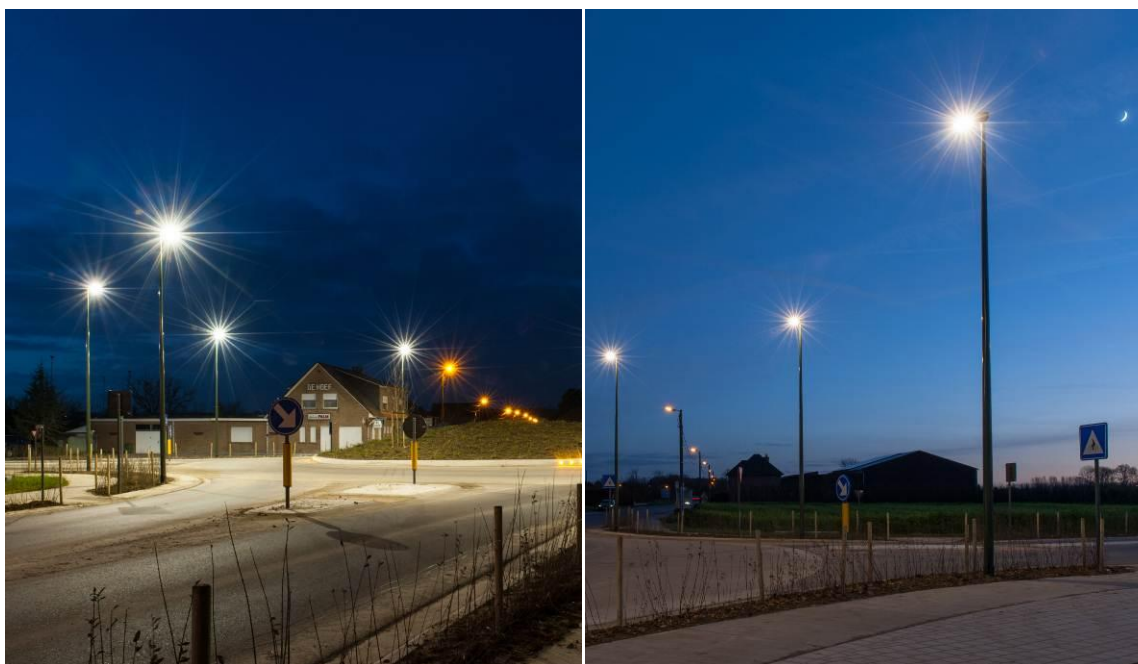
BLISS Better Lighting in Sustainable Streets

Technical Case Study

Hoeledensebaan, Kortenaken, B

Distributor – link road

21.02.2014
BLISS/IL/7.11/2013/TCS04



St. Helens Council



gemeente Eindhoven



INTERLEUVEN
ONDERNEMEND EN ONDERSTEUNEND



Better Lighting in Sustainable Streets

BLISS

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Key information

Year	2012
Theme	People
Scheme type	Distributor – link road
Scheme location	Kortenaken, B
Property type	Few houses in rural environment
Number of roads	1
Speed limit	44mph (70 kph)
Crime rate	Low
Existing installation	36W Low Pressure Sodium
Main consideration	Street renovation due to changed traffic function
New installation	CPO 90W
Distribution Network Operator INFRAX	

infrax

1.0 Background

The principal aim of this investment was to replace the existing street lighting as part of the renovation of an existing link road in the municipality of Kortenaken. The existing street lighting has become obsolete and inefficient. The replacement with modern street lighting luminaires will offer improved efficiency and light characteristics with a minimal energy usage and costs.

This investment includes the installation of a new lighting scheme incorporating 90W CPO (white light source) within a conventional side entry luminaire with a 8 meter mounting height to replace the existing installation.

1.1 Site description



This investment is situated in Kortenaken, a village with a population of 7,856 people, 25 km north-east of Leuven. It concerns a link road between the centre of Kortenaken and Hoeleden, a small village part of the municipality of Kortenaken.

This 2.5 miles (4.1 km) long renewed street, subject to a 44 mph (70 kph) speed limit, has an overall width of 6 metres, with a separated bike and footpath. The distance to the centre of Kortenaken is 1.2 miles (2 km). The whole environment is very rural with a lot of open space. The road is used as link road between Kortenaken and Hoeleden and further on to Tienen (8.7 miles/14 km). In this area are a number of key services including schools, medical centres, leisure centres, a supermarket and places of worship.



Image 1: Hoeledensebaan, new lighting scheme



Image 2: Hoeledensebaan, a BLISS investment

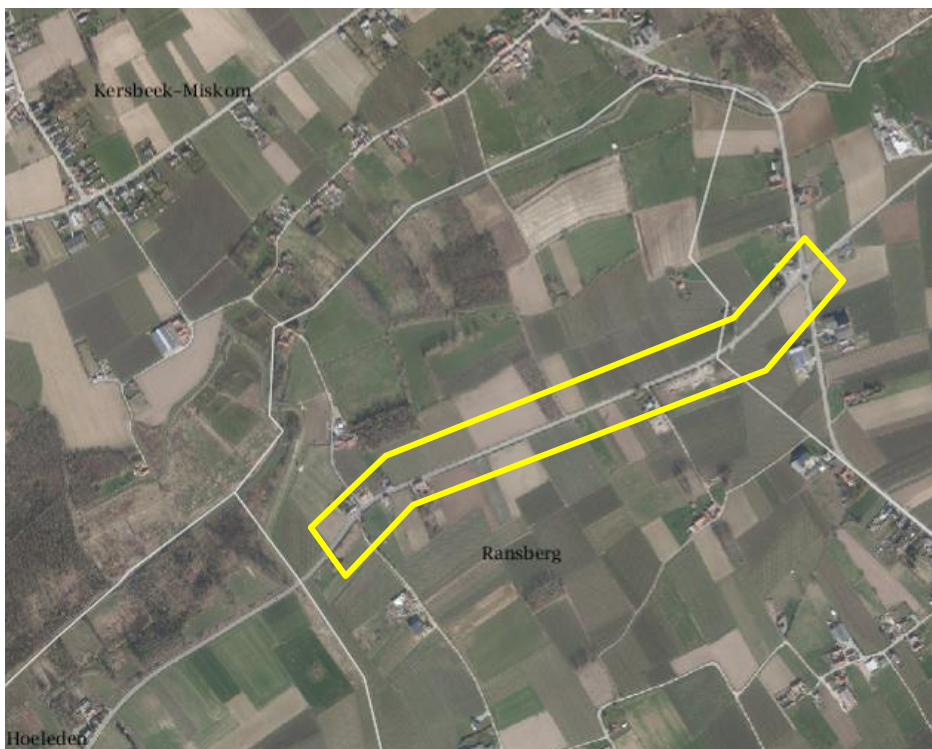


Image 3: aerial view (Middenschalige orthofotomozaiek, Vlaanderen, winteropnames (wordt jaarlijks vernieuwd), geldig op datum van vandaag 22/11/2013, AGIV en Provincie Vlaams-Brabant

1.2 Crime considerations



Before (3 years): **low**
 After (2 years): **not available**

Only those facts of crime in which the illumination of the street is relevant, are retained in these considerations: burglaries, car-thefts, car break-ins, bike thefts, vandalism, drug offenses, sexual offenses and arson; were also deter illegal dumping and graffiti.

In certain cases, we can't say if certain facts are street related or not. These facts were considered as possibly street related and are not included in the figures.⁷

Kortenaken - Hoeledense baan	crime - street related							
	2010	2011	2012	before	2013	2014	2015	after
DARK	0	1	0	1				
DUSK	1	3	0	4				
SEMI-DUSK	0	0	0	0				
	1	4	0	5				

Table 1: Crime – street related - figures

1.3 Accident considerations



Before (3 years): **low**
 After (2 years): **not available**

The accident statistics are based on all reported accidents: with fatalities, with bodily harm and material damage.

⁷Projectzone: ANG periode 2007-2012, extractie 9 sep 2013

Kortenaken - Hoeledense baan	Accidents							
	2010	2011	2012	before	2013	2014	2015	after
DARK	1	1	2	4				
DUSK	0	0	1	1				
SEMI-DUSK	0	0	0	0				
	1	1	3	5				

Table 2: Accidents – street related - figures

Remark: in traffic accidents with fatalities and/or injuries you are obliged to call the police. So we assume that these figures are correct and complete. The accidents with material damage, the police is not always informed. So these figures are just a minimum of the actual figures.⁸

1.4 Social demographic considerations



The information below shows key social economic data covering the area which helps to develop a representation of the potential activity in the hours of darkness.

Gender and age – Information obtained from the National Register – Rijksregister, verwerking door Steunpunt Sociale Planning (01.01.2013) - shows that the gender are fairly evenly divided. The age profiles show a majority of people in the age range of 30-44 and 45-64 years.

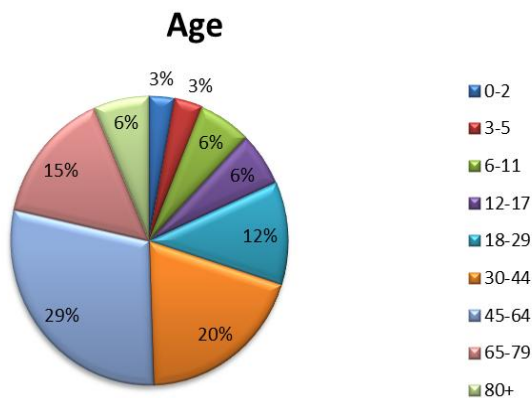


Chart 1: Age

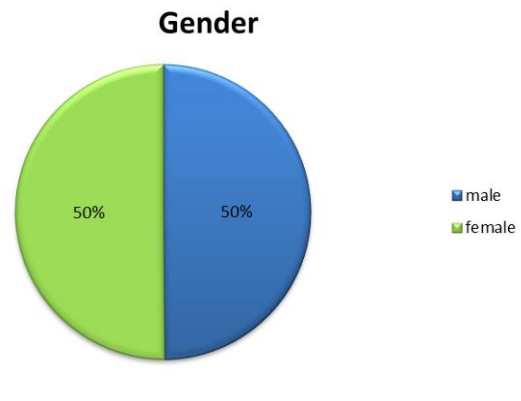


Chart 2: Gender

Social economic – Information obtained from “Kruispuntbank van de sociale zekerheid”(31.12.2010) shows that the group ‘salaried employees’ and ‘children’ is the most common group in the region of this investment.

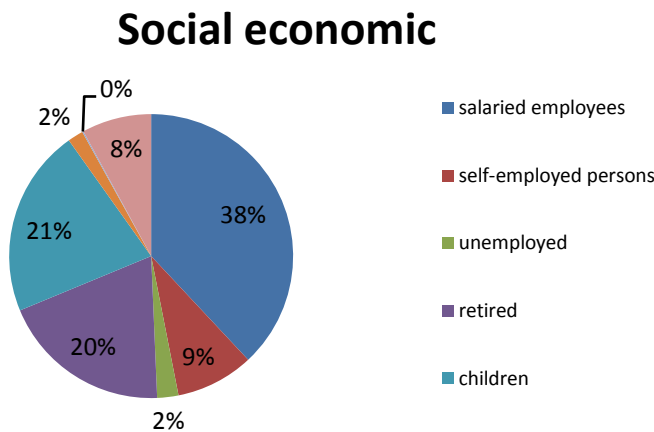


Chart 3: Social economic data

⁸ FedPol/CGOP/B, periode 2007-2012 (PV-gegevens).

2.0 Existing installation

No.	Age	Column type	Luminaire	Arrangement	Light source & wattage	Colour temperature (K)	CRI (Ra)	Efficacy (lm/w)	Energy consumption
91	35 years	10m Concrete, 1m bracket projection	Conventional (VZ Schreder)	Aligned, rear of footway	91no. 36W LPS	1800K Warm white	N/A	164 lm/w	19,028 kWh, 4,376 Kgs (*)

Table 3: Existing installation information

(*) 0,23 kgs CO₂/kWh

Due to the increasing traffic, an urgent renovation of this rural road was needed. The traffic function of this road is changed: the road, mainly used as a farm road (agricultural transport), has evolved over the years into a road with a connecting function between different villages. While the traffic rate is higher, security has become the main priority in the renewal of the road. Also, the light level of the public lighting should therefore be increased.

This investment project included also the renovation of the underground utility lines and drains.



Image 4 and 5: Hoelendensebaan, existing scheme

The rate of deterioration had continued and the installation was identified as being inefficient with respect to:

- ★ Poor colour rendering properties of the LPS lamps
- ★ Deteriorating lumen output
- ★ Increased number of reactive maintenance visits

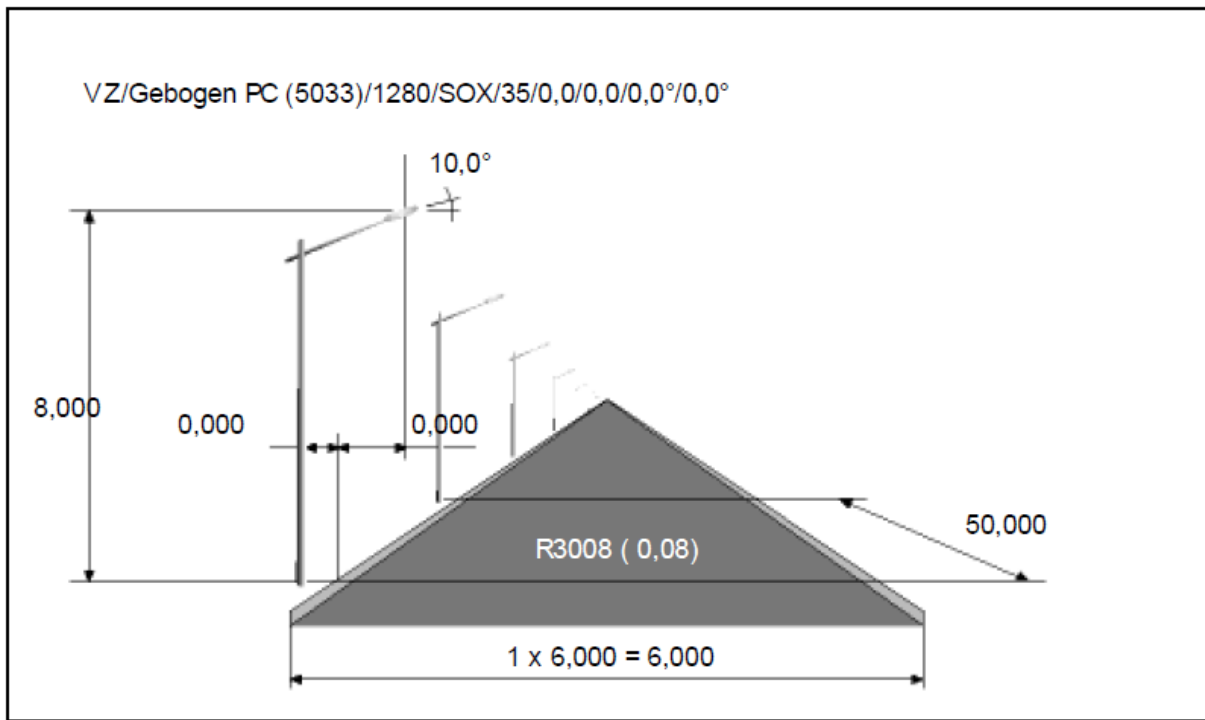


Table 4: Existing installation – design dimensions

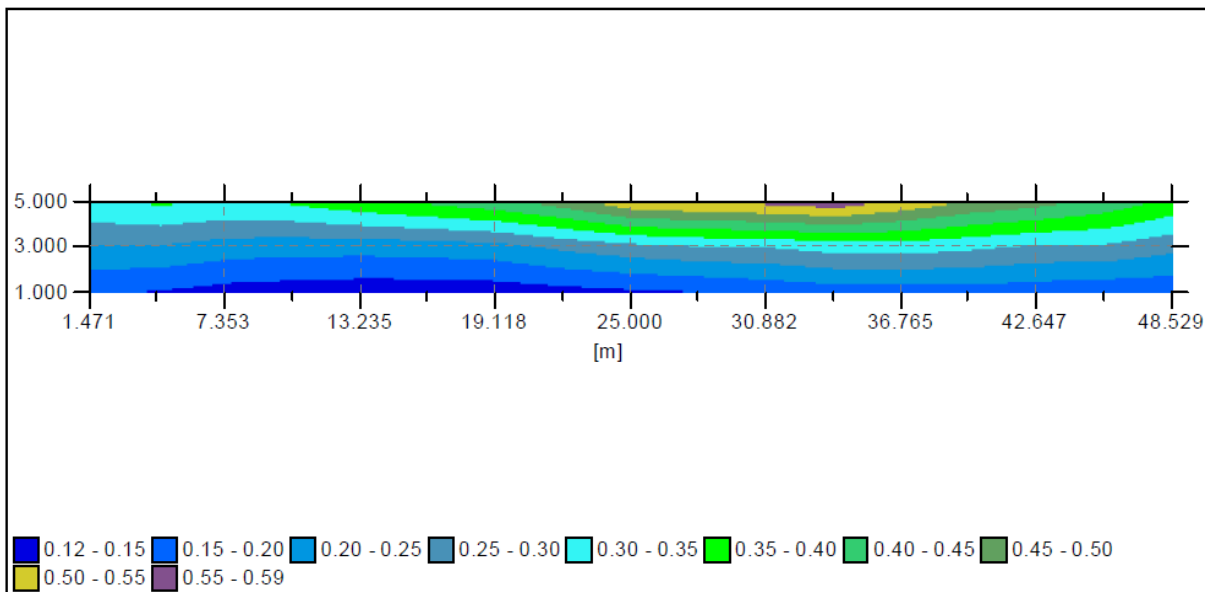


Table 5: Existing installation – calculated values

Calculations show us that the existing light level is situated in class Me6, average 0,3 cd/m². This was the correct light level for this rural road years ago.

3.0 Design development

Selection of the appropriate lighting classification;









Criteria	Description	Notes
 Road type	Distributor - link road	The traffic function of this road is changed: the road, mainly used as a farm road (agricultural transport), has evolved over the years into a road with a connecting function between different villages.
 Traffic flow	Medium	44 mph (70 kph) speed limit. No traffic calming or signage present. The road is a bus route.
 Crime rate	Low	Low identified for the road prior to scheme installation. No monitoring by any local authority CCTV surveillance equipment present.
 Colour rendition	Ra = 70	Ra = 70 chosen as appropriate for facial recognition (bicycle and footpath), CPO white light sources in the new scheme.
 Environmental zone	E2	Countryside, rural environment – link road between two small villages. Low surrounding brightness. Further details regarding sustainability can be found in section 6.0.
 Safe ease of passage	Generally good	No crossing for pedestrians and cyclists. A hedge separates bike and footpath from the road. There is no overgrown vegetation. The general visibility is good. Public transport links in surrounding area.
 Design uniformity	Uo – Me4b	Overall uniformity of illuminance (Uo) in accordance to the Me4b-class(*)
Control method	none	Dimming protocol was proposed to the municipality but not retained. For dimming some technical adjustments in three high voltage cabinets were necessary, including another underground cable network. The municipality government was not willing to bear these additional costs.
 Electricity supply	Distribution Network Operator	DNO low voltage system supply for public lighting use only (230V) continuous throughout the site.

Table 6: Primary and secondary design factors

(*) The following design standard was utilised within the design process in 2012:

- ★ NBN EN 13201: A Belgian standard as result of the translation of a European standard.

With consideration to the criteria above, an Me4b lighting classification of 0,75 cd/m² average was chosen to provide an appropriate level of illumination.

	Me4b	Design
L avg (cd/m ²)	0.75	0.76
U0	0.40	0.45
UI	0.50	0.75
TI max (%)	15.00	13.49

Table 7: Design standard in comparison with the Me4b standard

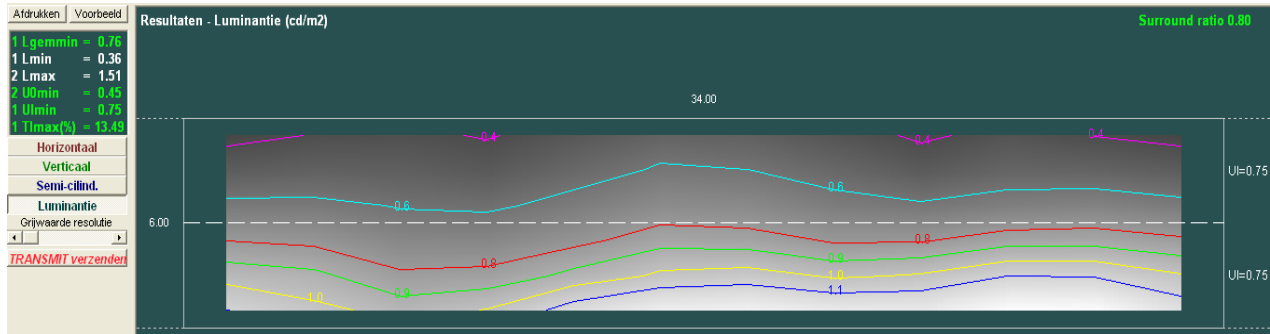


Image 6: Print screen from the calculation software

4.0 Total Cost of Ownership

To support the lighting design process focussing on an LED and CPO solution, a Total Cost of Ownership evaluation was undertaken. This determined which solution offered the most effective whole life cost. The evaluation was made in comparison with the guaranteed LED lifetime cycle of 60,000hrs (approx. 15 years), supposed to be the most efficient luminaire.

The number of units required was calculated during an initial desktop evaluation based on the luminaires utilised in the final scheme.

4.1 Initial capital expenditure

Three elements were considered:

- Site clearance costs of the existing installation
- Supply and installation of the equipment (luminaire, lamp, column and control)
- Electrical works (Distribution Network Operator)

Option	No.	Capital cost
HPS100W	120	€98,640
LED74W	128	€144,928
CPO90W	117	€96,174
Final design CPO 90W	117	€96,174

Table 8: Initial capital expenditure

Remark:

A dimming protocol was proposed to the municipality but not retained. For dimming some technical adjustments in three high voltage cabinets were necessary. This meant an additional cost of € 1.720,56. Additionally all luminaires should be equipped with another circuit with an extra cost of 130 euros per luminaire (a total of € 15.210). The municipal government was not willing to bear these additional costs.

4.2 Energy provision

Important remark:

Normally, according the Belgian standards, a HPS 100W lamp would be used for this type of road. Because of the BLISS-project, the Distribution Network Operator Infrac has chosen the CPO 90W lamp/luminaire. Because Infrac only works with certified and approved lamps, they could normally not use this CPO 90W lamp in the design development. This because the new public tender including CPO-luminaires was due to take place in January 2014. So, they started a

process of certification and from February 1st2014, the CPO 90W luminaire can be used as certified and approved luminaire in developments of Infrac.

Because the function of this road has changed, we didn't make a comparison with the previous energy consumption, but we make the most relevant comparison in this TCO-calculation: a comparison is made between the HPS 100W (which is normally used in this case), the CPO 90W and the LED 74W.

The energy provision was calculated using a cost per kWh based on Estimated Actual Consumption at commission year, excluding inflation and taxation:

- Energy cost per kWh = € 0.15
- Burning hours = 4,200 per year
- Carbon = 0.23 Kgs per kWh
 - www.synergrid.be – Impact of efficient public lighting on CO₂emissions – CE4-N35N-13.05.2009
- HPS 100W energy consumption=64,008kWh,14,721 Kgs of CO₂

Option	No.	Energy	% saving	Annual cost
HPS 100W	120	64,008 kWh 14,721 Kgs		€9,601
LED 74W	128	38,835 kWh 8,932 Kgs	39%	€5,825
CPO 90W	117	50,614 kWh 11,641 Kgs	21%	€7,592
Final design CPO 90W	117	50,614 kWh 11,641 Kgs	21%	€7,592

Table 9: Energy provision

4.3 Maintenance strategy

Planned maintenance regimes were considered; cyclic activities (lamp replacement, luminaire cleaning and structural inspection), electrical testing and inspection regimes.

A four year cyclic maintenance programme was applied to the HPS and CPO options. The LED luminaires have a predicted longer life, therefore only cleaning, structural inspection and electrical testing is needed. However, our own results from test sites showed us that the maintenance cycle/costs that are needed for the cleaning of the LED-luminaires is the same as the HPS/CPO-lamp replacement cycle.

4.4 Total Cost of Ownership 15-year expenditure

Table 10 outlines the total predicted expenditure over a 15-year life cycle(guaranteed LED lifetime cycle of 60,000hrs = approx. 15 years).

Option	Initial capital costs	Energy costs	Maintenance costs	Whole life cost
HPS100W	€98,640	€9,601		€108,241
LED74W	€144,928	€5,825		€150,753
CPO90W	€96,174	€7,592		€103,766
Final design CPO90W	€96,174	€7,592		€103,766

Table 10: TCO 15-year expenditure

The results indicate that a CPO scheme is the most cost effective solution. The LED scheme has high initial capital costs, however the energy costs are significantly reduced compared to a conventional scheme. The maintenance costs are the same.

The whole life cost of the chosen investment is comparable to the HPS baseline scheme and greater than a full LED scheme. The scheme also performs well in terms of reduced energy and maintenance costs.

5.0 Designspecification



Plan 1: Detailed design specification



Image 7: Luminaire Arc 80 CPO-TW 90W, 2800 Warm white



Image 8:
Hoeledensebaan
, new scheme

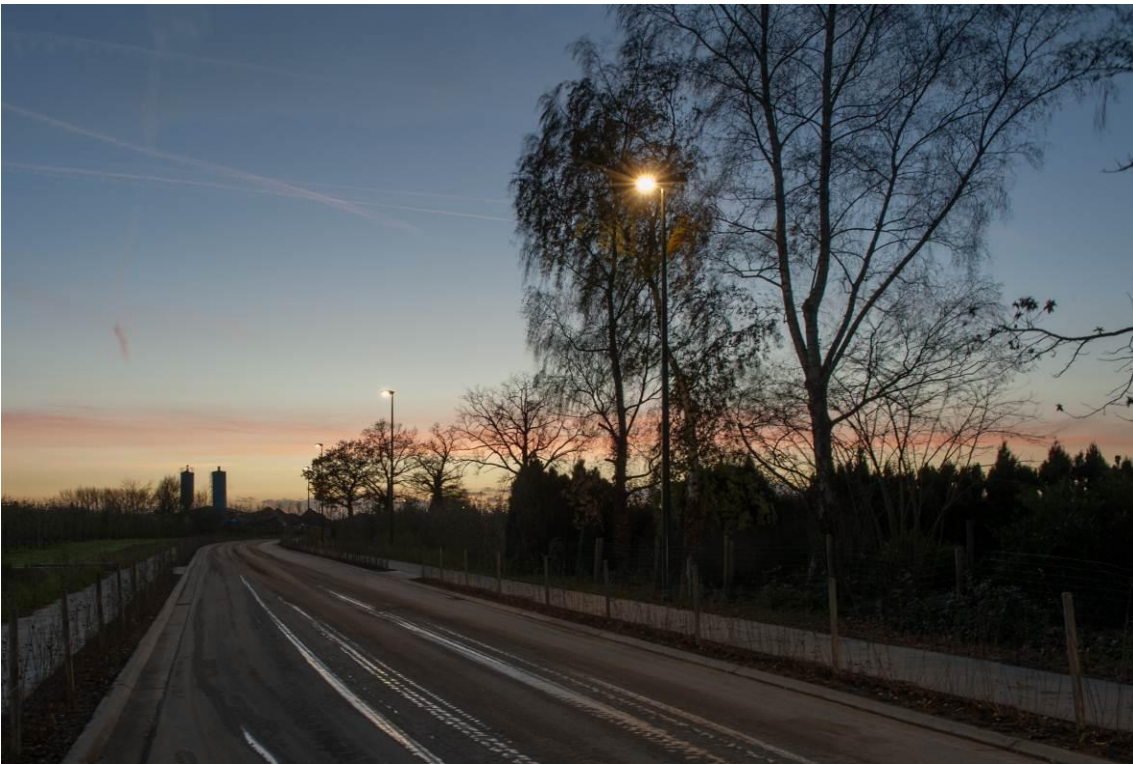
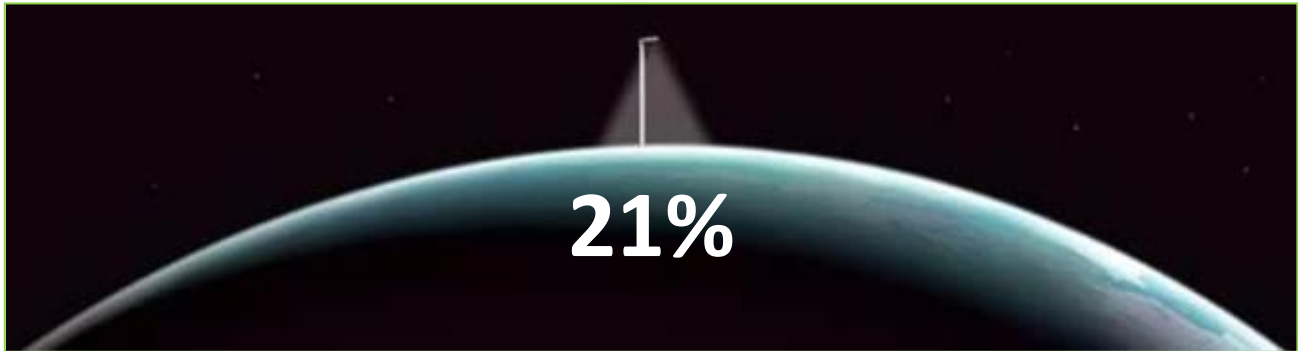


Image 9:
Hoeledensebaan
, new scheme

6.0 Sustainability



6.1 Energy

Predicted energy calculations were produced based on manufacturers' technical specifications to ensure that the new installation achieved a significant energy reduction, in accordance with the BLISS project aims.

Installed power (Watts)	
Original design	15,240W
Actual design (after becoming BLISS-partner)	12,051W
Savings (%)	3,189W (21%)

Table 11: Installed power

Energy consumption, CO ₂ emissions and savings per year (kWh, Kg CO ₂)		
Before	64,008 kWh	14,721 Kgs
After	50,614 kWh	11,641 Kgs
Savings (%)	13,394 kWh (21%)	3,080 Kgs (21%)

Table 12: Energy consumption

As identified in table 12, the use of more efficient light sources and control gear will reduce the energy consumption of street lighting, thereby reducing CO₂ emissions to generate the electricity whilst reducing the life cycle of the fuel and maintenance requirements.

6.2 Materials



The luminaire housings are made from aluminium (powder coated aluminum) with glass bowl protectors (slightly curved glass), which are both highly recyclable. The distribution network operator Infrac, responsible for this BLISS-investment, has a strict environmental policy. The manufacturers of lighting equipment are required to strictly follow the rules concerning recycling and the environment.



DNO Infrac also imposes requirements regarding light pollution and sky glow. These rules are based on the standard 'Typebestek 005 – Equipment for public lighting' (see 10.0). The manufacturer of the luminaires has to produce a very directional light source and produce minimal upward light, reducing the contribution to obtrusive light and sky glow. These kind of luminaires have no adverse effects on the local ecology.

6.3 Obtrusive light considerations



The environmental zone E2 'Countryside, rural environment', was selected for this road. Specific criteria from the manual CIE 150:2003 (*) relating to obtrusive light considerations were utilised during the equipment selection process.

(*) The manual CIE 150:2003 'Guide on the limitation of the effects of obtrusive light from outdoor lighting installations' contains guidelines for designers and governments to limit the sky glow (see 10.0).

25.0 Interleuven stakeholder research

Interleuven invited the inhabitants of the renewed street to comment the new lighting installations. 11% responded to the post survey. There was no pre survey organised. The main results are summarised below.



Post works survey

- ★ 70% of the residents felt safe walking alone during the night
- ★ 100% felt that the new installation is 'comfortable on the eye'
- ★ All respondents stated the new installation shows up the whole street well
- ★ All respondents can see people at a distance clearly and has no problem to see obstacles on the ground
- ★ None of the residents stated that the new lighting installation is still too dark
- ★ 11% says that the new installation doesn't show the colours properly

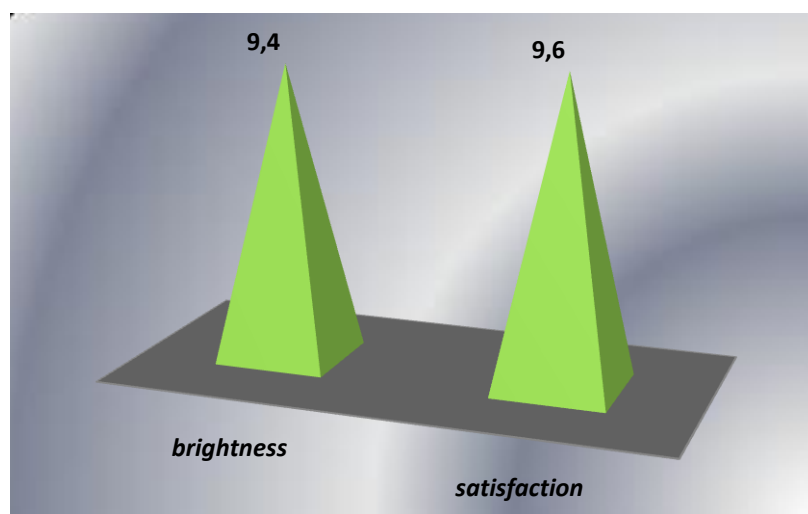
'How does the new street lighting compare with the previous street lighting?'

All of the respondents find the new lighting installation an improvement.

... and using a scale of 1 to 10 ...

... how bright is the street lighting

... how satisfied you are with the lighting



■ post survey

26.0 Results

A summary of the results:








	Before	After	Outcome
 Calculated energy	64,008 kWh 14,721 Kgs of CO ₂	50,614 kWh 11,641 Kgs of CO ₂	21% energy saving
 Number of luminaires	120no.100W HPS	117no. CPO	Decreased units
 Calculated colour rendition	Ra= 25	Ra= 70	Improved colour rendition
 Calculated colour temperature	2000K Warm white	2800K Warm white	Improved appearance
Control regime	None	None	/
 Interleuven research	/	<ul style="list-style-type: none"> ★ 70% felt safe alone at night ★ 0% poor visibility ★ 11% colour rendition ★ 100% 'comfortable on the eye' ★ Nobody says it's still too dark ★ Satisfaction 9.6 	/
 Measured crime	Low	/	/
 Measured accidents	5	/	/

Table 13: Results

9.0 Conclusion

The principal aim of this investment was to replace the existing street lighting as part of the renovation of an existing link road in the municipality of Kortenaeken. The existing street lighting has become obsolete and inefficient. Due to the increasing traffic, an urgent renovation of this rural road was needed. The traffic function of this road is changed: the road, mainly used as a farmroad (agricultural transport), has evolved over the years into a road with a connecting function between different villages. While the traffic rate is higher, security has become the main priority in the renewal of the road. Also, the light level of the public lighting should therefore be increased.

Normally, according to the Belgian standards, a HPS 100W lamp would be used for this type of road. Because of the BLISS-project, the Distribution Network Operator Infracore has chosen the CPO 90W lamp/luminaire.

The crime rate for the municipality of Kortenaeken, a rural village in the surroundings of Tienen, is low. Only those facts of crime in which the illumination of the street is relevant, are retained in the considerations. The accident rate is also very low. This investment was realized in 2013. Because of this late time investment the time is too short to become the crime and accident data. These data are expected mid-2014. Crime and accident figures on a later moment will give a view of the possible effect of the new lighting scheme.

The recorded demographics give an indication of the social profile of this area. The majority of people are in the age range of 45 – 64 and 38% of the residents are salaried employees. Most of the households are privately owned. This may mean that residents are more aware of their neighbourhood in terms of aesthetics and crime prevention.

To support the lighting design process a Total Cost of Ownership evaluation has to be made. This would determine which solution offered the most effective whole life cost. A CPO 90W lamp was chosen as most cost effective solution. Additionally the Distribution Network Operator Infrac has proposed a dimming system, but this proposal was not retained. For dimming some technical adjustments in three high voltage cabinets were necessary, including another underground cable network. The municipal government was not willing to bear these additional costs. The 90W CPO luminaires without a dimming protocol still gives an energy saving of 21%.

Lighting can only be evaluated by stakeholder opinions and technical evaluation, there is no practical way to evaluate if the new lighting increases social activity, encouraging residents to make use of their local amenities during the hours of darkness. The new lighting installation get a 9.6 on a scale of 10.

In conclusion, the change to white light appears to have had a positive impact on respondents perceptions of their environment during the hours of darkness. Careful consideration should be made based on a number of detailed location criteria before changing to white light, including financial and environmental considerations. White light provides improved colour rendition with a predominantly warm white colour temperature, which may help to discourage night crime issues.

10.0 Standards

For several types of spaces, several European and Belgian standards are applicable. This chapter provides a brief overview of legislation and standards used in the development of lighting projects in Flanders/Belgium.

EN 13201 standard for public lighting.

Part 2 of this European standard, the performance requirements, has been translated into a Belgian standard NBN EN 13201-2. Part 1 of the European standard concerning the 'selection of the lighting classifications' is not yet translated into a Belgian standard. The 'Belgisch Instituut voor Verlichting BIV' is investigating this part of the European standard.

This standard establishes minimum levels of illumination that are necessary when a road is illuminated. Go below this minimum (eg dimming) is possible, but it happens, just like the whole of the public lighting on the responsibility of the road authority.

In the selection of lighting classes a distinction is made between:

- the(regional) roads/primary roads and secondary roads both with a specified minimum value for luminance or illuminance,
- the (public or private) local connection or access roads (each inside and outside the village) for which minimum luminance values are indicated
- and a series of other (including bicycle paths, 30 kph zones, pedestrian areas, squares, ...) for which minimum illuminance values are specified.

Regional roads.

Categorie	Functie	Subcategorie	CEN Klasse	L gem [cd/m ²]	U ₁	U ₀	TI max [%] (2)	SR	E _h gem [lux]	U ₀ [E]	E _h min [lux]	E _v gem [lux]	E _v min [lux]	E _{sc} min [lux]
Hoofdweg / Primaire weg	Verbinden op internationaal en gewestelijk niveau	Conflictzones (ring, toelindingswegen...)	(1)	1,5	0,60	0,40	15	-	-	-	-	-	-	-
		Doorgaande wegsecties	ME3b	1,0	0,60	0,40	15	0,50	-	-	-	-	-	-
	Verzamelen op gewestelijk niveau	Rotondes	CE1	-	-	-	-	-	30	0,40	-	-	-	-
		Kruispunt primaire wegen	CE2	-	-	-	-	-	20	0,40	-	-	-	-
Secundaire weg	Verbinden (I) of verzamelen (II) op lokaal en bovenlokaal niveau	Conflictzones (ring, toelindingswegen...)	ME3b	1,0	0,60	0,40	15	0,50	-	-	-	-	-	-
		Rotondes	CE1	-	-	-	-	-	30	0,40	-	-	-	-
		Kruispunt primaire wegen	CE3	-	-	-	-	-	15	0,40	-	-	-	-

(1) Klasse ME3b met $L \geq 1,5 \text{ cd/m}^2$

(2) Een verhoging van 5% van de TI is aanvaardbaar in geval van gebruik van lichtbronnen met lage luminantie (Natrium Lage Druk en Fluorescentie buis), zijnde TI max = 20%

Table 14: Lighting classifications for regional roads

Regional roads, local connections or private roads.

Categorie	Functie	Subcategorie	Situatie (4)	CEN Klasse	L gem [cd/m ²]	U ₁	U ₀	TI max [%] (2)	SR	E _s gem [lux]	U ₀ [E]	E _s min [lux]	E _v gem [lux]	E _v min [lux]	E _{sc} min [lux]	
Lokale verbindingsweg	Verbinden op lokaal niveau	Algemeen	Buiten bebouwde kom	ME4a	0,75	0,60	0,40	15	0,50	-	-	-	-	-	-	
			Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	-	
Lokale gebiedsontsluitingsweg	Ontsluiten (verzamelen en verdelen) op lokaal niveau	Algemeen	Buiten bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-	-	
			Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	-	
Erftoegangs weg	Veel bebouwing	Verblijven en toegang verlenen tot de aanpalende percelen	Woonstraat/Ventweg	Buiten bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-	
			Woonstraat/Winkelstraat	Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	
	Weinig bebouwing		Woonstraat/Ventweg	Buiten bebouwde kom	ME5	0,50	0,40	0,35	15	0,50	-	-	-	-	-	
			Woonstraat/Winkelstraat	Binnen bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-	
Landelijke weg	Algemeen	Algemeen	Buiten bebouwde kom	(3)	0,30	0,40	0,35	20	-	-	-	-	-	-		
Andere	-	Aanliggend fietspad	-	(3)	CE Klasse van aanliggende rijweg -1											
		Vrijliggend fietspad Voetpad (naast weg) Wandelweg Voetgangers- en fietsbrug	-	(3)	S4	-	-	-	-	5	-	1	-	-	-	
		Zone 30	-	(3)	CE4	-	-	-	-	10	0,40	-	-	-	-	
		Voetgangerszone, voetgangersweg en woonerf	-	(3)	CE4 [ES5]	-	-	-	-	10	0,40	-	-	-	[2]	
		Plein	-	(3)	S4 [ES7]	-	-	-	-	5	-	1	-	-	[1]	
		Handels- en historische centra	-	(3)	CE3 [ES4]	-	-	-	-	15	0,40	-	-	-	[3]	
		Onderdoorgangen voetgangers en fietsers	Nacht	-	-	-	-	-	-	100	-	-	-	-	-	10
			Dag	(3)	-	-	-	-	-	200	-	-	-	-	-	20
Oversteekplaats	-	(3)	-	-	-	-	-	80	0,30	-	40	-	-			

(2) Een verhoging van 5% van de TI is aanvaardbaar in geval van gebruik van lichtbronnen met lage luminantie (Natrium Lage Druk en Fluorescentie buis), zijnde TI max = 20%

(3) ME6 Klas met TI <= 20%

(4) Binnen bebouwde kom: <= 50 km/h - Buiten bebouwde kom >= 50 km/h

Table 15: Lighting classifications for regional roads, local connections and private roads

For regional roads the performance requirements of NBN EN13201-2 are also translated into the 'StandardSpecification240' in which four categories of roads and spaces are distinguished. This standard defines the following accents: smooth and safe traffic (A), mixed use (B), visual comfort and safety (C) and the need of mood lighting (D).

Synergrid, the Federation of Distribution Network Operators, translated these performance requirements into the 'Typebestek 005 – Equipment for public lighting'. The distribution network operators use this 'Typebestek 005' to design the public lighting on local roads.

In the design of public lighting next standards and manuals are important:

- Vlarem II, the Flemish environmental legislation with rules to prevent light pollution.
- CIE-documents. In accordance with the standard 'EN13201-3Road lighting-Part 3: Performance Calculation' these CIE documents give technical guidelines for designers:
 - Report CIE 126-1997 'Guidelines for minimizing sky glow'.
 - The manual CIE 150:2003 'Guide on the limitation of the effects of obstrusive light from outdoor lighting installations' contains guidelines for designers and governments to limit the sky glow. In this guide techniques are described for lighting systems in relation to the requirements for astronomical observations. The upward flux of luminaires should be avoided in natural areas (environmental zone E1) (0%) and in rural areas (environmental zone E2) it must be limited to max 5%.

Environmentalzone	Area	Brightness of the environment	Examples
E1	Nature	Dark	Conservation area
E2	Rural	Low artificial brightness in the environment	Industrial, residential and rural areas
E3	Cities	Moderate artificial brightness in the environment	Urban residential areas with potential industry
E4	City centers	High artificial brightness in the environment	City center with a mix of residential and commercial functions

Table 16: Classification in areas for outdoor lighting design

- Evaluation and approval of lighting equipment. With 'Typebestek 005' as guide, Synergrid has made a list of approved luminaires. The distribution network operators preferably use these approved devices.

11.0 Images



Image 10: Hoeledensebaan, existing and new lighting scheme



Image 11: Hoeledensebaan, existing lighting scheme

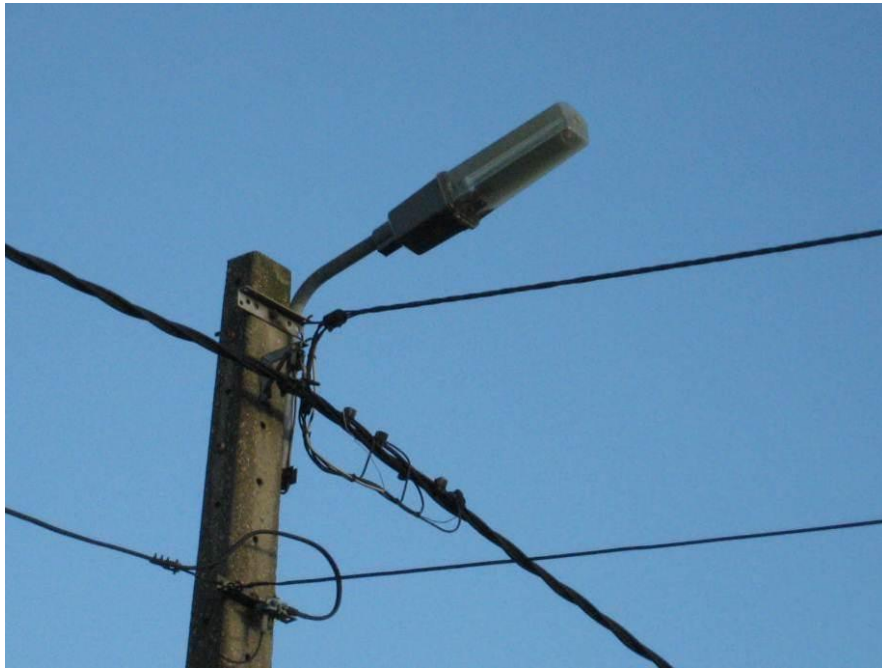


Image 12: Hoeledensebaan, existing luminaires



Image 13: Hoeledensebaan, new lighting scheme



Image 14: Hoeledensebaan, new luminaires

Kortenaken

Collectorwerken Hoeleden
*Deze duurzame straatverlichting met als doel
 “meer licht met minder energie”
 werd gerealiseerd met de steun van het Europees Fonds voor
 Regionale Ontwikkeling (EFRO) in het kader van het
 INTERREG IVB NWE PROGRAMMA*

infrac
 grondleggers van comfort

INTERLEUVEN
 ONDERNEMEND EN ONDERSTEUNEND

BLISS

Image 15: Hoeledensebaan, BLISS-publicity panel

For additional information contact:

BLISS International website: www.bliss-streetlab.eu

INTERLEUVEN
 +32 16 235836
 milieu@interleuven.be
 www.interleuven.be

Infrac
 +32 78 35 30 20
 www.infrac.be

Composer report: Stefan Kempeneers
stefan.kempeneers@interleuven.be, +32 16 284 221

Technical support: Koen Neyens
koen.neyens@infrac.be

BLISS Better Lighting in Sustainable Streets



Technical Case Study

Nieuwland, Aarschot, B Industrial area

21.02.2014
BLISS/IL/8.3/2013/TCS05



gemeente Eindhoven



Better Lighting in Sustainable Streets

BLISS

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Key information

Year	2012-2013
Theme	People
Scheme type	Industrial
Scheme location	Aarschot, B
Property type	Commercial buildings, SME's
Number of roads	9
Speed limit	44mph (70 kph) and 31 mph (50 kph)
Crime rate	Medium
Existing installation	90W Low Pressure Sodium
Main consideration	Renovation of an existing business site
New installation	LED and CPO

Distribution Network Operator EANDIS



1.0 Background

The principal aim of this investment was to replace the existing street lighting as part of the renovation of an existing regional business park. The renovation will take into account the existing road infrastructure, buildings and the existing SOX lighting installation. The old installation provides poor colour rendition and overall illumination of the area. The replacement with modern street lighting luminaires will offer improved efficiency, light characteristics and includes a direct side by side comparison of two preferred light sources.

This investment includes the installation of new lighting scheme incorporating various LED and CPO (white light source) within a conventional side entry luminaire with a predominantly 8 meter mounting height to replace the existing installation. Because the existing columns are still in a good condition, the new luminaires are mounted on these columns. Also installed is the intelligent switching to reduce energy consumption, light pollution and costs.

The Distribution Network Operator Eandis, responsible for this investment, build in two test cases in two of the streets on this industrial area. They wanted to compare the 90W CPO lamps with the 88W LED models. In one short dead-end street they placed 6 columns with Philips LUMA luminaires and 88W LEDs, in another dead-end street 6 columns with 90W CPO lamps were placed. Several measurements must give a good image of the efficiency of these different light sources.

1.1 Site description



Nieuwland is an industrial area in the city of Aarschot, a city with a population of 28,100 people, situated 12.4 miles (20 km) from Leuven. The industrial site, located on the west side of the city centre, is 1.3 miles (2 km) from the centre of Aarschot, where are a number of key services including; schools, medical centres, leisure centres, a supermarket and places of worship.

The business park is easily accessible: it has a good connection with the E314-highway and two local distributor roads, the N19 and the R25. There is also a train station nearby. The Demeris the river that flows through this area. This site (94.7 hectares) is managed by Interleuven and contains the streets: Nieuwland, Nieuwlandlaan and Demerstraat. There are approximately 80 companies on the site, with various industries. It includes both technological and non-technological industry.

The roads have an overall width of 9 metres, with 1.5 metre pedestrian footways and/or bicycle way.



Image 1: Industrial area Nieuwland, new luminaires



Image 2: The new luminaires, a BLISS investment



Image 3: aerial view (Middenschalige orthofotomozaïek, Vlaanderen, winteropnames (wordt jaarlijks vernieuwd), geldig op datum van vandaag 22/11/2013, AGIV en Provincie Vlaams-Brabant.

1.2 Crime considerations



Before (3 years): **medium (14 facts)**
After (2 years): **not available**

Only those facts of crime in which the illumination of the street is relevant, are retained in these considerations: burglaries, car-thefts, car break-ins, bike thefts, vandalism, drug offenses, sexual offenses and arson; were also deter illegal dumping and graffiti.

In certain cases, we can't say if certain facts are street related or not. These facts were considered as possibly street related and are not included in the figures.⁹

Aarschot - Nieuwland.	crime - street related							
	2010	2011	2012	before	2013	2014	2015	after
DARK	1	1	3	5				
DUSK	3	2	3	8				
SEMI-DUSK	0	0	1	1				
	4	3	7	14				

Table 1: Crime – street related - figures

This investment was realised in the mid-year of 2013. At this moment (January 2014) no crime and accident data are yet available.

1.3 Accident considerations



Before (3 years): **medium (16 accidents)**
After (2 years): **not available**

The accident statistics are based on all reported accidents: with fatalities, with bodily harm and material damage.

Aarschot - Nieuwland.	Accidents							
	2010	2011	2012	before	2013	2014	2015	after
DARK	2	1	2	5				
DUSK	1	2	3	6				
SEMI-DUSK	3	1	1	5				
	6	4	6	16				

Table 2: Accidents – street related - figures

Remark: in traffic accidents with fatalities and/or injuries you are obliged to call the police. So we assume that these figures are correct and complete. The accidents with material damage, the police is not always informed. So these figures are just a minimum of the actual figures.¹⁰

This investment was realised in the mid-year of 2013. At this moment (January 2014) no crime and accident data are yet available.

⁹Projectzone: ANG periode 2007-2012, extractie 9 sep 2013

¹⁰FedPol/CGOP/B, periode 2007-2012 (PV-gegevens).

1.4 Social demographic considerations



The information below shows key social economic data covering the area which helps to develop a representation of the potential activity in the hours of darkness.

Gender and age – Information obtained from the National Register – Rijksregister, verwerking door Steunpunt Sociale Planning (01.01.2013) - shows that the gender are fairly evenly divided. The age profiles of the city of Aarschot show a majority of people in the age range of 30-44 and 45-64 years.

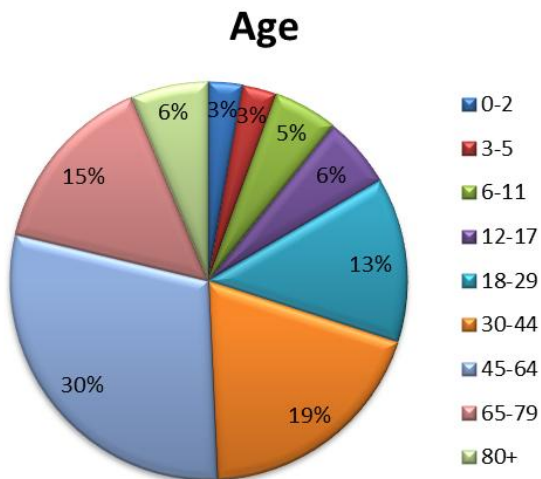


Chart 1: Age

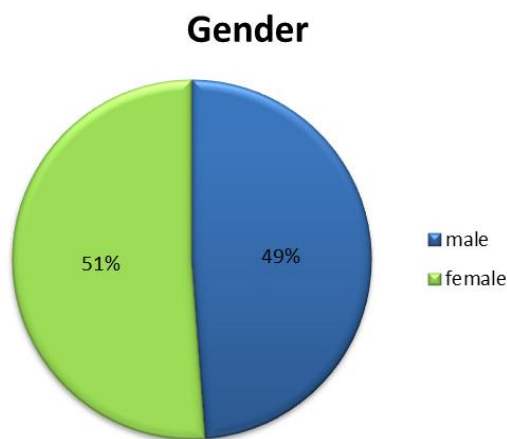


Chart 2: Gender

Social economic – Information obtained from “Kruispuntbank van de sociale zekerheid” (31.12.2010) shows that the group ‘salaried employees’, ‘retired’ and ‘children’ are the most common groups in the region of this investment (city of Aarschot).

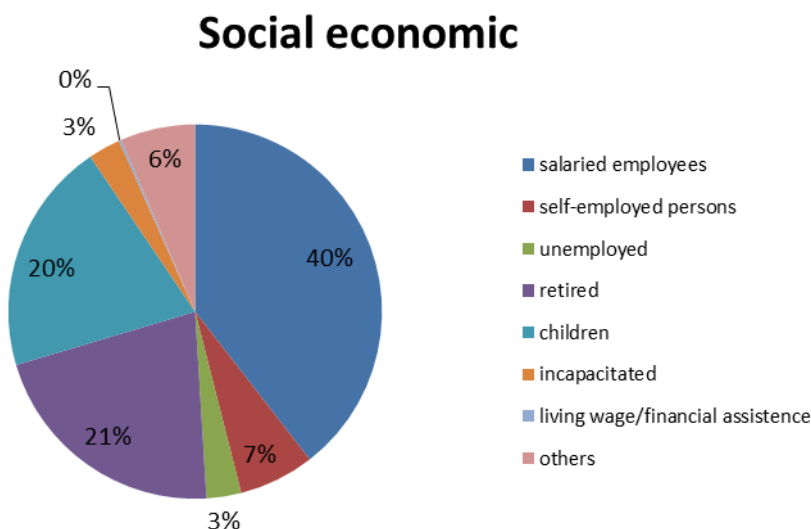


Chart 3: Social economic data

2.0 Existing installation

No.	Age	Column type	Luminaire	Arrangement	Light source & wattage	Colour temperature (K)	CRI (Ra)	Efficacy (lm/w)	Energy consumption
118	30 years	10m steel, 0.5m bracket projection	Conventional deep bowl	Staggered, rear of footway	118no. 115W SOX	1800K Warm white	N/A	N/A	66,689 kWh, 12,744 Kgs

Table 3: Existing installation information

The principal aim of this investment was to replace the existing street lighting as part of the renovation of an existing industrial area. The existing luminaires provided poor optical control and had reached the end of their useful life. The installation has become obsolete and inefficient.

The columns are still in a good condition and could be used to mount the new luminaires.



Image 4: Nieuwland, existing scheme

The rate of deterioration had continued and the installation was identified as being inefficient with respect to:

- ★ Poor colour rendering properties of the LPS lamps
- ★ Deteriorating lumen output
- ★ Increased number of reactive maintenance visits
- ★ High energy consumption
- ★ Safety precautions

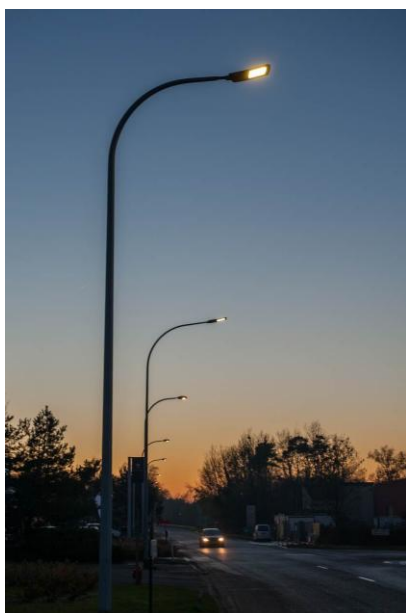


Image 5: Nieuwlandnewluminaires on existing columns

3.0 Design development

Selection of the appropriate lighting classification;









Criteria	Description	Notes
 Road type	Road on industrial area	Roads and footpaths and/or bicycle paths . Limited number of conflict areas. No inter linking pathways present.
 Traffic flow	Medium/high	44 mph (70 kph) and 31 mph (50 kph) speed limit. All the companies have off road parking. No traffic calming present. The Nieuwlandlaan is a bus route.
 Crime rate	Medium	Medium identified for the area prior to scheme installation. No monitoring by any local authority CCTV surveillance equipment present.
 Colour rendition	Ra ≥ 60	Ra ≥ 60 chosen as appropriate for facial recognition (bicycle path), CPO and LED white light sources in the new scheme.
 Environmental zone	E2	Industrial area with low till medium district brightness. Further details regarding sustainability can be found in section 6.0.
 Safe ease of passage	Generally good	Pedestrian ease of passage good; Pedestrian footfall low, adequate footpaths, off road parking, no overgrown vegetation, clear highway site lines, general visibility good, public transport links in surrounding area.
 Design uniformity	Uo – Me4b	Overall uniformity of illuminance (Uo) in accordance to the Me4b-class(*)
Control method	none	Dimming protocol was proposed to the municipality but not retained. For dimming a new underground cable network and new columns are necessary. However, this proposal was too expensive.
 Electricity supply	Distribution Network Operator	DNO low voltage system supply for public lighting use only (230V) continuous throughout the site.

Table 4: Primary and secondary design factors

(*) The following design standard was utilised within the design process in 2010/2011:

- ★ NBN EN 13201: A Belgian standard as result of the translation of a European standard.

With consideration to the criteria above, an Me4b lighting classification of 0,75 cd/m² average was chosen to provide an appropriate level of illumination.

	Me4b
L avg (cd/m ²)	0.75
U0	0.40
UI	0.50
TI max (%)	15.00

Table 4: The Me4b standard

Remark.

The Distribution Network Operator Eandis, responsible for this investment, build in two test cases in two of the streets on this industrial area. They wanted to compare the 90W CPO lamps with the 88W LED models. In one short dead-end street they placed 6 columns with Philips LUMA luminaires and 88W LEDs, in another dead-end street 6 columns with 90W CPO lamps were placed. Several measurements must give a good image of the efficiency of these different light sources.

4.0 Total Cost of Ownership

To support the lighting design process focussing on an LED and CPO solution, a Total Cost of Ownership evaluation must be undertaken. This would determine which solution offered the most effective whole life cost against a HPS baseline. The evaluation outlines full LED and CPO schemes, alongside the final chosen design based on a 25-year design life.

From the beginning of this development the designers have chosen for a combination between two light sources: CPO and LED. So, this investment gives a very good opportunity to compare LED 133W and CPO 90W schemes. In a particular case, Eandis wants to compare a LED 88W with a CPO 90W.

The number of units required was calculated during an initial desktop evaluation based on the luminaires utilised in the final scheme.

4.1 Initial capital expenditure

Three elements were considered:

- Site clearance costs of the existing installation
- Supply and installation of the equipment (luminaire and lamp)
 - Luminaires mounted on existing poles.
- Electrical works (Distribution Network Operator, Private Network Cable)

Option	No.	Capital cost
LED 88W	6	€ 5,811 (*)
LED 133W	53	€ 91,495
CPO 90W	70	€32,631 (*)
Final design LED & CPO	129	€ 124,784

Table 5: Initial capital expenditure

(*) CPO-LED test case Eandis: some extra installation costs are not calculated in the final capital cost.

4.2 Energy provision

The energy provision was calculated using a cost per kWh based on Estimated Actual Consumption at commission year, excluding inflation and taxation:

- Energy cost per kWh = € 0.20
- Burning hours = 4,200 per year
- Carbon = 0.23 Kgs per kWh
 - www.synergrid.be – Impact of efficient public lighting on CO₂emissions – CE4-N35N-13.05.2009

Option	No.	Energy	% saving	Annual cost
LED 88W	6	2,160 kWh 453 Kgs		€ 432
LED 133W	53	28,837 kWh 6,055 Kgs		€ 5,767
CPO 90W	70	25,773 kWh 5,412 Kgs		€ 5,154
Final design LED & CPO	129	56,770 kWh 11,921 Kgs		€ 11,353

Table 6: Energy provision

4.3 Maintenance strategy

Planned maintenance regimes were considered: cyclic activities (lamp replacement, luminaire cleaning and structural inspection), electrical testing and inspection regimes.

A four year cyclic maintenance programme is applied to the LED and CPO options. The LED luminaires have a predicted longer life, therefore only cleaning, structural inspection and electrical testing was included in the calculation. No additional LED module replacement cost was included in the evaluation.

Option	No.	Cost per luminaire	Cost per scheme
LED 88W	6	€ 250	€ 1,500
LED 133W	53	€ 250	€ 13,250
CPO 90W	70	€ 250	€ 17,500
Final design	LED		€ 32,250
	CPO		

Table 7: Maintenance operations

4.4 Total Cost of Ownership 25-year expenditure

Table 8 outlines the total predicted expenditure over a 25-year life cycle.

Option	Initial capital costs	Energy costs	Maintenance costs	Whole life cost
LED 88W	€ 5,811 (*)	€ 10,800	€ 1,500	€ 18,111
LED 133W	€ 91,495	€ 144,185	€ 13,250	€ 248,930
CPO 90W	€32,631 (*)	€ 128,865	€ 17,500	€ 178,996
Final design LED & CPO	€ 124,784	€ 283,850	€ 32,250	€ 440,884

Table 8: TCO 25-year expenditure

(*) CPO-LED test case Eandis: some extra installation costs are not calculated in the final capital cost.

4.5 LED or CPO only

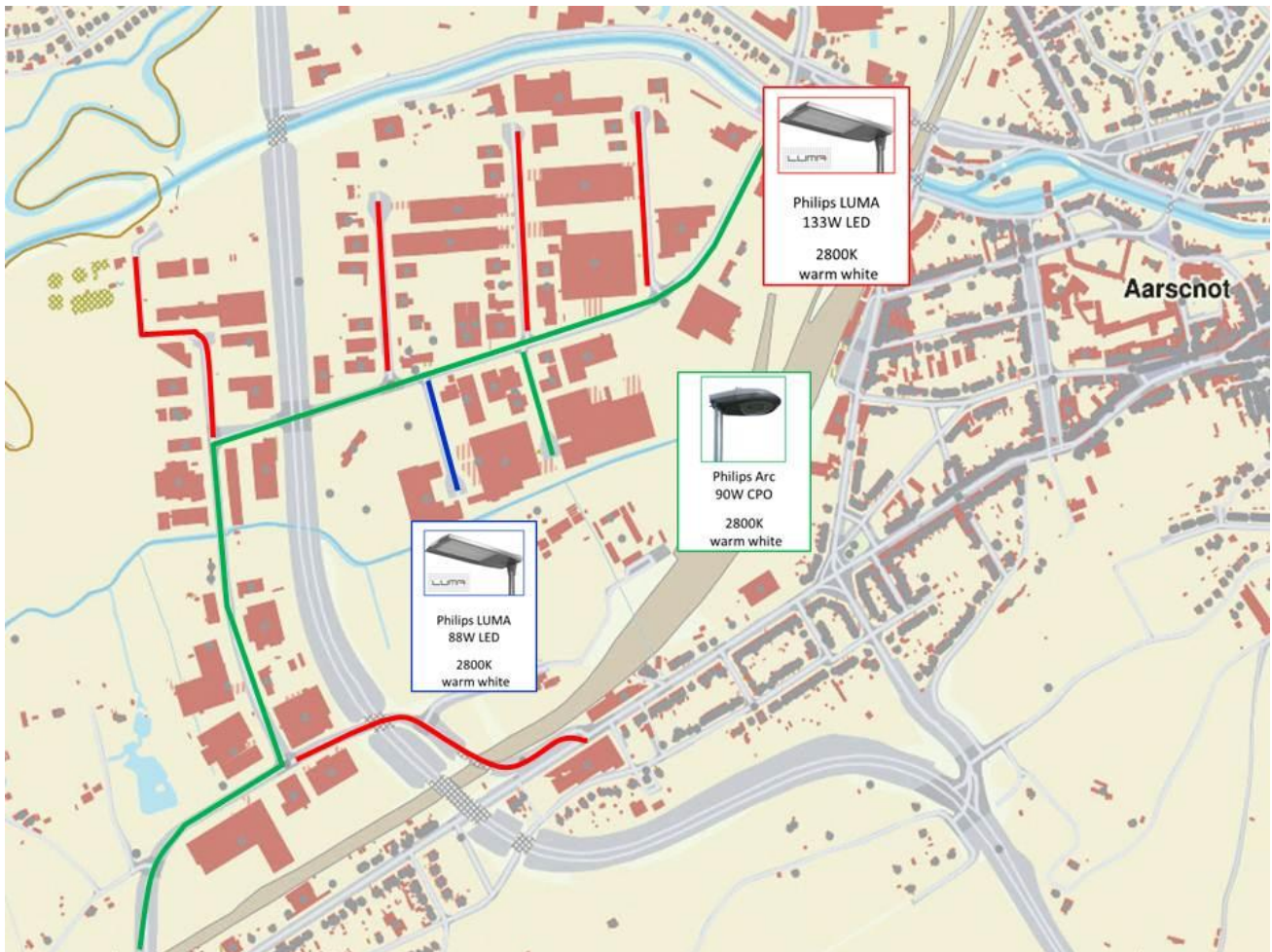
From in the beginning of this development the designers have chosen for a combination between two light sources: CPO and LED. So, this investment gives a very good opportunity to compare LED 133W and CPO 90W schemes. In a particular case, Eandis wants to compare a LED 88W with a CPO 90W. Table 8bis outlines the total predicted expenditure over a 25-year life cycle for 3 situations: CPO or LED only and the final design.

Option	No.	Initial capital costs	Energy costs	Maintenance costs	Whole life cost
CPO 90W only	129	€ 60,134	€ 232,200	€ 32,250	€ 324,584
LED 133W only	129	€ 222,695	€ 343,140	€ 32,250	€ 598,085
LED 88W	6	€ 5,811 (*)	€ 10,800	€ 1,500	€ 18,111
LED 133W	53	€ 91,495	€ 144,185	€ 13,250	€ 264,512
CPO 90W	70	€32,631 (*)	€ 128,865	€ 17,500	€ 187,256
Final design LED & CPO	129	€ 124,784	€ 283,850	€ 32,250	€ 440,884

Table 8bis: TCO 25-year expenditure

The 25-year expenditure when only CPO 90W lamps are used, is the most cost effective solution. Only LED 133W results in a high price tag.

5.0 Designspecification



Plan 1: Detailed design specification

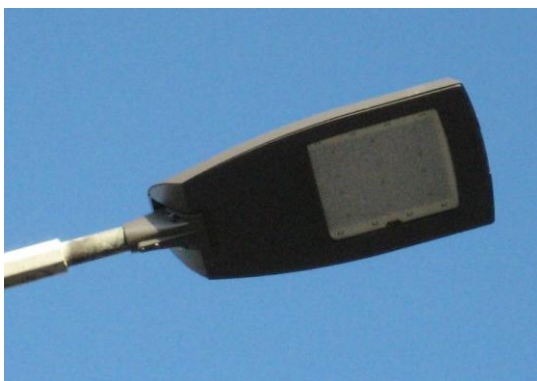


Image 6: Nieuwland new luminaires: Philips LUMA lantern with 133W LEDs



Image 7: Nieuwland new luminaires: Philips Arc lantern with 90W CPO



Image 8:Nieuwland new scheme



Image 9:Nieuwland new scheme

6.0 Sustainability



6.1 Energy

Predicted energy calculations were produced based on manufacturers’ technical specifications to ensure that the new installation achieved an energy reduction, in accordance with the BLISS project aims. In this particular case, there is only an energy saving of 7%. Only the old LPS luminaires are replaced by LED and CPO luminaires, mounted on the old columns. Dimming is not possible because the underground cable network is not suitable for it. Dimming would generate a bigger energy saving.

Installed power (Watts)	
Before	14,835 W
After	13,877 W
Savings (%)	958 W (7%)

Table 9: Installed power

Energy consumption, CO ₂ emissions and savings per year (kWh, Kg CO ₂)		
Before	60,690 kWh	12,745 Kgs
After	56,771 kWh	11,922 Kgs
Savings (%)	3,919 kWh (7%)	823 Kgs (7%)

Table 10: Energy consumption

As identified in table 10, the use of more efficient light sources will reduce the energy consumption of street lighting, thereby reducing CO₂ emissions to generate the electricity whilst reducing the life cycle of the fuel and maintenance requirements.

6.1.1 LED or CPO only

From in the beginning of this development the designers have chosen for a combination between two light sources: CPO and LED.

Table 10a outlines the total installed power for 3 situations: CPO or LED only and the final design.

Installed power (Watts)

	Final design CPO & LED	CPO 90W only	LED 133W only
Before	14,835 W	14,835 W	14,835 W
After	13,877 W	11,610 W	17,157 W
Savings (%)	958 W (7%)	3,225 W (22%)	-2,322 W (-15%)

Table 10a: Installed power

Table 10b outlines the total energy consumption for 3 situations: CPO or LED only and the final design.

Energy consumption, CO ₂ emissions and savings per year (kWh, Kg CO ₂)						
	Final design CPO & LED		CPO 90W only		LED 133W only	
Before	60,690 kWh	12,745 Kgs	60,690 kWh	12,745 Kgs	60,690 kWh	12,745 Kgs
After	56,771 kWh	11,922 Kgs	46,440 kWh	10,681 Kgs	68,628 kWh	15,784 Kgs
Savings (%)	3,919 kWh (7%)	823 Kgs (7%)	14,249 kWh (22%)	2,063 Kgs (16%)	-7,939 kWh (-13%)	-3,040 Kgs (-24%)

Table 10b: Energy consumption

Using only CPO 90W luminaires results in an energy saving of 22%.

Only LED 133W mains a higher consumption of 13%. The installed power for the LED luminaires is also higher. Saving energy will only be possible when using a dimming control regime.

6.2 Materials



The luminaire housings are made from aluminium (powder coated aluminum) with glass bowl protectors (slightly curved glass), which are both highly recyclable. The distribution network operator Eandis, responsible for this BLISS-investment, has a strict environmental policy. The manufacturers of lighting equipment are required to strictly follow the rules concerning recycling and the environment.



DNO Eandis also imposes requirements regarding light pollution and sky glow. These rules are based on the standard 'Typebestek 005 – Equipment for public lighting' (see 10.0). The manufacturer of the luminaires has to produce a very directional light source and produce minimal upward light, reducing the contribution to obtrusive light and sky glow. These kind of luminaires have no adverse effects on the local ecology.

6.3 Obtrusive light considerations



The environmental zone E2 'Countryside, rural environment', was selected for this road. This type of area also includes the industrial areas and business parks. Specific criteria from the manual CIE 150:2003 (*) relating to obtrusive light considerations were utilised during the equipment selection process.

(*) The manual CIE 150:2003 'Guide on the limitation of the effects of obtrusive light from outdoor lighting installations' contains guidelines for designers and governments to limit the sky glow (see 10.0).

7.0 Stakeholder research

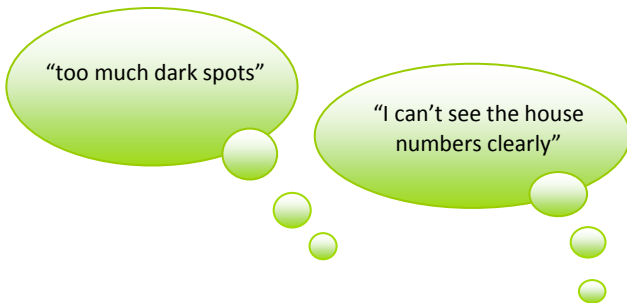
Interleuven invited the business owners and inhabitants of the industrial area Nieuwland to comment the pre and post installations. Interleuven invited 82 companies to comment regarding the pre and post installations. 25% responded to the pre and the post survey. The main results are summarised below.



Pre works survey

- ★ 42% of the residents felt safe walking alone during the night
- ★ 63% felt that the old installation was 'comfortable on the eye'
- ★ 42% stated the old installation shows up the whole street well
- ★ 26% can see people at a distance clearly and 37% has no problem to see obstacles on the ground
- ★ 59% of the residents stated that the old lighting installation was too dark
- ★ 75% says that the old installation doesn't show the colours properly

Additional residents' comments:



Post works survey

- ★ 61% of the residents felt safe walking alone during the night
- ★ 100% felt that the new installation is 'comfortable on the eye'
- ★ 78% stated the new installation shows up the whole street well
- ★ 61% can see people at a distance clearly and also 72% has no problem to see obstacles on the ground
- ★ 11% of the residents stated that the new lighting installation is still too dark
- ★ 18% says that the new installation doesn't show the colours properly

Additional residents' comments:



'How does the new street lighting compare with the previous street lighting?'

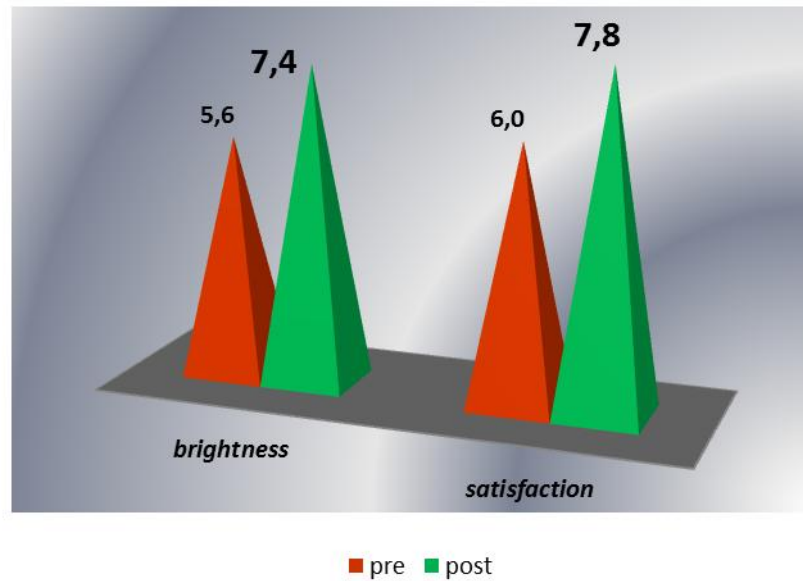
For 94% of the respondents the new lighting installation is an improvement.



... and using a scale of 1 to 10 ...

... how bright is the street lighting

... how satisfied you are with the lighting



Do the respondents experienced a difference between LED and CPO?

This case study is very important to make a comparison between LED and CPO lighting schemes. In the street where LED lighting has been installed, the number of people who responded to the survey was very low, not sufficient enough to make a relevant survey. Distribution Network Operator Eandis, responsible for this investment, has create a test case in two dead-ended streets. In these two streets they want to compare LED 88W luminaires with a CPO 90W scheme. A stakeholder survey is part of this comparison. Due to the short time between installation and the deadline for the Bliss case studies, there are no results yet.

8.0 Results

A summary of the results:








	Before	After	Outcome
 Calculated energy	60,690 kWh 12,745 Kgs of CO ₂	56,771 kWh 11,922 Kgs of CO ₂	7% energy saving
 Number of luminaires	118no. 115W SOX	129no.; 59no. LED 70no. CPO	Increased units
 Calculated colour rendition	$Ra \leq 20$	$Ra \geq 60$	Improved colour rendition
 Calculated colour temperature	1800K Warm white	2800K Warm white	Improved appearance
Control regime	None	None	/
 Interleuven research	<ul style="list-style-type: none"> ★ 42% felt safe alone at night ★ 58% poor visibility ★ 75% colour rendition ★ 63% 'comfortable on the eye' ★ 59% say it's too dark ★ Satisfaction 6.0 	<ul style="list-style-type: none"> ★ 61% felt safe alone at night ★ 22% poor visibility ★ 18% colour rendition ★ 100% 'comfortable on the eye' ★ 11% say it's still too dark ★ Satisfaction 7.8 	Improved perception
 Measured crime	Medium	N/A	N/A
 Measured accidents	16	N/A	N/A

Table 11: Results

9.0 Conclusion

The principal aim of this investment was to replace the existing street lighting as part of the renovation of an existing regional business park in Aarschot. This investment includes the installation of new lighting schemes incorporating various LED and CPO white light sources. The Distribution Network Operator Eandis, responsible for this investment, build in two test cases in two of the streets on this industrial area. They wanted to compare the 90W CPO lamps with the 88W LED models.

The crime rate for this industrial area is medium. Only those facts of crime in which the illumination of the street is relevant, are retained in the considerations. The accident rate is also medium. This investment was realized in 2013. Because of this late time investment the time is too short to become the crime and accident data. These data are expected mid-2014. Crime and accident figures on a later moment will give a view of the possible effect of the new lighting scheme.

The recorded demographics give an indication of the social profile of this area (municipality of Aarschot). The majority of people are in the age range of 45 – 64 and 40% of the residents are salaried employees. An industrial area like this has not much residents, only employees, visitors and traffic passing this area. The lighting scheme must give a good visibility for a high security (crime and accidents).

To support the lighting design process a Total Cost of Ownership evaluation has to be made. This would determine which solution offered the most effective whole life cost. From in the beginning of this development the designers have chosen for a combination between two light sources: CPO and LED. So, this investment gives a very good opportunity to compare LED 133W and CPO 90W schemes. In a particular case, Eandis wants to compare a LED 88W with a CPO 90W. Additionally the Distribution Network Operator Eandis has proposed a dimming system, but this proposal was not retained. For dimming some technical adjustments in high voltage cabinets were necessary, including an adjustment of the underground cable network. The municipality government was not willing to bear these additional costs. The combination of the 90W CPO and the 133W/88W LED luminaires without a dimming protocol still gives an energy saving of 7%. Using only CPO 90W luminaires results in an energy saving of 22%. Only LED 133W mains a higher consumption of 13%.

Lighting can only be evaluated by stakeholder opinions and technical evaluation, there is no practical way to evaluate if the new lighting increases social activity, encouraging residents to make use of their local amenities during the hours of darkness. The new lighting installation get a 7.8 against a 6.0 for the previous lighting scheme.

In conclusion, the change to white light appears to have had a positive impact on respondents' perceptions of their environment during the hours of darkness. Careful consideration should be made based on a number of detailed location criteria before changing to white light, including financial and environmental considerations. White light provides improved colour rendition with a predominantly warm white colour temperature, which may help to discourage night crime issues.

10.0 Standards

For several types of spaces, several European and Belgian standards are applicable. This chapter provides a brief overview of legislation and standards used in the development of lighting projects in Flanders/Belgium.

EN 13201 standard for public lighting.

Part 2 of this European standard, the performance requirements, has been translated into a Belgian standard NBN EN 13201-2. Part 1 of the European standard concerning the 'selection of the lighting classifications' is not yet translated into a Belgian standard. The 'Belgisch Instituut voor Verlichting BIV' is investigating this part of the European standard.

This standard establishes minimum levels of illumination that are necessary when a road is illuminated. Go below this minimum (eg dimming) is possible, but it happens, just like the whole of the public lighting on the responsibility of the road authority.

In the selection of lighting classes a distinction is made between:

- The (regional) roads/primary roads and secondary roads both with a specified minimum value for luminance or illuminance,
- The (public or private) local connection or access roads (each inside and outside the village) for which minimum luminance values are indicated
- and a series of other (including bicycle paths, 30 kph zones, pedestrian areas, squares, ...) for which minimum illuminance values are specified.

Regional roads.

Categorie	Functie	Subcategorie	CEN Klasse	L _{gem} [cd/m ²]	U _i	U _o	TI max [%] (2)	SR	E _h gem [lux]	U _o [E]	E _h min [lux]	E _v gem [lux]	E _v min [lux]	E _{sc} min [lux]
Hoofdweg / Primaire weg	Verbinden op internationaal en gewestelijk niveau	Conflictzones (ring, toelidingswegen...)	(1)	1,5	0,60	0,40	15	-	-	-	-	-	-	-
		Doorgaande wegsecties	ME3b	1,0	0,60	0,40	15	0,50	-	-	-	-	-	-
	Verzamelen op gewestelijk niveau	Rotondes	CE1	-	-	-	-	-	30	0,40	-	-	-	-
		Kruispunt primaire wegen	CE2	-	-	-	-	-	20	0,40	-	-	-	-
Secundaire weg	Verbinden (I) of verzamelen (II) op lokaal en bovenlokaal niveau	Conflictzones (ring, toelidingswegen...)	ME3b	1,0	0,60	0,40	15	0,50	-	-	-	-	-	-
		Rotondes	CE1	-	-	-	-	-	30	0,40	-	-	-	-
		Kruispunt primaire wegen	CE3	-	-	-	-	-	15	0,40	-	-	-	-

(1) Klasse ME3b met $L \geq 1,5 \text{ cd/m}^2$

(2) Een verhoging van 5% van de TI is aanvaardbaar in geval van gebruik van lichtbronnen met lage luminantie (Natrium Lage Druk en Fluorescentie buis), zijnde TI max = 20%

Table 12: Lighting classifications for regional roads

Regional roads, local connections or private roads.

Categorie	Functie	Subcategorie	Situatie (4)	CEN Klasse	L gem [cd/m ²]	U ₁	U ₀	TI max [%] (2)	SR	E _h gem [lux]	U ₀ [E]	E _h min [lux]	E _v gem [lux]	E _v min [lux]	E _{sc} min [lux]			
Lokale verbindingsweg	Verbinden op lokaal niveau	Algemeen	Buiten bebouwde kom	ME4a	0,75	0,60	0,40	15	0,50	-	-	-	-	-	-			
			Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	-			
Lokale gebiedsontsluitingsweg	Ontsluiten (verzamen en verdelen) op lokaal niveau	Algemeen	Buiten bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-	-			
			Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	-			
Erftoegangs weg	Veel bebouwing	Verblijven en toegang verlenen tot de aanpalende percelen	Woonstraat/Ventweg	Buiten bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-			
			Woonstraat/Winkelstraat	Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-			
	Woonstraat/Ventweg		Buiten bebouwde kom	ME5	0,50	0,40	0,35	15	0,50	-	-	-	-	-				
	Woonstraat/Winkelstraat		Binnen bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-				
Landelijke weg	Algemeen	Algemeen	Buiten bebouwde kom	(3)	0,30	0,40	0,35	20	-	-	-	-	-	-	-			
			Aanliggend fietspad	-	(3)	CE Klasse van aanliggende rijweg -1												
Andere	-	-	Vrijliggend fietspad Voetpad (naast weg) Wandelweg Voetgangers- en fietsbrug	-	(3)	S4	-	-	-	-	5	-	1	-	-	-		
			Zone 30	-	(3)	CE4	-	-	-	-	10	0,40	-	-	-	-		
			Voetgangerszone, voetgangersweg en woonerf	-	(3)	CE4 [ES5]	-	-	-	-	10	0,40	-	-	-	-	[2]	
			Plein	-	(3)	S4 [ES7]	-	-	-	-	5	-	1	-	-	-	[1]	
			Handels- en historische centra	-	(3)	CE3 [ES4]	-	-	-	-	15	0,40	-	-	-	-	[3]	
			Onderdoorgangen voetgangers en fietsers	Nacht	-	-	-	-	-	-	100	-	-	-	-	-	-	10
				Dag	(3)	-	-	-	-	-	200	-	-	-	-	-	-	20
			Oversteekplaats	-	(3)	-	-	-	-	-	80	0,30	-	40	-	-	-	

(2) Een verhoging van 5% van de TI is aanvaardbaar in geval van gebruik van lichtbronnen met lage luminantie (Natrium Lage Druk en Fluorescentie buis), zijnde TI max = 20%

(3) ME6 Klas met TI <= 20%

(4) Binnen bebouwde kom: <= 50 km/h - Buiten bebouwde kom >= 50 km/h

Table 13: Lighting classifications for regional roads, local connections and private roads

For regional roads the performance requirements of NBN EN13201-2 are also translated into the 'Standard Specification 240' in which four categories of roads and spaces are distinguished. This standard defines the following accents: smooth and safe traffic (A), mixed use (B), visual comfort and safety (C) and the need of mood lighting (D).

Synergriid, the Federation of Distribution Network Operators, translated these performance requirements into the 'Typebestek 005 – Equipment for public lighting'. The distribution network operators use this 'Typebestek 005' to design the public lighting on local roads.

In the design of public lighting next standards and manuals are important:

- Vlare II, the Flemish environmental legislation with rules to prevent light pollution.
- CIE-documents. In accordance with the standard 'EN13201-3 Road lighting-Part 3: Performance Calculation' these CIE documents give technical guidelines for designers:
 - Report CIE 126-1997 'Guidelines for minimizing sky glow'.
 - The manual CIE 150:2003 'Guide on the limitation of the effects of obtrusive light from outdoor lighting installations' contains guidelines for designers and governments to limit the sky glow. In this guide techniques are described for lighting systems in relation to the requirements for astronomical observations. The upward flux of luminaires should be avoided in natural areas (environmental zone E1) (0%) and in rural areas (environment zone E2) it must be limited to max 5%.

<u>Environmental zone</u>	<u>Area</u>	<u>Brightness of the environment</u>	<u>Examples</u>
E1	Nature	Dark	Conservation area
E2	Rural	Low artificial brightness in the environment	Industrial, residential and rural areas
E3	Cities	Moderate artificial brightness in the environment	Urban residential areas with potential industry
E4	City centers	High artificial brightness in the environment	City center with a mix of residential and commercial functions

Table 14: Classification in areas for outdoor lighting design

- Evaluation and approval of lighting equipment. With ‘Typebestek 005’ as guide, Synergrid has made a list of approved luminaires. The distribution network operators preferably use these approved devices.

11.0 Images



Image 10: new scheme Philips LUMA lantern with 133W LEDs



Image 11: new scheme Philips Arc lantern with 90W CPO



Image 12: new scheme, test case, Philips LUMA lantern with 88W LEDs



Image 13: Aarschot, industrial area Nieuwland, new scheme

12.0 Light mapping

BLISS partner Interleuven manages several industrial areas. To evaluate the insulation condition of the buildings, a thermographic aerial picture of several industrial zones was made during a night flight in the winter of 2013. On the industrial zone Nieuwland Aarschot, subject of this case study, simultaneously a light or luminance map was made.

A city or municipality can benefit from an efficient use and placement of public lighting. On the other hand it is interesting for cities to know, where public places are badly lit, which could result in a higher number of crime facts or dangerous traffic situations at these locations.

During the night flight the company Eurosense acquires aerial imagery with a light sensitive camera. All these measurements were processed to a detailed light map. This map is calibrated using luminance measurements executed on the terrain and a legend in absolute luminance values in Candela/m² is created.

Light maps showing the amount of light are an important policy instrument for cities and municipalities with regard to:

- Energy saving: locating excessive or inefficient lighting and potential savings.
- Safety: locating poorly lit areas, which may lead to increased crime and/or traffic hazard.
- Light pollution: pinpoint overexposed area by both private and public lighting elements.

Two kinds of maps were created - based on the European guidelines for public lighting (EN 13201): the “EN classification map” and the “overexposure map”.

The EN classification map.

The EN classification map had the purpose to compare the measured luminance with the luminance according the Belgian standard for public lighting NBN L 18-004 – selection of lighting classes. This standard is based on the European standard EN 13201-1.

The lighting map shows us the measured luminance value in Cd/m². This value is compared with the desired luminance value for this kind of street. This is a method to see if the luminance value is good according the standards.

A lot of research has shown that this method is not correct. The measured value of luminance from out of a plane (aerial light map) is not the same as the value of luminance in the standards. This luminance is measured from the eye level of a driver in a car and can't be compared with the values on the aerial map.



As part of another project Interleuven had the opportunity to make this aerial image. Despite the fact that this classification map doesn't give the desired results, it was still worth to make this image as a test case. This map was made before the new lighting scheme was installed.

Image 14: Aarschot, industrial area Nieuwland, classification map – luminance in Cd/m²

The overexposure map.

The overexposure map indicates the overexposed areas in colour. When the luminance value is too high, at this location energy can be saved (all light that shines upward is lost). With this map light pollution can be detected.

This map was also made before the new lighting scheme was installed. The results of this map were communicated to the business owners of this industrial area. The owners became some information about lighting efficiency and pollution and how to save energy bij improving the lighting.

For the public lighting, it would be very interesting to make a new aerial picture after the installation of the new CPO and LED luminaires. At this moment (January 2014) it is not clear whether a new picture will be taken.



Image 15: Aarschot, industrial area Nieuwland, overexposure map – luminance in Cd/m²

Some examples.

Public lighting – image 16: the light map shows some overexposed spots on the roundabout (crossing R25 and the Aarschotsesteenweg).

Private lighting – image 17: the light map shows some overexposed spots around an industrial building :

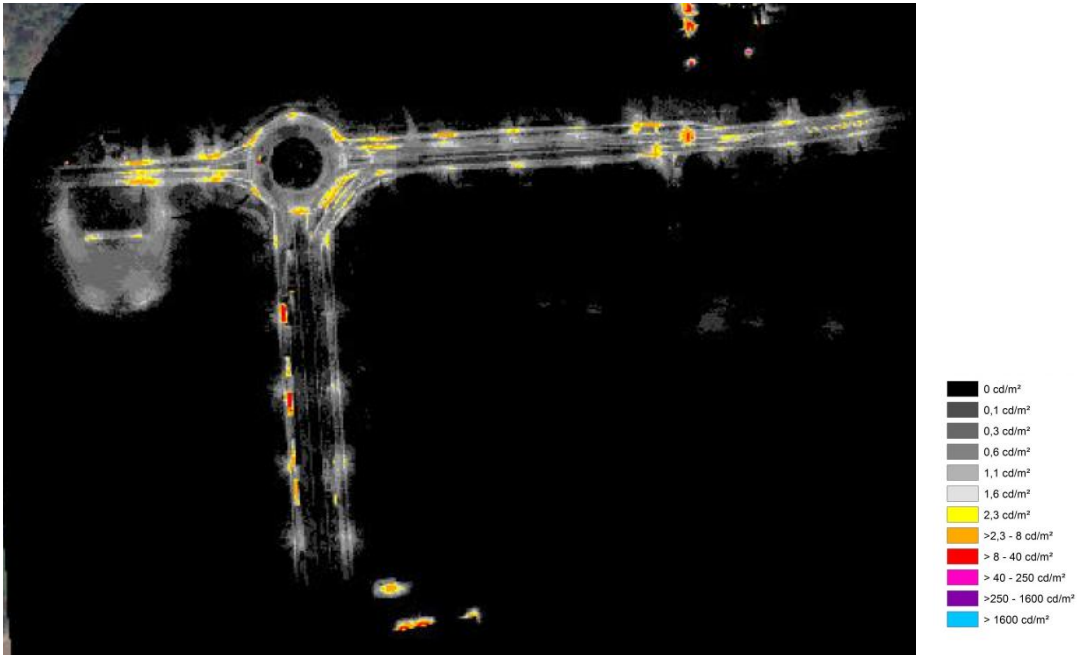


Image 16: Aarschot, industrial area Nieuwland, public lighting - some overexposed areas

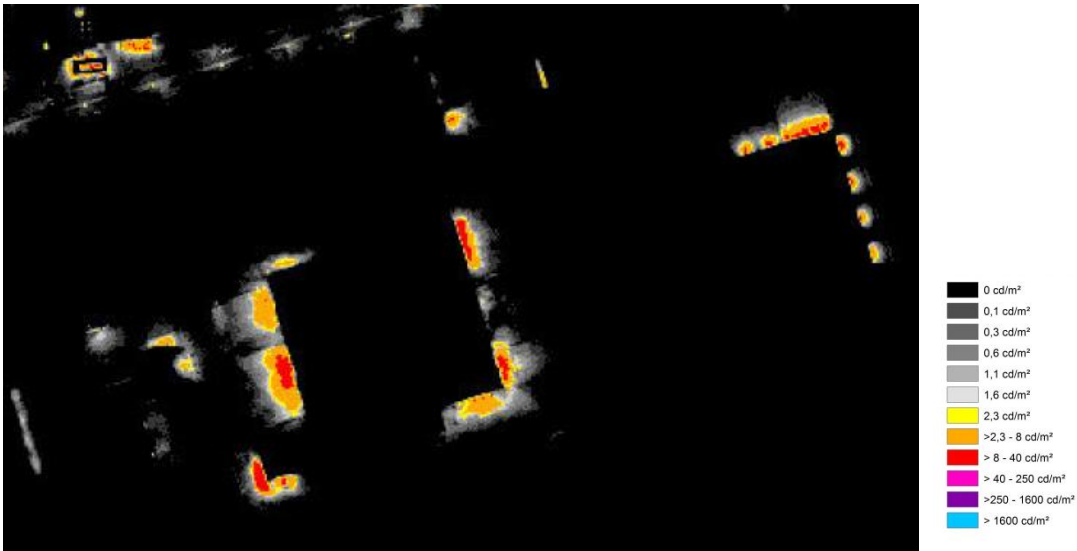


Image 17: Aarschot, industrial area Nieuwland, private lighting - some overexposed areas

In terms of energy-efficiency and light pollution, making an aerial lighting map can be a very useful tool to compare a pre and a post situation.

For additional information contact:

BLISS International website: www.bliss-streetlab.eu

INTERLEUVEN
+32 16 235836
milieu@interleuven.be
www.interleuven.be

Eandis
+32 78 35 35 34
www.eandis.be

Composer report: [Stefan Kempeneers](mailto:stefan.kempeneers@interleuven.be)
stefan.kempeneers@interleuven.be, +32 16 284 221

Technical support: [Marc Lemmens](mailto:marc.lemmens@eandis.be)
marc.lemmens@eandis.be

BLISS**Better Lighting in Sustainable Streets**

Technical Case Study

**Wakkerzeelsebaan,
Leuven, B****Distributor – link road**

21.02.2014

BLISS/IL/8.4/2013/TCS06



St. Helens Council



gemeente Eindhoven


INTERLEUVEN
 ONDERNEMEND EN ONDERSTEUNEND

**STADT
 KAISERSLAUTERN**


Better Lighting in Sustainable Streets

BLISS

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Key information

Year	2013
Theme	People
Scheme type	Distributor – link road
Scheme location	Wijgmaal, Leuven, B
Property type	Semi-detached and detached bungalows
Number of roads	1
Speed limit	44mph (70 kph)
Crime rate	Low
Existing installation	LPS, CPO and HPS
Main consideration	Renovation of a street
New installation	LED luminaire

Distribution Network Operator EANDIS



1.0 Background

The principal aim of this investment was to replace the existing street lighting as part of the renovation of an existing distributor or link road in Wijgmaal, part of the city of Leuven. The existing street lighting has become obsolete and inefficient. The replacement with modern street lighting luminaires will offer improved efficiency and light characteristics with a minimal energy usage and costs.

This investment includes the installation of a new lighting scheme incorporating 126W LED (white light source) within a conventional side entry luminaire with a 8 meter mounting height to replace the existing installation.

1.1 Site description



This investment is situated in Wijgmaal, a small village, part of Leuven. Wijgmaal has 3,600 inhabitants, Leuven 98,000 people in total.

This 1.4 miles (2 km) long renewed street, subject to a 44 mph (70 kph) speed limit, has an overall width of 6 metres, with a separated bike/footpath. The distance to the centre of Leuven is 4.2 miles (8 km). The Wakkerzeelsebaan is situated on the outskirts of Leuven and is very rural with a lot of open space behind the properties. The road is used as link road between Rotselaar and Leuven. In this area are a number of key services including schools, medical centres, leisure centres, a supermarket and places of worship.



Image 1: Wakkerzeelsebaan, Leuven. Renovation of a residential street.

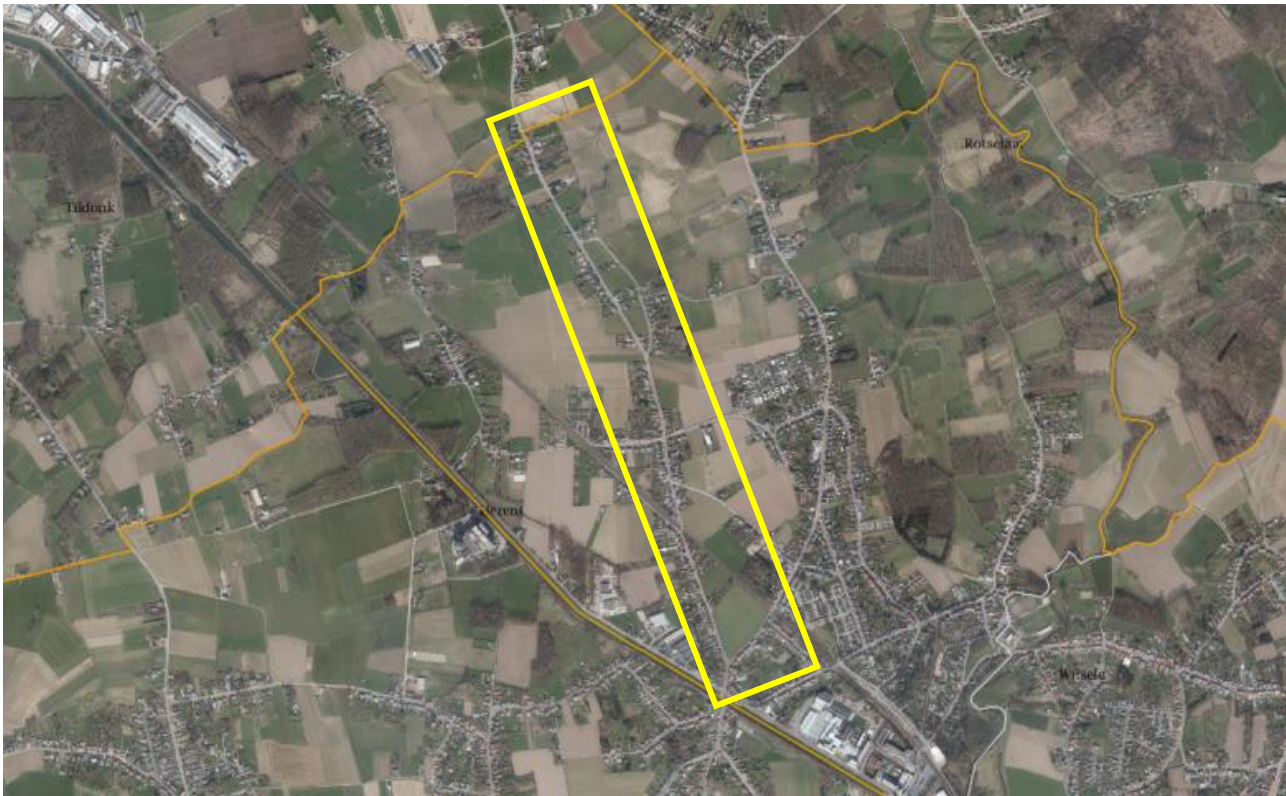


Image 2: aerial view (Middenschalige orthofotomozaïek, Vlaanderen, winteropnames (wordt jaarlijks vernieuwd), geldig op datum van vandaag 22/11/2013, AGIV en Provincie Vlaams-Brabant.

1.2 Crime considerations



Before (3 years): **low**
 After (2 years): **not available**

Only those facts of crime in which the illumination of the street is relevant, are retained in these considerations: burglaries, car-thefts, car break-ins, bike thefts, vandalism, drug offenses, sexual offenses and arson; were also deter illegal dumping and graffiti.

In certain cases, we can't say if certain facts are street related or not. These facts were considered as possibly street related and are not included in the figures.¹¹

Leuven - wakkerzeels ebaan	crime - street related							
	2010	2011	2012	before	2013	2014	2015	after
DARK	1	1	0	2				
DUSK	0	0	0	0				
SEMI-DUSK	0	1	0	1				
	1	2	0	3				

Table 1: Crime – street related - figures

This investment was realised end of 2013. At this moment (January 2014) no crime and accident data are yet available.

¹¹Projectzone: ANG periode 2007-2012, extractie 9 sep 2013

1.3 Accident considerations



Before (3 years): **medium**
 After (2 years): **not available**

The accident statistics are based on all reported accidents: with fatalities, with bodily harm and material damage.

Leuven - wakkerzeels ebaan	Accidents							
	2010	2011	2012	before	2013	2014	2015	after
DARK	2	1	2	5				
DUSK	0	1	1	2				
SEMI-DUSK	0	0	0	0				
	2	2	3	7				

Table 2: Accidents – street related - figures

Remark: in traffic accidents with fatalities and/or injuries you are obliged to call the police. So we assume that these figures are correct and complete. The accidents with material damage, the police is not always informed. So these figures are just a minimum of the actual figures.¹²

This investment was realised end of 2013. At this moment (January 2014) no crime and accident data are yet available.

1.4 Social demographic considerations



The information below shows key social economic data covering the area which helps to develop a representation of the potential activity in the hours of darkness.

Gender and age – Information obtained from the National Register – Rijksregister, verwerking door Steunpunt Sociale Planning (01.01.2013) - shows that the gender are fairly evenly divided. The age profiles show a majority of people in the age range of 30-44 and 45-64 years.

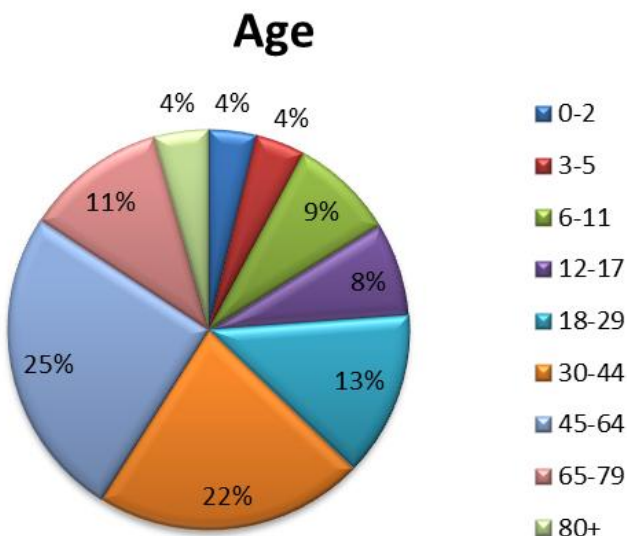


Chart 1: Age

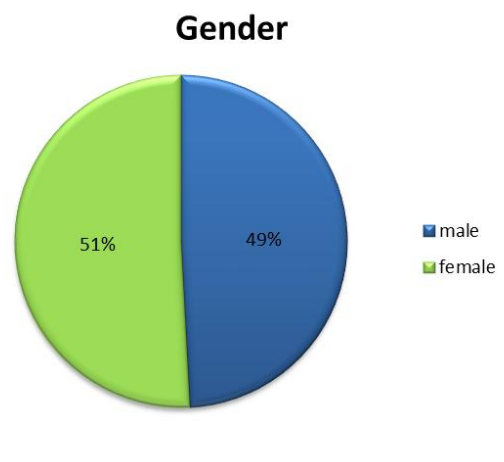


Chart 2: Gender

¹² FedPol/CGOP/B, periode 2007-2012 (PV-gegevens).

Social economic – Information obtained from “Kruispuntbank van de sociale zekerheid” (31.12.2010) shows that the group ‘salaried employees’ and ‘children’ is the most common group in the region of this investment.

Social economic

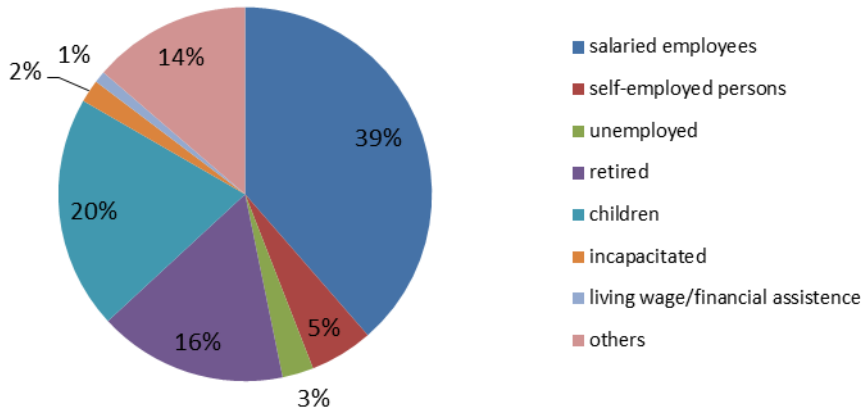


Chart 3: Social economic data

2.0 Existing installation

No.	Age	Column type	Luminaire	Arrangement	Light source & wattage	Colour temperature (K)	CRI (Ra)	Efficacy (lm/w)	Energy consumption
63	20 years	10m Concrete, 0.5m bracket projection	Conventional deep bowl	Staggered, rear of footway	12no. 135W LPS	1800K Warm white	N/A	N/A	25,680 kWh, 5,395.95 Kgs
					30no. 90W CPO	2400K Neutral white	N/A	N/A	
					21no. 100W HPS	1800K Warm white	N/A	N/A	

Table 3: Existing installation information

Due to the increasing traffic, an urgent renovation of this distributor road was needed. The traffic has increased tremendously. While the traffic rate is higher, security has become the main priority in the renewal of the road. Also, the light level of the public lighting should therefore be increased. Another reason for this renovation was the poor condition of the road.

This project included also the renovation of the underground utility lines and drains.



Image 3 and 4: Wakkerzeelsebaan existing scheme.

The rate of deterioration had continued and the installation was identified as being inefficient with respect to:

- ★ Poor colour rendering properties of the LPS lamps
- ★ Deteriorating lumen output
- ★ Increased number of reactive maintenance visits
- ★ High energy consumption
- ★ The uneven distribution of light



Image 5: Wakkerzeelsebaan Leuven existing scheme



Image 6: Wakkerzeelsebaan Leuven existing scheme

3.0 Design development

Selection of the appropriate lighting classification;










Criteria	Description	Notes
 Road type	Distributor - link road	Situated on the outskirts of Leuven, very rural with a lot of open space behind the properties. Link road between Rotselaar and Leuven. Limited number of conflict areas.
 Traffic flow	Medium/high	44 mph (70 kph) speed limit. Majority of properties have off road parking. Also vehicles parked on the street. No traffic calming present. The estate is a bus route.
 Crime rate	Low	Low identified for the estate prior to scheme installation. No monitoring by any local authority CCTV surveillance equipment present.
 Colour rendition	Ra ≥ 60	Ra ≥ 60 chosen as appropriate for facial recognition (bicycle path), LED white light sources in the new scheme.
 Environmental zone	E3	Moderate artificial brightness in the environment. Small town centres or suburban locations. Further details regarding sustainability can be found in section 6.0.
 Safe ease of passage	Generally good	Pedestrian ease of passage good; Pedestrian footfall low, adequate footpaths, off road parking, no overgrown vegetation, general visibility good, public transport links in surrounding area.
 Design uniformity	Uo – Me4b	Overall uniformity of illuminance (Uo) in accordance to the Me4b-class(*)
 Control method	50% lumen output 22:00 – 06:00	Autonomous variable light control method with LED luminaires; Low pedestrian and traffic flow, especially during the hours of darkness, low crime rate, colour rendering index ≥ 60.
 Electricity supply	Distribution Network Operator	DNO low voltage system supply for public lighting use only (230V) continuous throughout the site.

Table 4: Primary and secondary design factors

(*) The following design standard was utilised within the design process in 2010/2011:

- ★ NBN EN 13201: A Belgian standard as result of the translation of a European standard.

With consideration to the criteria above, an Me4b lighting classification of 0,75 cd/m² average was chosen to provide an appropriate level of illumination.

Me4b	
L avg (cd/m ²)	0.75
U0	0.40
UI	0.50
TI max (%)	15.00

Table 5: The Me4b standard

4.0 Total Cost of Ownership

To support the lighting design process a Total Cost of Ownership evaluation has to be made. This would determine which solution offered the most effective whole life cost. However, due to the vision of the city government a LED solution was proposed, as part of a pilot case on Intelligent Street Light.

Finally, the Distribution Network Operator Eandis has proposed a dimming system. The city government has agreed with this solution.

The number of units required was calculated during an initial desktop evaluation based on the luminaires utilised in the final scheme.

4.1 Initial capital expenditure

Three elements were considered:

- Site clearance costs of the existing installation
- Supply and installation of the equipment (luminaire, lamp, column and control)
- Electrical works (Distribution Network Operator, Private Network Cable)

Option	No.	Capital cost
LED 126W	63	€ 75,849
Final design LED	63	€ 75,849

Table 6: Initial capital expenditure

Remark: The capital cost includes a dimming option. Eandis demands of the suppliers that each luminaire has a dimming system. Luminaires without a dimming option are refused.

4.2 Energy provision

The energy provision was calculated using a cost per kWh based on Estimated Actual Consumption at commission year, excluding inflation and taxation:

- Energy cost per kWh = € 0.20
- Burning hours = 4,200 per year
- immed hours = 2,100 (7 days per day)
- Carbon = 0.23 Kgs per kWh
 - www.synerggrid.be – Impact of efficient public lighting on CO₂emissions – CE4-N35N-13.05.2009
- 50% reduced lumen output between 22:00 – 06:00

Option	No.	Energy	% saving	Annual cost
LED 126 W	63	31,752 kWh 6,670 Kgs		€ 6,350.40
LED 126 W with dimming	63	15,876 kWh 3,335 Kgs	50 %	€ 3,175.20
Final design LED with dimming	63	15,876 kWh 3,335 Kgs	50 %	€ 3,175.20

Table 7: Energy provision

4.3 Maintenance strategy

Planned maintenance regimes were considered: cyclic activities (lamp replacement, luminaire cleaning and structural inspection), electrical testing and inspection regimes.

A four year cyclic maintenance programme is applied to the LED option.

No additional LED module replacement cost was included in the evaluation.

Option	No.	Cost per luminaire	Cost per scheme
LED 126 W	63	€ 250	€ 15,750
LED 126 W with dimming	63	€ 250	€ 15,750
Final design LED with dimming	63	€ 250	€ 15,750

Table 8: Maintenance operations

4.4 Total Cost of Ownership 25-year expenditure

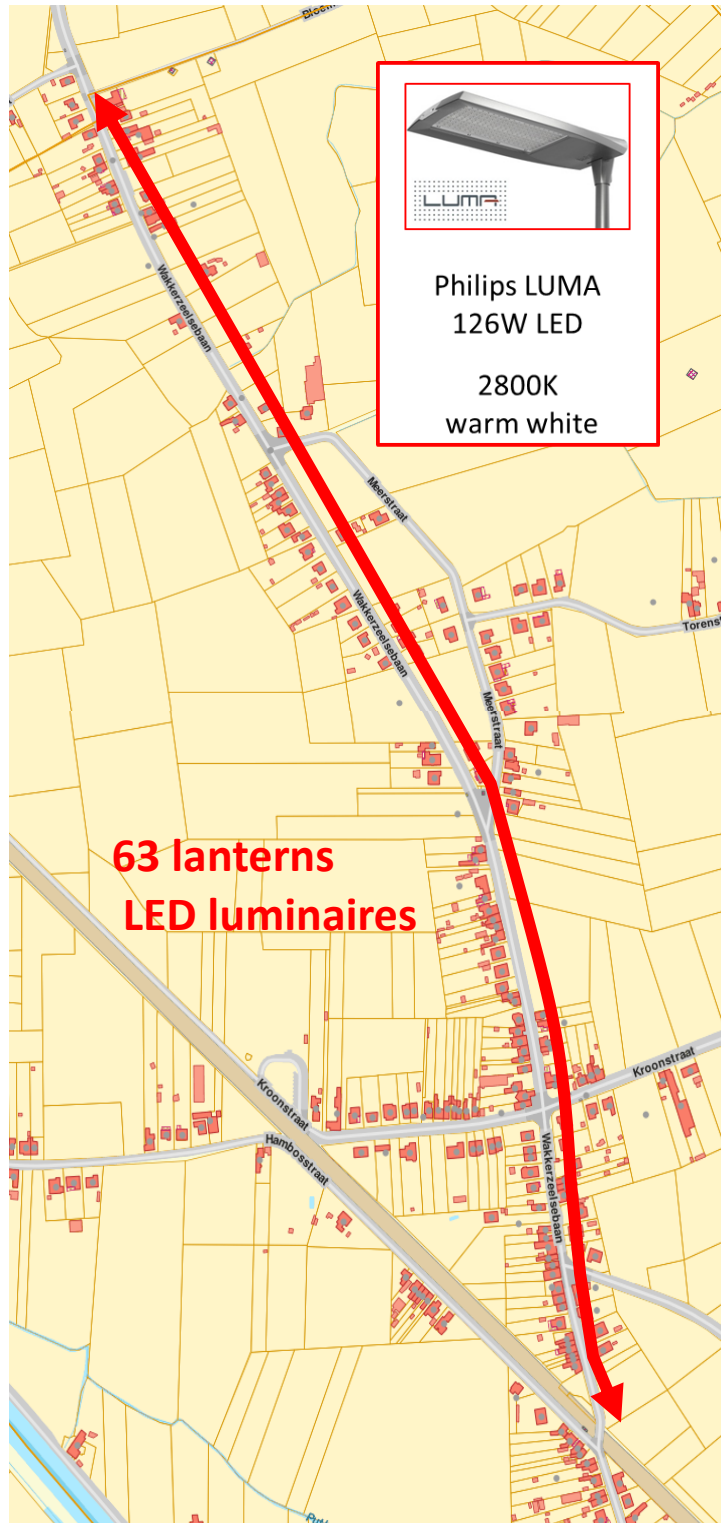
Table 9 outlines the total predicted expenditure over a 25-year life cycle.

Option	Initial capital costs	Energy costs	Maintenance costs	Whole life cost
LED 126 W	€ 75,849	€ 158,760	€ 15,750	€ 250,359
LED 126 W with dimming	€ 75,849	€ 79,380	€ 15,750	€ 170,979
Final design LED with dimming	€ 75,849	€ 79,380	€ 15,750	€ 170,979

Table 9: TCO 25-year expenditure

The results indicate that a LED scheme with dimming is the most cost effective solution. A LED scheme has the potential to reduce maintenance visits, resulting in environmental gains for a more sustainable solution. The scheme also performs well in terms of reduced energy and maintenance costs.

5.0 Designspecification



Plan 1: Detailed design specification

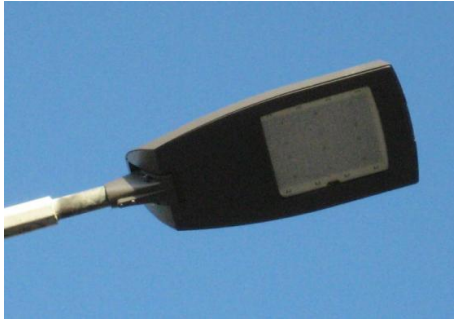


Image 7: Wakkerzeelsebaan new luminaires: Philips LUMA luminaires with 126W LEDs



Image 8:
Wakkerzeelsebaan
new scheme

6.0 Sustainability



6.1 Energy

Predicted energy calculations were produced based on manufacturers' technical specifications to ensure that the new installation achieved a significant energy reduction, in accordance with the BLISS project aims.

Installed power (Watts)	
Before	6,420 W
After (with dimming)	3,969 W
Savings (%)	2,451 W (38%)

Table 10: Installed power

Energy consumption, CO ₂ emissions and savings per year (kWh, Kg CO ₂)		
Before	25,680 kWh	5,394 Kgs
After (with dimming)	15,876 kWh	3,335 Kgs
Savings (%)	9,804 kWh (38%)	2,059 Kgs (38%)

Table 11: Energy consumption

As identified in table 11, the use of more efficient light sources and control gear will reduce the energy consumption of street lighting, thereby reducing CO₂ emissions to generate the electricity whilst reducing the life cycle of the fuel and maintenance requirements.

6.2 Materials



The luminaire housings are made from aluminium (powder coated aluminum) with glass protectors (slightly curved glass), which are both highly recyclable. The distribution network operator Eandis, responsible for this BLISS-investment, has a strict environmental policy. The manufacturers of lighting equipment are required to strictly follow the rules concerning recycling and the environment.



ecology.

DNO Eandis also imposes requirements regarding light pollution and sky glow. The manufacturer of the luminaires has to produce a very directional light source and produce minimal upward light, reducing the contribution to obtrusive light and sky glow. These kind of luminaires have no adverse effects on the local

6.3 Obtrusive light considerations



The environmental zone E3 'Urban residential areas – moderate artificial brightness', was selected for this road. Specific criteria from the manual CIE 150:2003 (*) relating to obtrusive light considerations were utilised during the equipment selection process.

(*) The manual CIE 150:2003 'Guide on the limitation of the effects of obtrusive light from outdoor lighting installations' contains guidelines for designers and governments to limit the sky glow (see 10.0).

7.0 Interleuven stakeholder research

Interleuven invited 160 properties (of the renewed street) to comment regarding the pre and post installations. 48% responded to the pre survey and only 8% to the post survey. The main results are summarised below.



Pre works survey

- ★ 79% of the residents felt safe walking alone during the night
- ★ 91% felt that the old installation was 'comfortable on the eye'
- ★ 51% stated the old installation shows up the whole street well
- ★ 68% can see people at a distance clearly and 68% has no problem to see obstacles on the ground
- ★ 42% of the residents stated that the old lighting installation was too dark
- ★ 69% says that the old installation doesn't show the colours properly

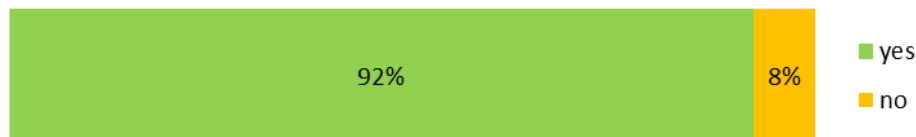


Post works survey

- ★ all of the respondents felt safe walking alone during the night
- ★ all felt that the new installation is 'comfortable on the eye'
- ★ all stated the new installation shows up the whole street well
- ★ all can see people at a distance clearly and also no one has a problem to see obstacles on the ground
- ★ none of the residents stated that the new lighting installation is still too dark
- ★ no one says that the new installation doesn't show the colours properly

'How does the new street lighting compare with the previous street lighting?'

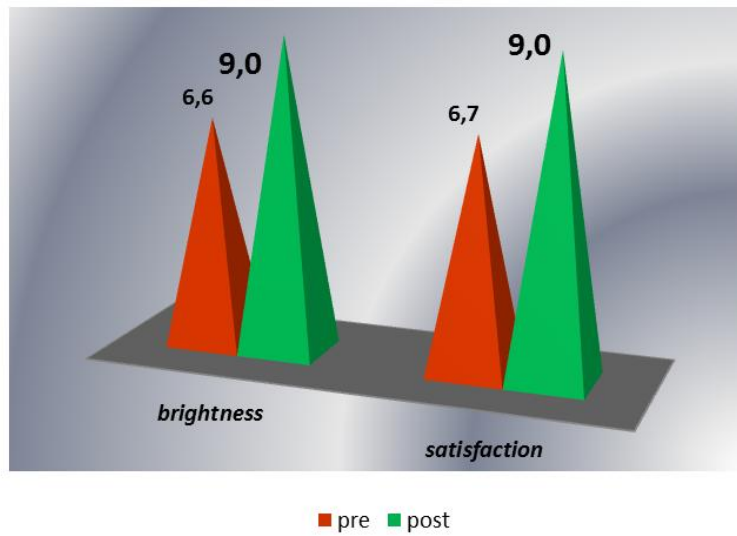
For 92% of the respondents the new lighting installation is an improvement.



... and using a scale of 1 to 10 ...

... how bright is the street lighting

... how satisfied you are with the lighting



8.0 Results

A summary of the results:

		Before	After	Outcome
	Calculated energy	25,680 kWh 5,394 Kgs of CO ₂	5,394 kWh 3,335 Kgs of CO ₂	38% energy saving
	Number of luminaires	63no.; 12no. 135W LPS 30no. 90W CPO 21no. 100W PS	63no. LED	Same number of units
	Calculated colour rendition	Ra ≤ 20	Ra ≥ 60	Improved colour rendition
	Calculated colour temperature	1800K – 2400K Warm white	2800K Warm white	Improved appearance
	Control regime	None	50% 22:00 – 06:00	Improved functionality
	Interleuven research	<ul style="list-style-type: none"> ★ 79% felt safe alone at night ★ 49% poor visibility ★ 69% colour rendition ★ 91% 'comfortable on the eye' ★ 42% say it's too dark ★ Satisfaction 6.7 	<ul style="list-style-type: none"> ★ All felt safe alone at night ★ 0% poor visibility ★ 0% colour rendition ★ 100% 'comfortable on the eye' ★ Nobody says it's too dark ★ Satisfaction 9.0 	Improved perception
	Measured crime	Low	N/A	/
	Measured accidents	7	N/A	/

Table 12: Results

9.0 Conclusion

The principal aim of this investment was to replace the existing street lighting as part of the renovation of an existing distributor or link road in Wijgmaal, part of the city of Leuven. Due to the increasing traffic, an urgent renovation was needed. The city government of Leuven proposed LED luminaires, as part of a pilot case on Intelligent Street Light. This investment includes the installation of 126W LED white light sources.

The crime rate for this area is low. The accident figures are low, despite the increasing traffic. This investment was realized in 2013. Because of this late time investment the time is too short to become the crime and accident data for the Wakkerzeelsebaan in Leuven. These data are expected mid-2014. On this moment there are no figures yet to see if there is any positive impact of the new street lighting. The change to a white light source, producing an improved night environment, may be a contributory factor in the reduction of criminal incidents and traffic accidents.

The recorded demographics give an indication of the social profile of this area. The majority of people are in the age range of 45 – 64 and 39% of the residents are salaried employees. Most of the households are privately owned. This may mean that residents are more aware of their neighbourhood in terms of aesthetics and crime prevention.

To support the lighting design process a Total Cost of Ownership evaluation has to be made. This would determine which solution offered the most effective whole life cost. As part of a pilot case, the city government of Leuven has chosen for a LED solution. Additionally the Distribution Network Operator Eandis has proposed a dimming system: the lumen output will be reduced with 50% between 22:00 and 06:00. The calculated energy saving is 38%.

Lighting can only be evaluated by stakeholder opinions and technical evaluation, there is no practical way to evaluate if the new lighting increases social activity, encouraging residents to make use of their local amenities during the hours of darkness. The post survey results in a 9 for the new lighting scheme, against the 6.7 for the previous scheme.

No negative comments or results have been obtained in relation to the reduction in lumen output to 50% between 22:00 and 06:00, following evaluation of the postal survey. Respondents generally appeared to be more concerned about the appearance and safety of where they live.

In conclusion, the change to white light appears to have had a positive impact on respondents' perceptions of their environment during the hours of darkness. Careful consideration should be made based on a number of detailed location criteria before changing to white light, including financial and environmental considerations. White light provides improved colour rendition with a predominantly warm white colour temperature, which may help to discourage night crime issues.

10.0 Standards

For several types of spaces, several European and Belgian standards are applicable. This chapter provides a brief overview of legislation and standards used in the development of lighting projects in Flanders/Belgium.

EN 13201 standard for public lighting.

Part 2 of this European standard, the performance requirements, has been translated into a Belgian standard NBN EN 13201-2. Part 1 of the European standard concerning the 'selection of the lighting classifications' is not yet translated into a Belgian standard. The 'Belgisch Instituut voor Verlichting BIV' is investigating this part of the European standard.

This standard establishes minimum levels of illumination that are necessary when a road is illuminated. Go below this minimum (eg dimming) is possible, but it happens, just like the whole of the public lighting on the responsibility of the road authority.

In the selection of lighting classes a distinction is made between:

- The (regional) roads/primary roads and secondary roads both with a specified minimum value for luminance or illuminance,

- the(public or private) local connection or access roads (each inside and outside the village) for which minimum luminance values are indicated
- and a series of other (including bicycle paths, 30 kph zones, pedestrian areas, squares, ...) for which minimum illuminance values are specified.

Regional roads.

Categorie	Functie	Subcategorie	CEN Klasse	L _{gem} [cd/m ²]	U _i	U _o	TI max [%] (2)	SR	E _b gem [lux]	U _o [E]	E _b min [lux]	E _v gem [lux]	E _v min [lux]	E _{sc} min [lux]
Hoofdweg / Primaire weg	Verbinden op internationaal en gewestelijk niveau	Conflictzones (ring, toelindingswegen...)	(1)	1,5	0,60	0,40	15	-	-	-	-	-	-	-
		Doorgaande wegsecties	ME3b	1,0	0,60	0,40	15	0,50	-	-	-	-	-	-
	Verzamelen op gewestelijk niveau	Rotondes	CE1	-	-	-	-	-	30	0,40	-	-	-	-
		Kruispunt primaire wegen	CE2	-	-	-	-	-	20	0,40	-	-	-	-
Secundaire weg	Verbinden (I) of verzamelen (II) op lokaal en bovenlokaal niveau	Conflictzones (ring, toelindingswegen...)	ME3b	1,0	0,60	0,40	15	0,50	-	-	-	-	-	-
		Rotondes	CE1	-	-	-	-	-	30	0,40	-	-	-	-
		Kruispunt primaire wegen	CE3	-	-	-	-	-	15	0,40	-	-	-	-

(1) Klasse ME3b met L >= 1,5 cd/m²

(2) Een verhoging van 5% van de TI is aanvaardbaar in geval van gebruik van lichtbronnen met lage luminantie (Natrium Lage Druk en Fluorescentie buis), zijnde TI max = 20%

Table 13: Lighting classifications for regional roads

Regional roads, local connections or private roads.

Categorie	Functie	Subcategorie	Situatie (4)	CEN Klasse	L _{gem} [cd/m ²]	U _i	U _o	TI max [%] (2)	SR	E _b gem [lux]	U _o [E]	E _b min [lux]	E _v gem [lux]	E _v min [lux]	E _{sc} min [lux]	
Lokale verbindingsweg	Verbinden op lokaal niveau	Algemeen	Buiten bebouwde kom	ME4a	0,75	0,60	0,40	15	0,50	-	-	-	-	-	-	
			Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	-	
Lokale gebiedsontsluitingsweg	Ontsluiten (verzamelen en verdelen) op lokaal niveau	Algemeen	Buiten bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-	-	
			Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	-	
Erftoegangs weg	Veel bebouwing	Verblijven en toegang verlenen tot de aanpalende percelen	Woonstraat/Ventweg	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-	-	
			Woonstraat/Winkelstraat	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	-	
	Woonstraat/Ventweg		ME5	0,50	0,40	0,35	15	0,50	-	-	-	-	-	-		
	Woonstraat/Winkelstraat		ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-	-		
Landelijke weg	Algemeen	Algemeen	Buiten bebouwde kom	(3)	0,30	0,40	0,35	20	-	-	-	-	-	-	-	
			Aanliggend fietspad	-	(3)	CE Klasse van aanliggende rijweg - 1										
Andere	-	-	Vrijliggend fietspad Voetpad (naast weg) Wandelweg Voetgangers- en fietsbrug	(3)	S4	-	-	-	-	5	-	1	-	-	-	
			Zone 30	(3)	CE4	-	-	-	-	10	0,40	-	-	-	-	
			Voetgangerszone, voetgangersweg en woonerf	(3)	CE4 [ES5]	-	-	-	-	10	0,40	-	-	-	[2]	
			Plein	(3)	S4 [ES7]	-	-	-	-	5	-	1	-	-	[1]	
			Handels- en historische centra	(3)	CE3 [ES4]	-	-	-	-	15	0,40	-	-	-	[3]	
			Onderdoorgangen voetgangers en fietsers	Nacht	-	-	-	-	-	100	-	-	-	-	-	10
				Dag	(3)	-	-	-	-	200	-	-	-	-	-	20
Oversteekplaats	(3)	-	-	-	-	-	80	0,30	-	40	-	-				

(2) Een verhoging van 5% van de TI is aanvaardbaar in geval van gebruik van lichtbronnen met lage luminantie (Natrium Lage Druk en Fluorescentie buis), zijnde TI max = 20%

(3) ME6 klas met TI < 20%

(4) Binnen bebouwde kom: < 50 km/h - Buiten bebouwde kom >= 50 km/h

Table 14: Lighting classifications for regional roads, local connections and private roads

For regional roads the performance requirements of NBN EN13201-2 are also translated into the 'StandardSpecification240' in which four categories of roads and spaces are distinguished. This standard defines the following accents: smooth and safe traffic (A), mixed use (B), visual comfort and safety (C) and the need of mood lighting (D).

Synergrid, the Federation of Distribution Network Operators, translated these performance requirements into the 'Typebestek 005 – Equipment for public lighting'. The distribution network operators use this 'Typebestek 005' to design the public lighting on local roads.

In the design of public lighting next standards and manuals are important:

- Vlare II, the Flemish environmental legislation with rules to prevent light pollution.
- CIE-documents. In accordance with the standard 'EN13201-3 Road lighting-Part 3: Performance Calculation' these CIE documents give technical guidelines for designers:
 - Report CIE 126-1997 'Guidelines for minimizing sky glow'.
 - The manual CIE 150:2003 'Guide on the limitation of the effects of obtrusive light from outdoor lighting installations' contains guidelines for designers and governments to limit the sky glow. In this guide techniques are described for lighting systems in relation to the requirements for astronomical observations. The upward flux of luminaires should be avoided in natural areas (environmental zone E1) (0%) and in rural areas (environment zone E2) it must be limited to max 5%.

<u>Environmental zone</u>	<u>Area</u>	<u>Brightness of the environment</u>	<u>Examples</u>
E1	Nature	Dark	Conservation area
E2	Rural	Low artificial brightness in the environment	Industrial, residential and rural areas
E3	Cities	Moderate artificial brightness in the environment	Urban residential areas with potential industry
E4	City centers	High artificial brightness in the environment	City center with a mix of residential and commercial functions

Table 15: Classification in areas for outdoor lighting design

- Evaluation and approval of lighting equipment. With 'Typebestek 005' as guide, Synergrid has made a list of approved luminaires. The distribution network operators preferably use these approved devices.

11.0 Images



Image 9: Wakkerzeelsebaan new scheme



Image 10: Wakkerzeelsebaan existing scheme



Image 11: Wakkerzeelsebaan new scheme

For additional information contact:

BLISS International website: www.bliss-streetlab.eu

INTERLEUVEN
+32 16 235836
milieu@interleuven.be
www.interleuven.be

[Composer report: Stefan Kempeneers](#)
stefan.kempeneers@interleuven.be, [+32 16 284 221](tel:+3216284221)

Eandis
+32 78 35 35 34
www.eandis.be

[Technical support: Marc Lemmens](#)
marc.lemmens@eandis.be

BLISS

Better Lighting in Sustainable Streets

Technical Case Study

Stadspark, Aarschot, B

Open Space – city park

21.02.2014

BLISS/IL/8.6/2013/TCS07



gemeente Eindhoven



Better Lighting in Sustainable Streets

BLISS

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Key information

Year	2013
Theme	People
Scheme type	Open Space
Scheme location	Aarschot, Belgium
Crime rate	Low
Existing installation	70W MHHP-TC
Main consideration	Renovation
New installation	LED luminaire
Distribution Network Operator EANDIS	



1.0 Background

The principal aim of this investment was to replace the existing lighting in the city park of Aarschot. The existing lighting has become obsolete and inefficient. The old installation provides poor colour rendition and overall illumination of the area. The replacement with modern street lighting luminaires will offer improved efficiency, light characteristics and control (dimming) with a minimal energy usage and costs. The new installation has to reduce light pollution in the city park.

This investment includes the installation of new lighting scheme incorporating 77W LED (warm white light source) within a conventional side entry luminaire with a 5 meter mounting height to replace the existing installation.

1.1 Site description



The city of Aarschot has a population of 28,100 people and is situated 12.4 miles (20 km) from Leuven. City parks and green spaces have an important function in urban agglomerations. A park has primarily a recreational function for the visitors. This city park, located in the city centre, has also a very important functional value: it is a transit route (footpath) from the center (Grote Markt) to the town hall and the Capucienenklooster, an old monastery that now houses the municipal academy of art and several meeting and conference rooms. This building is being renovated for the moment.

Due to the vision of the city government, the uniformity in the surroundings of the city park and the town hall, is an important issue. The footpath on the other side of the river Demer is equipped with LED luminaires. Therefore, the city government has chosen to replace the existing city park lighting installation with LED luminaires.



Image 1: Aarschot, renovation of the city park



Image 2: Aarschot city park, renovation of the municipal academy of art

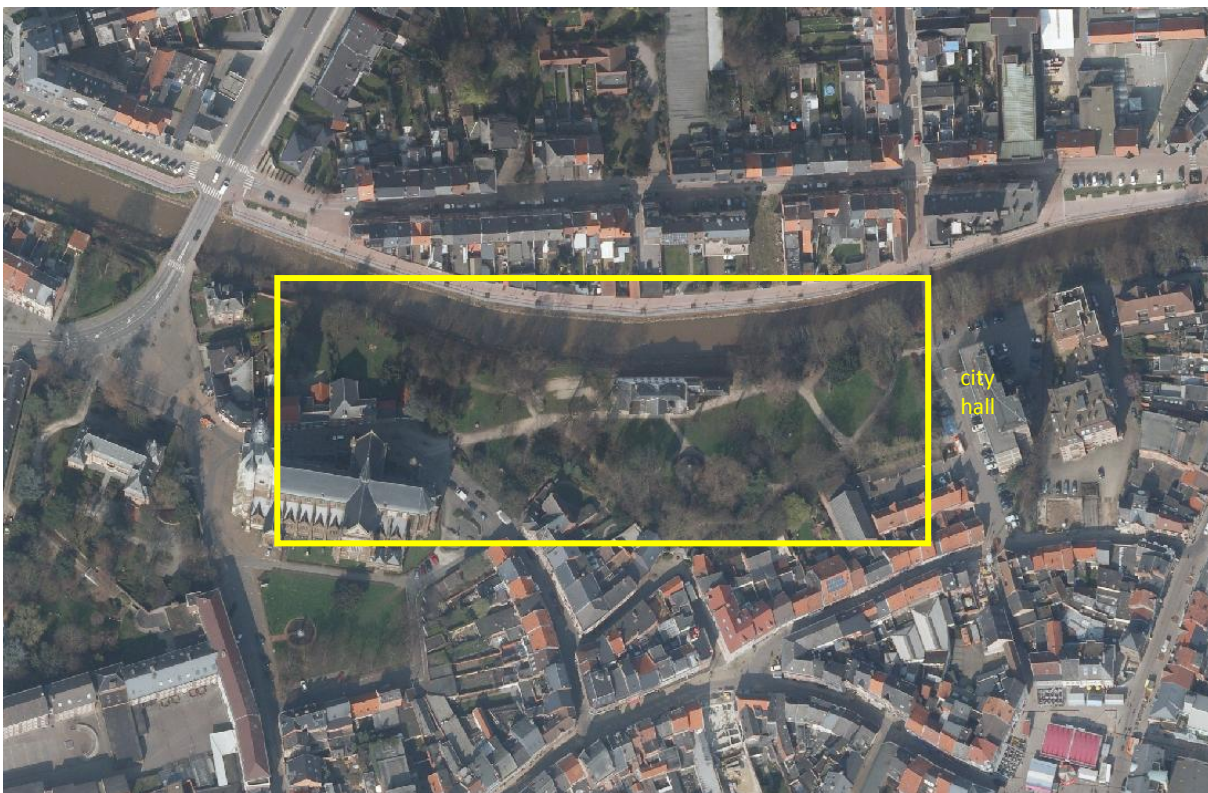


Image 3: aerial view (Middenschalige orthofotomozaïek, Vlaanderen, winteropnames (wordt jaarlijks vernieuwd), geldig op datum van vandaag 22/11/2013, AGIV en Provincie Vlaams-Brabant.

1.2 Crime considerations



Before (3 years): **low**
After (2 years): **not available**

Only those facts of crime in which the illumination of the street/park is relevant, are retained in these considerations: burglaries, car-thefts, car break-ins, bike thefts, vandalism, drug offenses, sexual offenses and arson; were also deter illegal dumping and graffiti.

In certain cases, we can't say if certain facts are street/park related or not. These facts were considered as possibly street related and are not included in the figures.¹³

The crime rates in the city park of Aarschot are very low, because there is a lot of social control during the evening periods: people going to the academy of art, people going to the city hall, ...

Aarschot - stadspark	crime - street related							
	2010	2011	2012	before	2013	2014	2015	after
DARK	0	1	1	2				
DUSK	0	0	0	0				
SEMI-DUSK	0	1	0	1				
	0	2	1	3				

Table 1: Crime – street related - figures

This investment was realised in December 2013. At this moment (January 2014) no crime data are yet available.

1.3 Accident considerations



Before (4 years): **inapplicable**
 After (2 years): **inapplicable**

Because traffic is not allowed in the city park of Aarschot, there are no accidents.¹⁴

1.4 Social demographic considerations



The information below shows key social economic data covering the area which helps to develop a representation of the potential activity in the hours of darkness.

Gender and age – Information obtained from the National Register – Rijksregister, verwerking door Steunpunt Sociale Planning (01.01.2013) - shows that the gender are fairly evenly divided. The age profiles show a majority of people in the age range of 30-44 and 45-64 years.

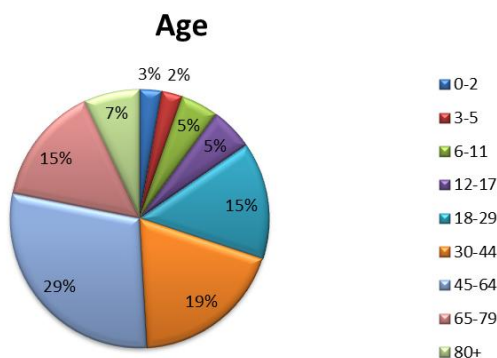


Chart 1: Age

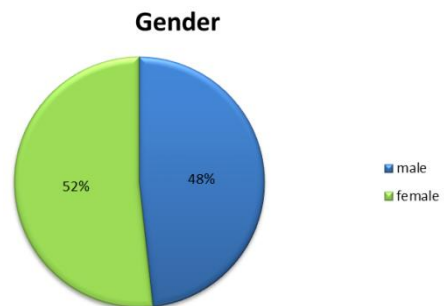


Chart 2: Gender

¹³ Projectzone: ANG periode 2007-2012, extractie 9 sep 2013

¹⁴ FedPol/CGOP/B, periode 2007-2012 (PV-gegevens).

Social economic – Information obtained from “Kruispuntbank van de sociale zekerheid”(31.12.2010) shows that the groups ‘salaried employees’, ‘children’ and ‘retired’ are the most common groups in the region of this investment.

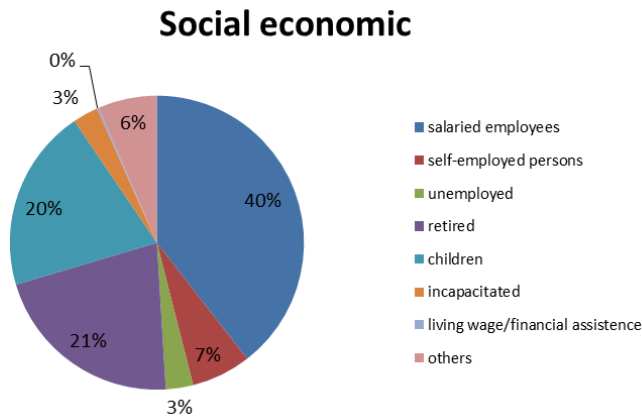


Chart 3: Social economic data

2.0 Existing installation

No.	Age	Column type	Luminaire	Arrangement	Light source & wattage	Colour temperature (K)	CRI (Ra)	Efficacy (lm/w)	Energy consumption
32	20 years	5m aluminium pole	Conventional deep bowl	Staggered, rear of footway	32no. 70W MHHP-TC	1800K Warm white	N/A	N/A	8,960 kWh, 1,881 Kgs

Table 2: Existing installation information

The existing luminaires provided poor optical control and had reached the end of their useful life. The existing park lighting has become obsolete and inefficient. Together with the renovation of the old monastery (academy of art), the new lighting installation must give the visitors a very comfortable and safe feeling.

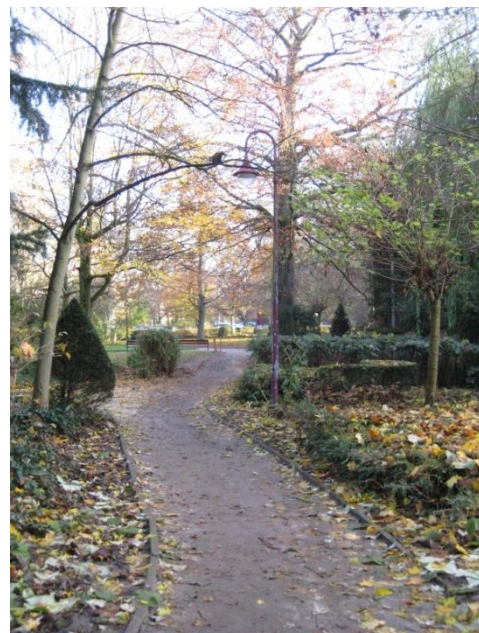


Image 4 and 5: Aarschot city park, existing scheme

The designers had also to look at:

- the vision of the city government and the uniformity in the surroundings of the city park.
- the safety considerations and the safety feeling of the visitors in the park.

The rate of deterioration had continued and the installation was identified as being inefficient with respect to:

- ★ Poor colour rendering properties of the 70W MHHP-TC lamps
- ★ Deteriorating lumen output
- ★ Increased number of reactive maintenance visits
- ★ High energy consumption

3.0 Design development

Selection of the appropriate lighting classification;










Criteria	Description	Notes
 Road type	N/A	Open space, city park. No traffic road. Only footways.
 Traffic flow	N/A	No traffic in the city park.
 Crime rate	Low	Low identified for the city park prior to scheme installation (but high feeling of insecurity). No monitoring by any local authority CCTV surveillance equipment present.
 Colour rendition	Ra ≥ 60	Ra ≥ 60 chosen as appropriate for facial recognition, LED white light sources in the new scheme.
 Environmental zone	E3	City area. Medium artificial brightness in the environment. City park in small town centre. Further details regarding sustainability can be found in section 6.0.
 Safe ease of passage	Generally good	Pedestrian ease of passage good; Pedestrian footfall low, adequate footpaths, general visibility good, public transport links in surrounding area.
 Design uniformity	Not specified in standards	In a city park area an overall uniformity of illuminance (Uo) is preferred (*).
 Control method	50% lumen output 22:00 – 06:00	Autonomous variable light control method with LED luminaires; Low pedestrian and traffic flow, especially during the hours of darkness, medium crime rate, colour rendering index ≥ 60.
 Electricity supply	Distribution Network Operator	DNO low voltage system supply for public lighting use only (230V) continuous throughout the site.

Table 3: Primary and secondary design factors

(*) The following design standard was utilised within the design process in 2011/2012:

- ★ NBN EN 13201: A Belgian standard as result of the translation of a European standard.

For this type of area, a park in a city center, and with consideration to the criteria above, a ME6 lighting classification was chosen to provide an appropriate level of illumination (see table 13 on page 16). The designers focussed on next characteristics: $T_i \leq 20\%$ and an average of 0.75 cd/m^2 .

Due to the vision of the city government, the uniformity in the surroundings of the city park and the town hall is very important. Therefore, the designers have chosen LED luminaires, in accordance with the LED lighting installation on the other side of the river Demer. Along this river is a footway that leads to the city park and the town hall.

The distribution network operator Eandis proposed some standardized LED luminaires to the city government. They have chosen the attractive Schröder Perla luminaires with 64 LEDs.

4.0 Total Cost of Ownership

To support the lighting design process a Total Cost of Ownership evaluation has to be made. This would determine which solution offered the most effective whole life cost. However, due to the vision of the city government, the uniformity in the surroundings of the city park and the town hall is very important. Therefore, the designers have chosen LED luminaires, in accordance with the LED lighting installation on the other side of the river Demer.

Finally, the Distribution Network Operator Eandis has proposed a dimming system. The city government has agreed with this solution.

4.1 Initial capital expenditure

Three elements were considered:

- Site clearance costs of the existing installation
- Supply and installation of the equipment (luminaire, lamp, column and control)
- Electrical works (Distribution Network Operator, Private Network Cable)

Option	No.	Capital cost
LED 77W	25	€ 57,767
LED 77W	25	€ 57,767

Table 4: Initial capital expenditure

Remark: The capital cost includes a dimming option. Eandis demands of the suppliers that each luminaire has a dimming system. Luminaires without a dimming option are refused.

4.2 Energy provision

The energy provision was calculated using a cost per kWh based on Estimated Actual Consumption at commission year, excluding inflation and taxation:

- Energy cost per kWh = € 0.20
- Burning hours = 4,200 per year
- Dimmed hours = 2,100 (7 days per day)
- Carbon = 0.23 Kgs per kWh
 - www.synerggrid.be – Impact of efficient public lighting on CO₂emissions – CE4-N35N-13.05.2009
- 50% reduced lumen output between 22:00 – 06:00

Option	No.	Energy	% saving	Annual cost
LED 77W	25	7,700 kWh 1,617 Kgs		€ 1,540
LED 77Wwith dimming	25	4,235 kWh 889 Kgs	45%	€ 847
Final design LED with dimming	25	4,235 kWh 889 Kgs	45%	€ 847

Table 5: Energy provision

4.3 Maintenance strategy

Planned maintenance regimes were considered:

cyclic activities (lamp replacement, luminaire cleaning and structural inspection), electrical testing and inspection regimes.

A four year cyclic maintenance programme is applied to the CPO scheme. No additional LED module replacement cost was included in the evaluation.

Option	No.	Cost per luminaire	Cost per scheme
LED 77W with dimming	25	€ 360	€ 9,000
Final design LED 77W with dimming	25	€ 360	€ 9,000

Table 6: Maintenance operations

Normally the municipality pays a maintenance fee of € 250 per luminaire, only if it is a standardized luminaire according to the standards of Synergrid, the Federation of Distribution Network Operators (see chapter 10.0 page 17 - 'Typebestek 005 – Equipment for public lighting'). The distribution network operators use this standard to design the public lighting on local roads. The luminaire used in this investment is not a standardized type. That means a higher maintenance cost of € 368 per luminaire.

4.4 Total Cost of Ownership 25-year expenditure

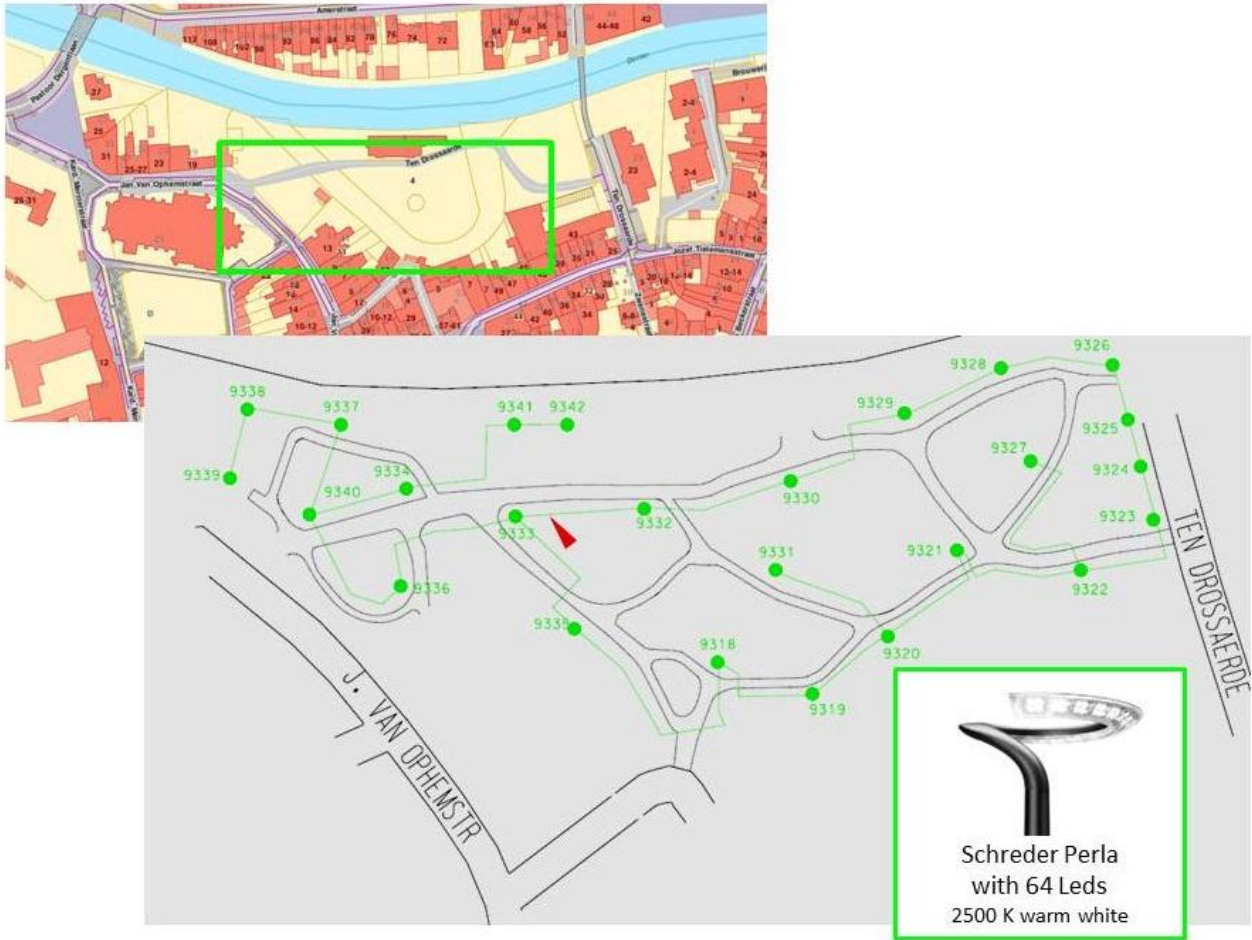
Table 7 outlines the total predicted expenditure over a 25-year life cycle.

Option	Initial capital costs	Energy costs	Maintenance costs	Whole life cost
LED 77W with dimming	€ 57,767	€ 38,500	€ 9,000	€ 105,267
Final design LED 77W with dimming	€ 57,767	€ 38,500	€ 9,000	€ 105,267

Table 7: TCO 25-year expenditure

The results indicate that an LED scheme is a cost effective solution. The LED scheme has high initial capital costs, however the energy and maintenance costs are significantly reduced compared to a conventional scheme. The scheme also performs well in terms of reduced energy and maintenance costs.

5.0 Designspecification



Plan 1: Detailed design specification



Image 6: Schröder Perla with 64 LEDs, 2500K warm white



Image 7: Schröder Perla luminaires in the city park of Aarschot

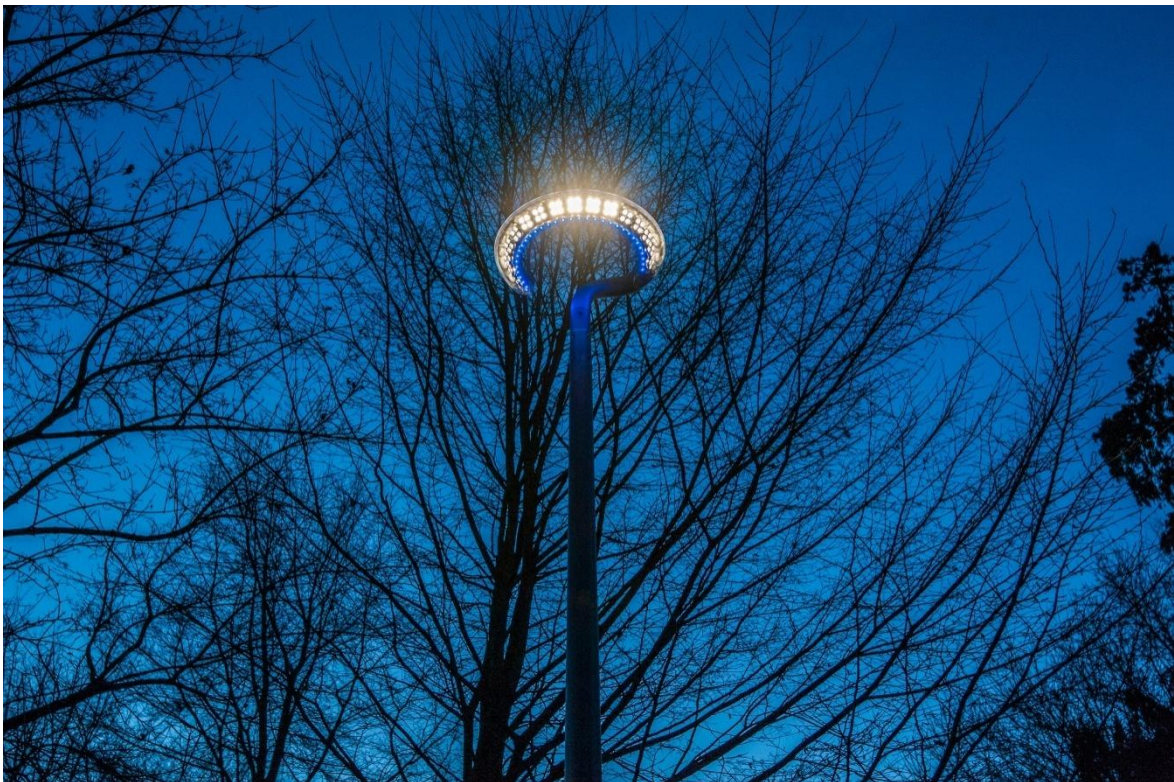


Image 8: Schröder Perla luminaires in the city park of Aarschot

6.0 Sustainability



6.1 Energy

Predicted energy calculations were produced based on manufacturers' technical specifications to ensure that the new installation achieved a significant energy reduction, in accordance with the BLISS project aims.

Installed power (Watts)	
Before	2,240 W
After (with dimming)	962 W
Savings (%)	1,278W (53%)

Table 8: Installed power

Energy consumption, CO ₂ emissions and savings per year (kWh, Kg CO ₂)		
Before	8,960 kWh	1,881 Kgs
After (with dimming)	4,235 kWh	889 Kgs
Savings (%)	4,725 kWh (53%)	992 Kgs (53%)

Table 9: Energy consumption

As identified in table 9, the use of more efficient light sources and control gear will reduce the energy consumption of street lighting, thereby reducing CO₂ emissions to generate the electricity whilst reducing the life cycle of the fuel and maintenance requirements.

6.2 Materials



The luminaire housings are made from aluminium (powder coated aluminum) with glass protectors (slightly curved glass), which are both highly recyclable. The distribution network operator Eandis, responsible for this BLISS-investment, has a strict environmental policy. The manufacturers of lighting equipment are required to strictly follow the rules concerning recycling and the environment.



DNO Eandis also imposes requirements regarding light pollution and sky glow. The manufacturer of the luminaires has to produce a very directional light source and produce minimal upward light, reducing the contribution to obtrusive light and sky glow. These kind of luminaires have no adverse effects on the local ecology.

6.3 Obtrusive light considerations



The environmental zone E3 'City area (Moderate artificial brightness in the environment)', was selected for this area. Specific criteria from the manual CIE 150:2003 (*) relating to obtrusive light considerations were utilised during the equipment selection process.

(*) The manual CIE 150:2003 'Guide on the limitation of the effects of obtrusive light from outdoor lighting installations' contains guidelines for designers and governments to limit the sky glow (see 10.0).

7.0 Interleuven stakeholder research

On a Monday evening in December 2013 (pre) and January 2014 (post), some employees of Interleuven organised a survey in the city park of Aarschot. People passing the park and the footpath near the river Demer and visitors of the town hall (opened during Monday evening) were asked to comment the pre and post installations.

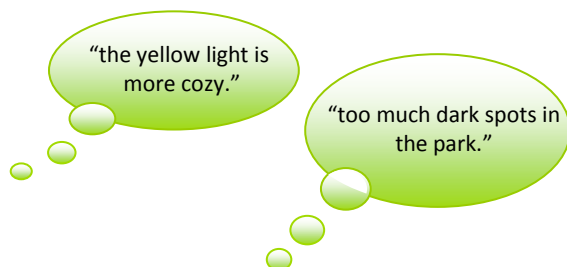
In December 2013 15 people answered the pre survey, in January 2014 23 persons responded the post survey.



Pre works survey

- ★ 33% of the people felt safe walking alone during the night
- ★ 27% felt that the old installation was 'comfortable on the eye'
- ★ 20% stated the old installation shows up the whole footpath well
- ★ 7% can see people at a distance clearly and 33% has no problem to see obstacles on the ground
- ★ 73% of the people stated that the old lighting installation was too dark
- ★ 60% says that the old installation doesn't show the colours properly

Additional residents' comments:



Post works survey

- ★ 30% of the people felt safe walking alone during the night
- ★ 83% felt that the new installation is 'comfortable on the eye'
- ★ 74% stated the new installation shows up the whole street well
- ★ 74% can see people at a distance clearly and also 91% has no problem to see obstacles on the ground
- ★ 14% of the people stated that the new lighting installation is still too dark
- ★ 45% says that the new installation doesn't show the colours properly

Additional residents' comments:



Remark! A lot of people don't feel safe in the park, day and evening/night. The crime rate is low, but the feeling of insecurity is high. The new lighting system has not always an effect on it. When someone feels insecure during the day, a new lighting installation don't give a better feeling.

'How does the new street lighting compare with the previous street lighting?'

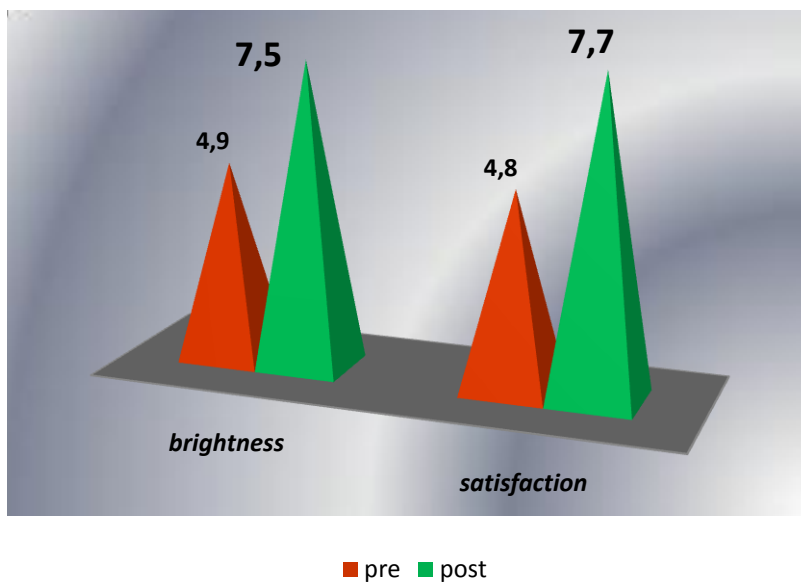
For 95% of the respondents the new lighting installation is an improvement.



... and using a scale of 1 to 10 ...

... how bright is the street lighting

... how satisfied you are with the lighting



8.0 Results

A summary of the results:

		Before	After	Outcome
53%	Calculated energy	8,960 kWh 4,235 Kgs of CO ₂	1,881 kWh 889 Kgs of CO ₂	53% energy saving
	Number of luminaires	32no.70W MHHP-TC	25noLED	Decreased units
	Calculated colour rendition	Ra ≤ 20	Ra ≥ 60	Improved colour rendition
	Calculated colour temperature	1800K Warm white	2500K Warm white	Improved appearance




	Control regime	None	50% 22:00 – 06:00	Improved functionality
	Interleuven research	<ul style="list-style-type: none"> ★ 33% felt safe alone at night ★ 80% poor visibility ★ 27% 'comfortable on the eye' ★ 73% say it's too dark ★ Satisfaction 4.8 	<ul style="list-style-type: none"> ★ 30% felt safe alone at night ★ 26% poor visibility ★ 83% 'comfortable on the eye' ★ 14% say it's too dark ★ Satisfaction 7.7 	Improved perception
	Measured crime	Low	Low	N/A

Table 10: Results

9.0 Conclusion

The primary objective of the new lighting scheme in the city park of Aarschot was to evaluate the effectiveness of available LED technology, ensuring sustainability whilst gaining public acceptance. All performance aspects of the new luminaires as detailed in section 8.0 performed well, including reported energy savings of 53%, improved colour rendition and improved lighting levels aiding the visual task for pedestrians.

Due to the vision of the city government, the uniformity in the surroundings of the city park and the town hall, is an important issue. The footpath on the other side of the river Demer is equipped with LED luminaires. Therefore, the city government has chosen to replace the existing city park lighting installation with LED luminaires.

The scheme aimed to create an environment that increased the feelings of safety. Records indicate that the crime rate is rather low in this area, but there is a high feeling of insecurity among the respondents of the survey. At first sight the new lighting scheme has not changed the feeling of the respondents. Even during day time this feeling is dominant.

The recorded demographics give an indication of the social profile of the city of Aarschot. The majority of people are in the age ranges of 30 – 44 and 45 – 64. 40% of the people are 'salaried employees' what may mean that these people visit the town hall during the evening opening hours and that they may use the footway through the city park. A good lighting installation is important for them. Most of the visitors of the city park (town hall, academy, ...) are residents from Aarschot what may mean that they are more aware of their neighbourhood in terms of aesthetics and crime prevention.

To support the lighting design process a Total Cost of Ownership evaluation has to be made. This would determine which solution offered the most effective whole life cost. However, due to the uniformity in the city centre a LED 77W lamp was chosen. Additionally the Distribution Network Operator Eandis has proposed a dimming system: the lumen output will be reduced with 50% between 22:00 and 06:00. The calculated energy saving is 53%.

Lighting can only be evaluated by stakeholder opinions and technical evaluation, there is no practical way to evaluate if the new lighting increases social activity, encouraging residents to make use of their local amenities during the hours of darkness. However respondents' comments suggest that some may feel more confident to use local facilities during the hours of darkness.

No negative comments or results have been obtained in relation to the reduction in lumen output to 50% between 22:00 – 06:00, following evaluation of the postal survey. Respondents generally appeared to be more concerned about the appearance and safety of where they live, and many may see the lighting as a vital part of this security and the overall perception of their surrounding area. This may suggest a shift towards a more objective lighting design with careful consideration for social issues, in addition to the technical requirements.

In conclusion, the change to warm white LED-light appears to have had a positive impact on residents' perceptions of their environment during the hours of darkness. Careful consideration should be made based on a number of detailed location criteria before changing to white light, including financial and environmental considerations. White light provides improved colour rendition with a predominantly warm white colour temperature, which may help to discourage night crime issues.

10.0 Standards

For several types of spaces, several European and Belgian standards are applicable. This chapter provides a brief overview of legislation and standards used in the development of lighting projects in Flanders/Belgium.

EN 13201 standard for public lighting.

Part 2 of this European standard, the performance requirements, has been translated into a Belgian standard NBN EN 13201-2. Part 1 of the European standard concerning the 'selection of the lighting classifications' is not yet translated into a Belgian standard. The 'Belgisch Instituut voor Verlichting BIV' is investigating this part of the European standard.

This standard establishes minimum levels of illumination that are necessary when a road is illuminated. Go below this minimum (eg dimming) is possible, but it happens, just like the whole of the public lighting on the responsibility of the road authority.

In the selection of lighting classes a distinction is made between:

- The (regional) roads/primary roads and secondary roads both with a specified minimum value for luminance or illuminance,
- The (public or private) local connection or access roads (each inside and outside the village) for which minimum luminance values are indicated
- and a series of other (including bicycle paths, 30 kph zones, pedestrian areas, squares, ...) for which minimum illuminance values are specified.

Regional roads.

Categorie	Functie	Subcategorie	CEN Klasse	L _{gem} [cd/m ²]	U ₁	U ₀	TI max [%] (2)	SR	E _h gem [lux]	U ₀ [E]	E _h min [lux]	E _v gem [lux]	E _v min [lux]	E _{sc} min [lux]
Hoofdweg / Primaire weg	Verbinden op internationaal en gewestelijk niveau	Conflictzones (ring, toelidingswegen...)	(1)	1,5	0,60	0,40	15	-	-	-	-	-	-	-
		Doorgaande wegsecties	ME3b	1,0	0,60	0,40	15	0,50	-	-	-	-	-	-
	Verzamelen op gewestelijk niveau	Rotondes	CE1	-	-	-	-	-	30	0,40	-	-	-	-
		Kruispunt primaire wegen	CE2	-	-	-	-	-	20	0,40	-	-	-	-
Secundaire weg	Verbinden (I) of verzamelen (II) op lokaal en bovenlokaal niveau	Conflictzones (ring, toelidingswegen...)	ME3b	1,0	0,60	0,40	15	0,50	-	-	-	-	-	-
		Rotondes	CE1	-	-	-	-	-	30	0,40	-	-	-	-
		Kruispunt primaire wegen	CE3	-	-	-	-	-	15	0,40	-	-	-	-

(1) Klasse ME3b met $L \geq 1,5 \text{ cd/m}^2$

(2) Een verhoging van 5% van de TI is aanvaardbaar in geval van gebruik van lichtbronnen met lage luminantie (Natrium Lage Druk en Fluorescentie buis), zijnde TI max = 20%

Table 11: Lighting classifications for regional roads

Regional roads, local connections or private roads.

Categorie	Functie	Subcategorie	Situatie (4)	CEN Klasse	L _{gem} [cd/m ²]	U _i	U _o	TI max [%] (2)	SR	E _g gem [lux]	U _o [E]	E _g min [lux]	E _v gem [lux]	E _v min [lux]	E _{sc} min [lux]			
Lokale verbindingsweg	Verbinden op lokaal niveau	Algemeen	Buiten bebouwde kom	ME4a	0,75	0,60	0,40	15	0,50	-	-	-	-	-	-			
			Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	-			
Lokale gebiedsontsluitingsweg	Ontsluiten (verzamelen en verdelen) op lokaal niveau	Algemeen	Buiten bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-	-			
			Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-	-			
Erftoegangs weg	Veel bebouwing	Verblijven en toegang verlenen tot de aanpalende percelen	Woonstraat/Ventweg	Buiten bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-			
			Woonstraat/Winkelstraat	Binnen bebouwde kom	ME3b	1,00	0,60	0,40	15	0,50	-	-	-	-	-			
	Weinig bebouwing		Woonstraat/Ventweg	Buiten bebouwde kom	ME5	0,50	0,40	0,35	15	0,50	-	-	-	-	-			
			Woonstraat/Winkelstraat	Binnen bebouwde kom	ME4b	0,75	0,50	0,40	15	0,50	-	-	-	-	-			
Landelijke weg	Algemeen	Algemeen	Buiten bebouwde kom	(3)	0,30	0,40	0,35	20	-	-	-	-	-	-				
Andere	-	-	Aanliggend fietspad	-	(3)	CE Klasse van aanliggende rijweg -1												
			Vrijliggend fietspad Voetpad (naast weg) Wandelweg Voetgangers- en fietsbrug	-	(3)	S4	-	-	-	-	5	-	1	-	-	-		
			Zone 30	-	(3)	CE4	-	-	-	-	10	0,40	-	-	-	-		
			Voetgangerszone, voetgangersweg en woonerf	-	(3)	CE4 [ES5]	-	-	-	-	10	0,40	-	-	-	-	[2]	
			Plein	-	(3)	S4 [ES7]	-	-	-	-	5	-	1	-	-	-	[1]	
			Handels- en historische centra	-	(3)	CE3 [ES4]	-	-	-	-	15	0,40	-	-	-	-	[3]	
			Onderdoorgangen voetgangers en fietsers	Nacht	-	-	-	-	-	-	100	-	-	-	-	-	-	10
				Dag	(3)	-	-	-	-	-	200	-	-	-	-	-	-	20
Oversteekplaats	-	(3)	-	-	-	-	-	80	0,30	-	40	-	-	-				

(2) Een verhoging van 5% van de TI is aanvaardbaar in geval van gebruik van lichtbronnen met lage luminantie (Natrium Lage Druk en Fluorescentie buis), zijnde TI max = 20%

(3) ME6 Klas met TI <= 20%

(4) Binnen bebouwde kom: <= 50 km/h - Buiten bebouwde kom >= 50 km/h

Table 12: Lighting classifications for regional roads, local connections and private roads

For regional roads the performance requirements of NBN EN13201-2 are also translated into the 'Standard Specification 240' in which four categories of roads and spaces are distinguished. This standard defines the following accents: smooth and safe traffic (A), mixed use (B), visual comfort and safety (C) and the need of mood lighting (D).

Synergrid, the Federation of Distribution Network Operators, translated these performance requirements into the 'Typebestek 005 – Equipment for public lighting'. The distribution network operators use this 'Typebestek 005' to design the public lighting on local roads.

In the design of public lighting next standards and manuals are important:

- Vlarem II, the Flemish environmental legislation with rules to prevent light pollution.
- CIE-documents. In accordance with the standard 'EN13201-3 Road lighting-Part 3: Performance Calculation' these CIE documents give technical guidelines for designers:
 - Report CIE 126-1997 'Guidelines for minimizing sky glow'.
 - The manual CIE 150:2003 'Guide on the limitation of the effects of obtrusive light from outdoor lighting installations' contains guidelines for designers and governments to limit the sky glow. In this guide techniques are described for lighting systems in relation to the requirements for astronomical observations. The upward flux of luminaires should be avoided in natural areas (environmental zone E1) (0%) and in rural areas (environment zone E2) it must be limited to max 5%.

<u>Environmental zone</u>	<u>Area</u>	<u>Brightness of the environment</u>	<u>Examples</u>
E1	Nature	Dark	Conservation area
E2	Rural	Low artificial brightness in the environment	Industrial, residential and rural areas
E3	Cities	Moderate artificial brightness in the environment	Urban residential areas with potential industry
E4	City centers	High artificial brightness in the environment	City center with a mix of residential and commercial functions

Table 13: Classification in areas for outdoor lighting design

- Evaluation and approval of lighting equipment. With 'Typebestek 005' as guide, Synergrid has made a list of approved luminaires. The distribution network operators preferably use these approved devices.

11.0 Images



Image 9: Aarschot city park, existing scheme



Image 10: City park of Aarschot, new lighting scheme



Image 11: Schröder Perla luminaires in the city park of Aarschot



Image 12 and 13: Schröder Perla luminaires in the city park of Aarschot

For additional information contact:

BLISS International website: www.bliss-streetlab.eu

INTERLEUVEN
+32 16 235836
milieu@interleuven.be
www.interleuven.be

[Composer report: Stefan Kempeneers](#)
stefan.kempeneers@interleuven.be, +32 16 284 221

Eandis
+32 78 35 35 34
www.eandis.be

[Technical support: Marc Lemmens](#)
marc.lemmens@eandis.be

This publication has been compiled by the BLISS partners; St. Helens Council, Eindhoven, Interleuven and Stadt Kaiserslautern. Preface by Allen Creedy, partner of Ethical Partnership. Allen is an European specialist in Sustainability and Urban Planning. www.ethicalpartnership.co.uk

*Graphic design and layout cover and backside:
José van den Boom, City of Eindhoven, assisted by Denise van der Net, FabContent.*

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*St.Helens
Mark Davies
Bernadette Latham
Rory Lingham
Bill May
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John Sheward
Kathryn Williams*

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Alwin Beernink
Serge van den Berg
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Sus Bergmans
Sabrina De Donder
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Hugo Reynaerts
Willy Vlaeyen*

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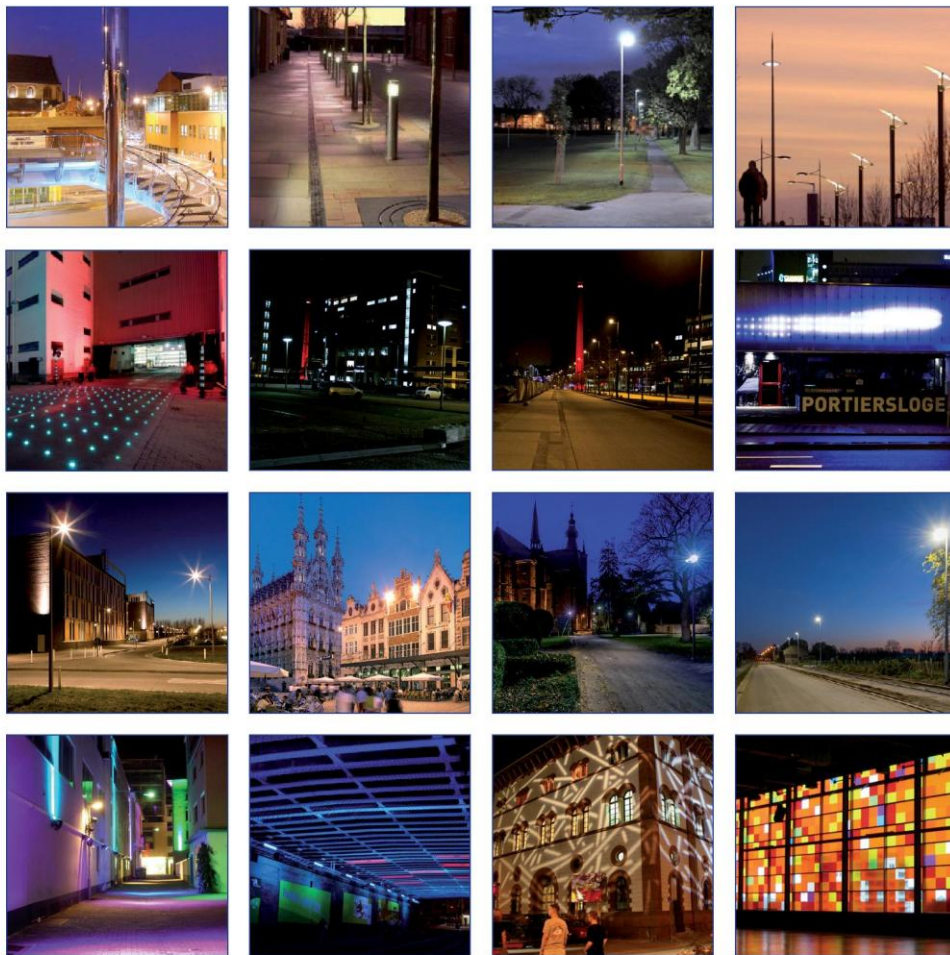
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