



White light

Transforming your urban nightscape

PHILIPS

sense and simplicity



This brochure gives you an indication of the many ways in which white light can transform urban streets at night. And by 'transform' we don't mean only aesthetically, but also in terms of safety, security and energy efficiency.

The brochure is divided into two sections. The first section gives a general overview of the various benefits offered by white light, while the second contains research and other data that validate these claims.

Contents

Section 1

Beating the darkness	page 4 - 5
A new era in outdoor lighting	page 6 - 7
Aesthetic enhancement	page 8 - 9
Security	page 10 - 11
Accident prevention	page 12 - 14
Energy efficiency	page 15

Section 2

Aesthetic enhancement	page 16 - 18
Security	page 19 - 23
Accident prevention	page 24 - 25
Energy efficiency	page 26 - 28
Product overview lamps	page 29 - 31
Product overview luminaires	page 32 - 33
Product overview LED	page 34



Plaza de la Libertad, Porto, Portugal

Beating the darkness

Daylight. One of the most fundamental components of our lives. It is dynamic, invigorating, surprising, life-giving. And despite its ever-changing nature, it is also used as the reference for all other types of lighting.



When there is insufficient or no daylight, we have to rely on alternatives to illuminate our world. As far back as 1417, lanterns with candles inside were used on the streets of London during winter nights. The subsequent invention of gas, oil and finally electric street lighting helped bring urban areas out of the dark ages. Today, billions of people take street lighting for granted.

Historical context of yellow light

High-pressure sodium lamps have often been first choice in street lighting for a number of years, basically because they produce high levels of illumination for a given amount of energy and have a long, reliable lifespan. However, their distinctive yellow/orange light makes it difficult to distinguish colours. The unnatural tint of our urban streets at night time is something we have mainly got used to through necessity rather than choice.

“High-pressure and low-pressure sodium must not be used for any new lighting, as the yellow light gives poor colour rendering.”

Spokesperson for Camden Borough Council, London, England



Situation before with high-pressure sodium
Eindhoven, The Netherlands



Situation after with MASTER CityWhite

The changing role of outdoor lighting

The role of outdoor (street) lighting has evolved over the years. Its function in the 1930s was to make driving safer. Three decades later it also provided visual comfort for motorists. By the 1980s street lighting had an additional role; increasing pedestrians' feeling of safety. Nowadays, lighting is often central in helping create more liveable and inviting streets with a better ambience.



Placencia, Spain

A new era in outdoor lighting

Today, outdoor lighting solutions no longer have to rely only on yellow light. There is an alternative which is much more successful in combining the qualities of daylight with the energy efficiency associated with high-pressure sodium. This alternative is high quality white light.

White light offers many clear benefits when compared to yellow light. For a start, the ambience is perceived as being brighter and natural. Various tests have shown that a considerable majority of people find it preferable and more pleasant*.

This greater clarity also gives a general feeling of improved security. Easier recognition of people's faces and other details can act as a deterrent to crime, and also help generate sharper CCTV (Closed Circuit Television, for example security cameras) images.



By increasing visibility for motorists, pedestrians and cyclists, the roads become safer as well. Research has shown that white light enables drivers to see movement at the roadside from a greater distance, giving them more time to brake.

And that's not all. Modern white light sources have comparable or even better energy efficiency than high-pressure sodium lamps. In addition, the latest independent research shows that white light sources are visually more effective than yellow sources at the typical lighting levels used outdoors at night. That means you can dim lamps or even use lower wattage alternatives - both of which equate to lower energy consumption - while producing the same perceivable result. A CIE** technical committee is currently working on recommendations for white light, which takes the spectral sensitivity of the eye at low lighting levels into account.

Each of these benefits - aesthetic enhancement, security, accident prevention and energy efficiency - is explained in greater detail on the following pages.

“We wanted to use white light, not only to improve amenities for residents and visitors but because it plays an important part in accident reduction. It also helps us and our police to fight crime by providing much better pictures from our CCTV equipment.”

Terry Felstead, street lighting manager for London's Royal Borough of Kensington and Chelsea, England, on the Philips lamps and gear installed on Ladbroke Grove, one of the city's main thoroughfares



* The results of this and other relevant research that backs up the claims made about white light are in section 2 of this brochure.

** Commission Internationale de l'Eclairage (International Commission on Illumination) is an independent, non-profit organisation devoted to worldwide cooperation and the exchange of information on all matters relating to the science and art of light and lighting, colour and vision, and image technology.



Saint Michaels quarter, Ghent, Belgium

Aesthetic enhancement

Bringing out the best in buildings, streets and other features of the urban nightscape

White light is not the only choice for lighting up the urban landscape at night. There are also other options available, and invariably a combination of different lamp types is used.



“We are very satisfied indeed. The lighting complies with our strict aesthetic requirements. The white light is closer to natural vision, which increases the feeling of safety and the quality of life for local inhabitants - as well as increasing property values in the area.”

President of the Somosaguas Neighbourhood Association, Madrid, Spain

However, few - if any - offer the flexibility of white light. It is suitable for general ambience, floodlighting, illuminating facades and many other applications. It is equally effective complementing modern construction materials like glass, steel and polished stone as it is highlighting classical structures. It even gives (landscaped) greenery a healthy, verdant look.

Yet it is also perfect for functional lighting of streets and communal areas, producing a natural ambience that is generally preferred by many to the traditional yellow glow of sodium; almost 90% of respondents in one recent survey perceived it as being more authentic.

And when you take other benefits into consideration, such as improved safety, heightened feeling of security among pedestrians and low energy use, it becomes clear that using white light really is the undisputed choice for making the streets more liveable and enjoyable.



“The white light floodlighting system emphasises the spacing and nuances in the Palace’s large construction. It gives a lift to the decorative details that were not previously visible in the evening light.”

Architect Johan Celsing commenting on the Philips MASTER CityWhite floodlighting used at the Swedish Royal Palace in Stockholm

Royal Palace, Stockholm, Sweden



Security

Making people feel safer when they go out at night

Many people can be worried about walking through certain streets after dark. Often this has to do with a distrust of the unknown; in poorly-lit areas faces are harder to recognise and you don't know who could be lingering in the shadows. In recent research in Poland, almost three quarters of participants said they feared for their safety when walking in an unlit area.*

* Please see page 19 for more information.



“White light assists in reducing crime by improving lighting levels and increasing facial and colour recognition. This deters criminals and assists the police.”

Spokesperson for Neath Port Talbot Council, Wales

“The improvement in the picture quality of the CCTV footage has improved dramatically with white light. This is a great benefit to us in terms of establishing reliable evidence. Crime in the roughest areas has reduced greatly, and residents feel safer.”

Inspector Jeanette Harris, Avon and Somerset Police Force, commenting on pilot white light projects in Bristol, England



White light improves CCTV (security camera) footage



Clippers Quay, Docklands, London, England

White light is crucial in helping people feel safer when being outdoors at night. Through superior colour rendering and a higher perceived brightness, it becomes easier to distinguish objects, colours, shapes and other details. In particular, facial recognition is easier, even from a distance, which goes a long way towards removing anxiety.

There are no intimidating areas of shadow either, as was shown in a test in China. When asked which light source gave the most even outdoor illumination, everyone participating chose Philips MASTER CosmoWhite lamps over high-pressure sodium discharge.

White light creates what you could call a ‘virtuous circle’. If city dwellers feel safer about their streets, they will use them more often. Having greater numbers of people walking, cycling and playing makes the streets welcoming and less desolate, and should discourage acts of vandalism and crime.



Vechta, Germany

Accident prevention

Making the streets safer for drivers and pedestrians

Improved visibility is a major contributor to road safety. Tests have shown that drivers can detect movement at the roadside faster and from a greater distance with white light. Crucially, this can give them more time to stop if a child, adult, cyclist or animal is about to cross their path, or if another car approaches unexpectedly.

The converse is also true; pedestrians are more likely to see oncoming traffic and react accordingly. White light therefore makes our roads safer and potentially prevents serious injury or even fatalities. This once again contributes to increasing the quality of life enjoyed by residents in built-up areas at night.

There is even emerging research which proves that better visibility also lowers accident rates among pedestrians, because they are less likely to trip over obstacles or uneven surfaces on footpaths and pavements.

“White light improves vision and therefore plays an important part in accident reduction.”

Terry Felstead, street lighting manager for London's Royal Borough of Kensington and Chelsea, England.



Sion, Switzerland



“Visual comfort when driving has been improved, both when identifying other cars and pedestrians. It is our wish that all new lighting installations will be white light.”

Somosaguas Neighbourhood Association private security worker, Madrid, Spain



“Thanks to MASTER CosmoWhite we not only have white light but also an energy saving of 22%.”

Rudy de Bock, public lighting department, Antwerp, Belgium

Energy efficiency

Producing the required amount of light while consuming less power. Save money and the environment!

In the past, one of the main justifications for using high-pressure sodium lighting was energy efficiency. However, ongoing performance improvements mean the latest white light sources (MASTER CosmoWhite - compact ceramic metal halide) are more energy efficient than their sodium counterparts.

These sources are therefore the ‘green switch’ solution for outdoor installations, allowing you to realise significant savings in a number of ways. For instance, it’s possible to specify a greater distance between luminaires in new installations, reduce the mounting height during refurbishment, or install lower wattage lamps in upgrades. That way you have reduced running costs - and CO₂ emissions at a level lower than was previously considered possible - as well as superior light quality.

The distinct advantage of white light is its proven higher perceived brightness. Because white light is experienced as being brighter than yellow light at low light levels, it becomes feasible to actually reduce light output while still giving people what they expect. The savings associated with this are enormous.

This advantage has already been recognised in British lighting standards. In the UK, the level of illumination required by law on subsidiary roads and paths may be reduced by as much as 30% when the light source used has a colour rendering of 60 or more, which is the case with white light (but not with high-pressure sodium).

South Tyneside, England



Frankrijk Lei, Antwerp, Belgium



Breskens, The Netherlands

“I have always been in favour of sensible investments that pay in the long term. If you offset the cost of purchasing the new lighting (MASTER CosmoWhite) against the fact that we save up to 50% on energy consumption, then it is certainly worthwhile. The saving per kilometre is roughly €2000 per year. At current energy prices the investment is fully paid for within eight years.”

Günther Nacke, local government officer responsible for road lighting, Vechta, Germany

Section 2 - Introduction

This section provides more detailed information on research results and other data, to support the claims made on the previous pages on:

- aesthetic enhancement
- security
- accident prevention
- energy efficiency

Note:

As mentioned on pages 4 and 5, yellow light has for some years been the traditional choice for road lighting. One of the most common lamps used for this purpose today is the MASTER SON PIA high-pressure sodium lamp, due to its high efficacy and reliability over lifetime. For this reason, the MASTER SON PIA is used as the reference yellow lamp in all comparisons on the following pages.

Aesthetic enhancement

White light is suitable for many different applications in illuminating the urban nightscape, is perceived by many as being preferable to yellow light, and plays a key role in making streets more liveable and enjoyable.

Measuring people's perception of lighting colour: the EVALUM* field test

Field testing was carried out in 2005 in Lyon, France, by a partnership consisting of the Lyon Public Lighting Department, Philips Lighting, EDF** and ADEME***.

Participants were students living on the INSA campus and residents in the town's so-called '6th district'.

The participants were asked to evaluate various types of lighting by filling out a questionnaire. The results are shown in figure 1.

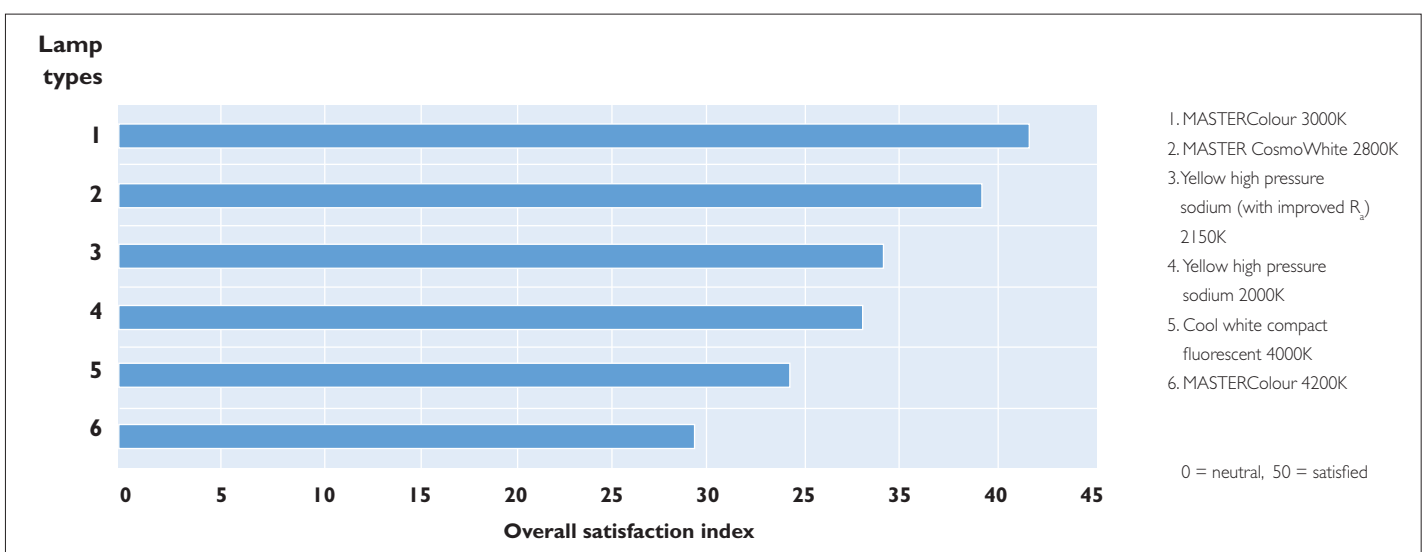


Figure 1: EVALUM test results on perception of lighting colour

There was a clear preference for the kind of warm white light produced by lamps like MASTERColour 3000K and MASTER CosmoWhite. The satisfaction levels of these lamps were higher than those of yellow high-pressure sodium lamps and cold white light (4000-4200K).

* EVALUM: Evaluation de lumières urbaines pour un éclairage durable (Evaluation of Light sources for Sustainable Lighting)

** Électricité de France (EDF): La principale entreprise de production et de distribution d'électricité en France. (Principal enterprise for production and distribution of Electricity in France)

*** ADEME: L'agence de l'environnement et de la maîtrise de l'énergie (Agency for energy management and environment)

**** INSA : Institut National des Sciences Appliquées de Lyon (National Institute for Applied Sciences in Lyon)

Street lighting in China



North Henan Road, Shanghai – yellow high-pressure sodium light (250W)



Qi Pu Road, Shanghai - MASTER CosmoWhite (140W)

White light is ideal for illuminating streets and communal areas. It produces a natural ambience that is preferred by many to the traditional yellow glow of sodium. This and other conclusions can be derived from a survey carried out in 2007 in Shanghai by the Electric Light Research Centre of the FuDan University. The results are given in figure 2.

The survey looks at the lighting of two roads with comparable light levels; North Henan Road, illuminated by 250W high-pressure sodium lamps, and Qi Pu Road, illuminated by 140W MASTER CosmoWhite.

Questions	North Henan Road (yellow high pressure sodium)	Qi Pu Road (white outdoor compact ceramic metal halide)
Which road do you think is more brightly lit?	7.7%	92.3%
Which road has more clearly lit objects when viewed from a similar distance?	3.8%	96.2%
Which road is more evenly illuminated?	0%	100%
Which road is more dazzlingly lit?	57.7%	42.3%
Which road do you think is more uniformly lit between the centre and the side of the road?	11.5%	88.5%
Which road do you think offers a more authentic lighting effect of the persons or objects under the street lamps?	11.5%	88.5%
Which road do you think offers a better and more comfortable environment in general?	7.7%	92.3%

Figure 2: Survey Results, Shanghai, China (n=96)

All people questioned said that the street was more evenly illuminated with MASTER CosmoWhite. Another striking result is that almost 90% of people questioned thought white light was 'more authentic'. An even higher proportion felt that it offered a better and more comfortable environment in general.

Testing levels of perceived brightness

Paired comparison testing was carried out in 2006/2007 at the Lighting Research Center* in Troy, New York, to evaluate the effect of lamp spectra on how people experience the effect of street lighting at night. The research was conducted by Yukio Akashi and John Bullough of the Lighting Research Center.

61 different people, ranging from 16 to 70 years of age, were asked to express a preference for one of two lamp types – MASTER CosmoWhite or yellow high-pressure sodium - when considering the following issues:

- Under which lighting do the objects and street appear brighter?***
- Under which lighting do the objects and street appear more clearly?***
- Under which lighting do the colours of objects, pavement markings, and greenery appear more natural?
- Under which lighting do the colours of objects, pavement markings, and greenery appear more preferable?
- Under which lighting would you feel safer walking at night?
- Which lighting would you prefer to see from your window?
- Which lighting is more suitable to sit, socialise, and chat if you were at a street cafe?

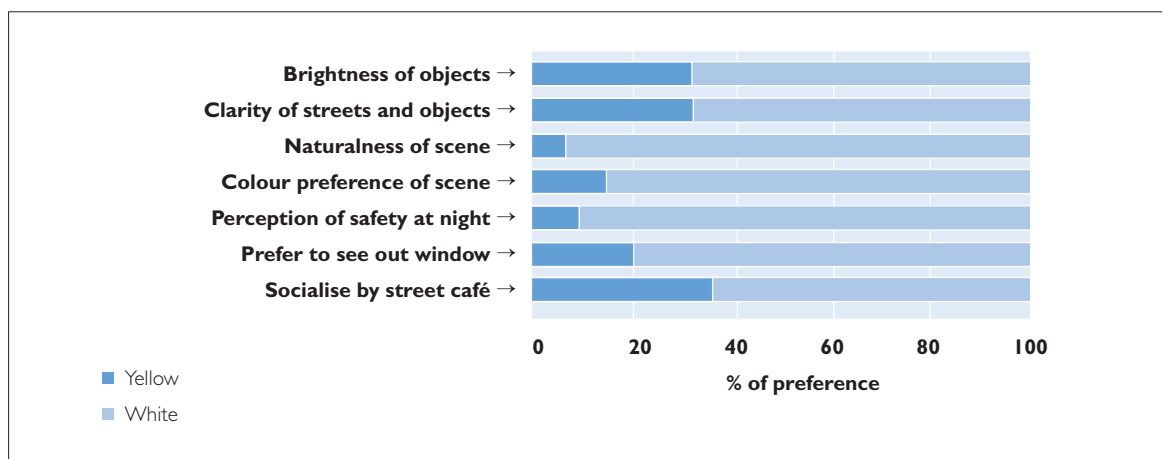


Figure 3: Preference for lamp types

Figure 3 shows a comparison of people's preference for the two lamp types. When the comparison is made between white and yellow at the same lighting level (5 Lux), there is a preference expressed for white for every

one of the above seven questions. For example, almost 90% of people questioned perceive white light safer for walking than high-pressure sodium.

* The Lighting Research Center is the world's leading university-based research and education centre devoted to lighting. It is based in Troy, New York, USA.

*** The results of the first two questions are explained more extensively in the section about security on page 23.

Security

White light is crucial in helping people feel safer when outdoors at night. Through better colour rendering and a higher perceived brightness, it becomes easier to distinguish objects, colours, shapes and other details. In particular, facial recognition is easier, even from a distance, which goes a long way towards removing anxiety. Even though the next three studies (STOEN RWE Foundation, Painter and Farrington and the National Institute of Law Enforcement and Criminal Justice) don't mention white light, they clearly demonstrate that better light quality can increase the perceived safety in cities.

Making the streets feel safer through light

The notion that better lit streets make people feel safer is backed by research carried out in Warsaw, Poland in February 2006. The STOEN RWE Foundation*

interviewed 1001 people over the age of 18 and asked them two straightforward questions regarding safety on the streets after dark.

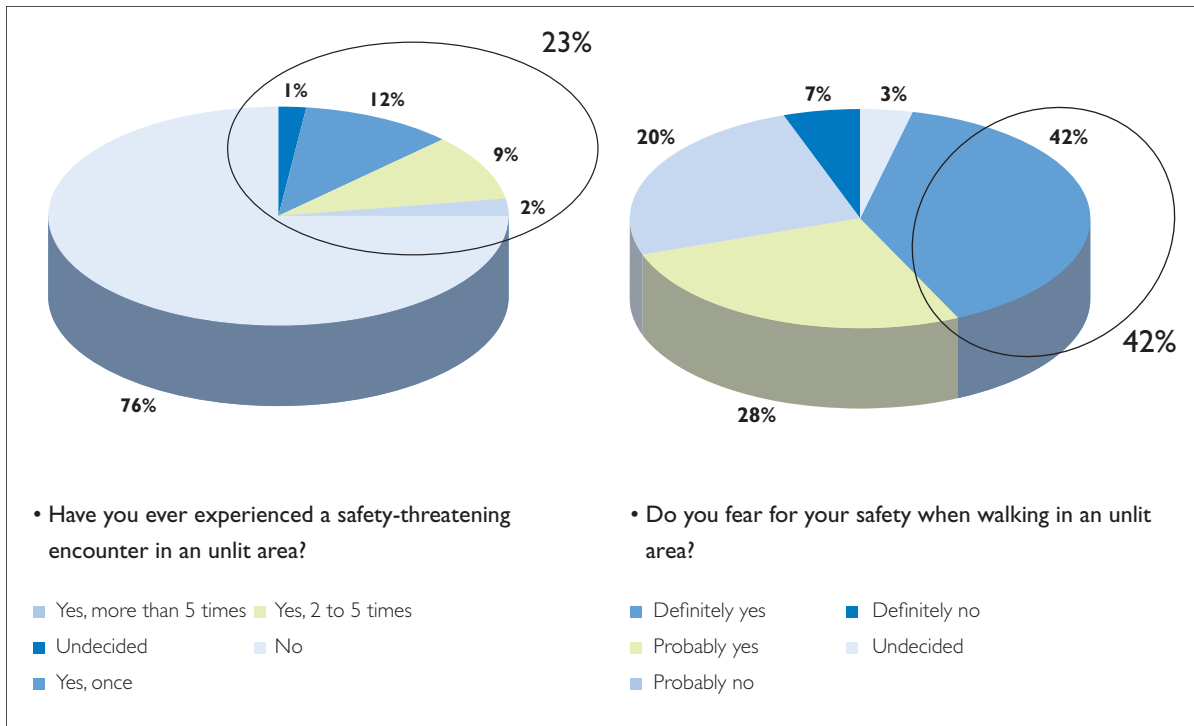


Figure 4: Street lighting vs. feeling of safety (sample 1001 persons aged 18 and over)

Almost a quarter of people asked said they had experienced a safety-threatening encounter at least once in an unlit area, with 70% saying that they feared for their

safety to a certain extent. This would suggest a clear need for properly lit streets in urban areas.

* STOEN RWE is a Polish energy company serving the Warsaw region. The STOEN RWE Foundation supports the local communities, e.g. via a scholarship program for students of the Electrical Engineering Faculty at the Warsaw University of Technology.

A UK institute of criminology links improved street lighting with a reduction in crime

Two research projects were carried out in 2000 by Painter and Farrington of the University of Cambridge's Institute of Criminology, to investigate the effects of improved street lighting on crime in Dudley and Stoke-on-Trent, both urban areas in the UK.

In Dudley, crimes decreased by 41% in the experimental area, compared to a 15% decrease in a control area. In Stoke, crimes decreased by 43% in the experimental area and by 45% in two adjacent areas, compared with a decrease of only 2% in two control areas. Painter and Farrington concluded that, in the two projects, the financial savings from reduced crimes exceeded the

financial costs of the street lighting improvements by between 2.4 and 10 times after one year. It was therefore extremely cost effective.

Although it is virtually impossible to pin down the exact reasons for changes in crime patterns, the study carried out by Painter and Farrington is indicative of the important role that good lighting can play. This is consistent with the conclusions published by Ken Pease of the University of Huddersfield, UK, after an extensive review of literature dealing with the effects of street lighting on crime.

Thorough study from US links better lighting with decreased fear of crime

The National Institute of Law Enforcement and Criminal Justice of the US Department of Justice presented a thorough study of sixty street lighting projects to the US Congress in February 1977. The abstract states, in part: "In particular, while there is no statistically significant evidence that street lighting impacts the level of crime, especially if crime displacement is taken into account, there is a strong indication that increased lighting - perhaps lighting uniformity - decreases the fear of crime."

In 2002, one of the authors of a related 1997 report to the National Institute of Justice of the US Department of Justice, Eck, said: "The recent lighting studies from Great Britain appear to remove the lingering doubts about lighting's efficacy. Lighting appears to work in public areas, especially residential communities."

White light and facial recognition

Peter Raynham from the Bartlett School of Graduate Studies at University College London submitted a paper to the International conference Illuminat 2007 & Balkanlight 2007 entitled 'Public Lighting in Cities'. In this paper he touched on the issue of facial recognition. Extracts of his work are given below.

The basic ideas about personal spaces were developed by Edward Hall, and he categorised the personal spaces around a person into intimate, personal, social-consultative and public.

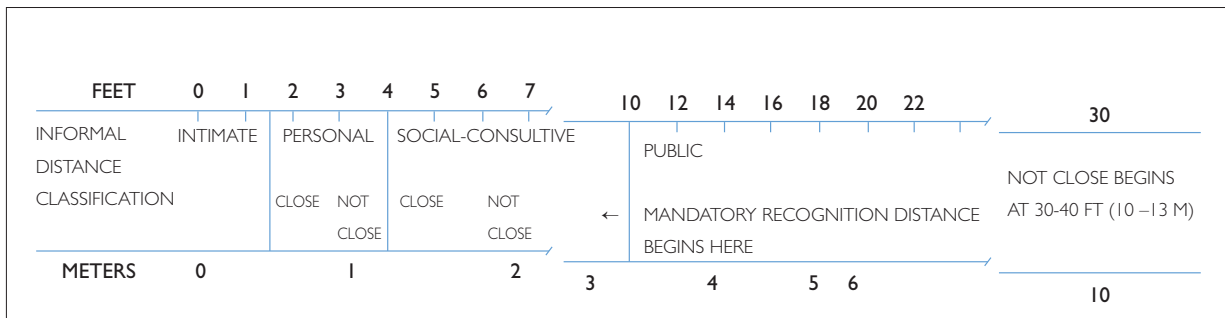


Figure 5: Hall's personal spaces (reproduced from Raynham)

Figure 5 shows the spaces and the distances at which they occur. Hall discussed the importance of these zones and why people felt uncomfortable with letting strangers entering their personal spaces (at distances of less than 3 m) unless they recognise them. The importance of facial recognition to pedestrians was first reported by Van Bommel and Caminada in 1980. They used Hall's basic ideas to explain why pedestrians at night did not

like coming too close to other people that could not be recognised. They proposed the use of the criterion that street lighting should permit the recognition of a face at a distance of 4 m. Van Bommel and Caminada then went on to establish that semi-cylindrical luminance on a person's face was key to them being recognised. Further research confirmed these findings.

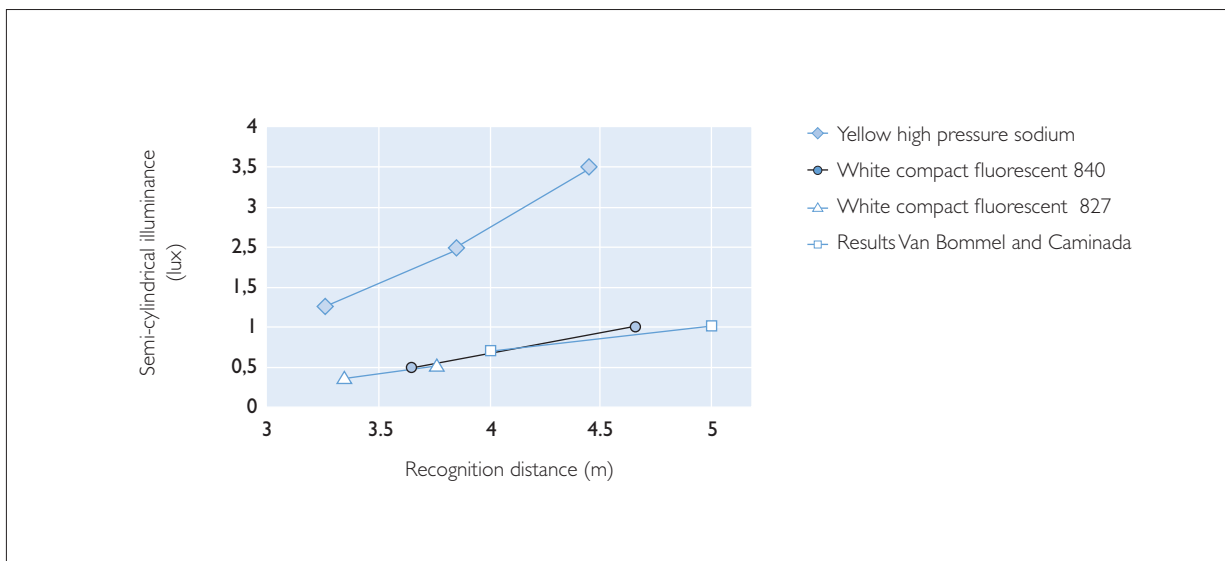


Figure 6: Facial recognition distance with different light sources (reproduced from Raynham)

More recently, Raynham and Saksvikrønning (2003) used facial recognition as a tool to compare the effectiveness of different light sources; figure 6 shows some of their findings.

The key finding from the work of Raynham and Saksvikrønning was that white light with a good colour rendering (R_a 80) is much better for facial recognition than light with low colour rendering from sources such

as high-pressure sodium lamps. Figure 6 also shows the results of Van Bommel and Caminada's research, with their data closely matching that for white light sources. In this study, white light sources with a R_a of 60 were also used. In conclusion this study shows that you need at least double light levels with high-pressure sodium in comparison to white light to be able to recognize faces from the same distance.

White light 'feel good factor' similar in Spain and the Netherlands

Field tests comparing the characteristics of yellow and white light with regards to perception and facial/colour recognition were carried out in the Netherlands by IPM* and in Spain by Advira** during the course of 2006/2007.

In both countries, face-to-face interviews were carried out with approximately 200 inhabitants of residential areas that had new white light installations. The residents were questioned before and after the white light sources were installed.

In general, the results from Spain and the Netherlands were consistent with each other. Almost all respondents said they considered white light was an improvement in terms of quantity, light quality and safety feelings because of the increased perception of brightness and better visibility. Facial recognition improved on average by 20-30%. This adds to people's feelings of comfort, because it makes it easier to identify others out on the street. Residents felt they were 'sure' of colours from further away with white light. They identified more colours correctly with white light than with yellow light.

Eindhoven, The Netherlands



Before: yellow high-pressure sodium



After: MASTER CityWhite

Navalcarnero, Spain



Before: yellow high-pressure sodium



After: MASTER CityWhite

* IPM is a Dutch marketing research and consultancy agency.

** Advira is a Spanish research agency.

Testing levels of perceived safety

In the previous chapter on aesthetic enhancement, the research of the Lighting Research Center in Troy, New York* was explained. Two of the issues mentioned in this research have to do with perceived safety:

- Under which lighting do the objects and street appear brighter?

- Under which lighting would you feel safer walking at night?

In figure 7, the results at different light levels are shown.

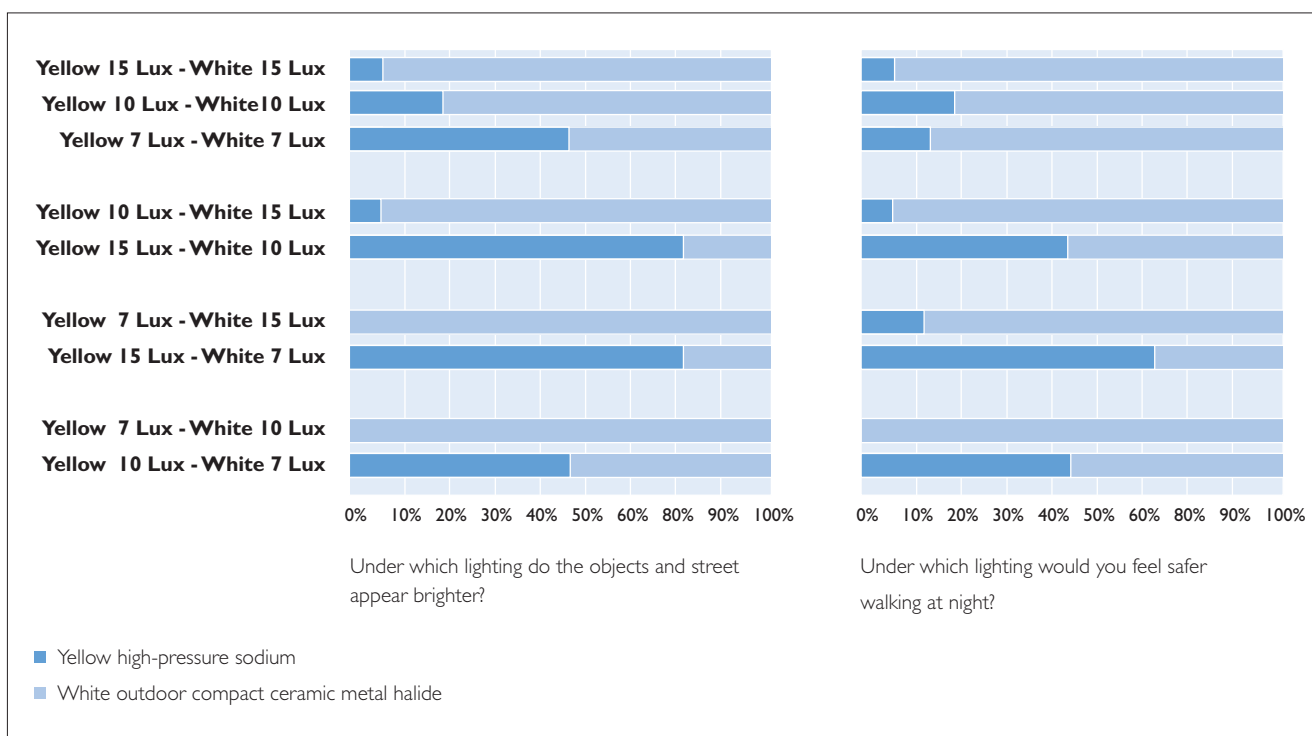


Figure 7: Comparison of perceived brightness and safety

At the same lighting levels, considerably more people in the test (always in excess of 80%) said they would feel safer under white illumination. Significantly, perception of safety was judged to be similar even when the light level of the white light was approximately 30% lower than that of yellow light.

* See page 18 for more information about this research.

Accident prevention

By increasing visibility for motorists, pedestrians and cyclists, the roads become safer. Research has shown that white light can play a significant role in this.

Are the benefits of white light perceived and appreciated by drivers?

Research carried out at the Lighting Research Center in Troy, New York by Yukio Akashi examined whether white light can improve the (peripheral) vision of motorists. This research was published in 2007 in *Lighting Research & Technology*.

A special board was placed beside a stretch of road which simulated movement towards as well as away from the road (see figure 8).

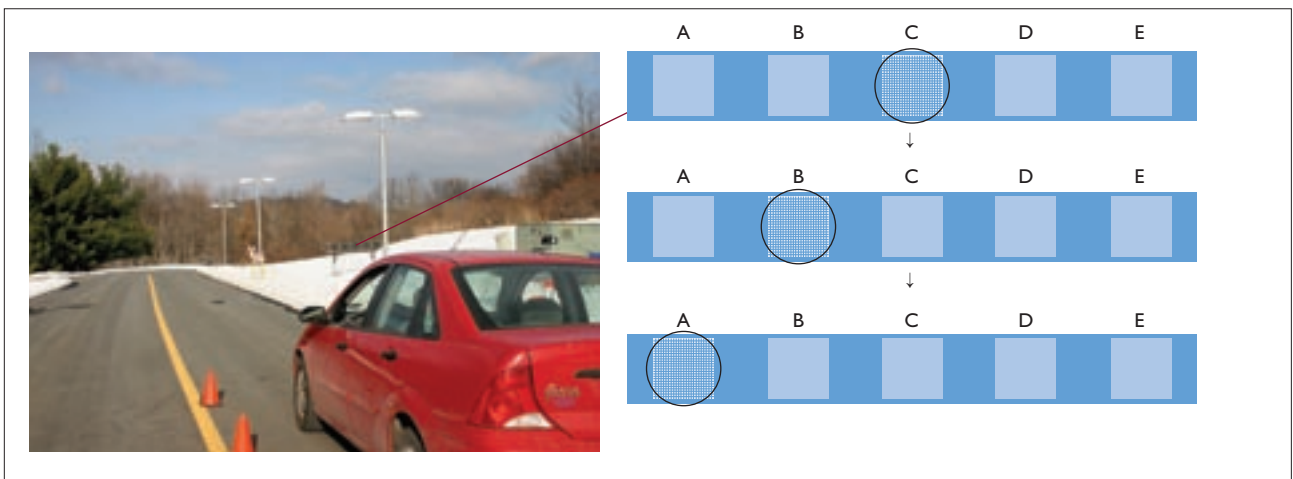


Figure 8: Test set-up at LRS. Detection targets simulating movement toward the street, creating a single moving target from discrete, temporally sequenced, targets

13 Subjects underwent a series of tests during daytime and then at night-time with CosmoWhite and yellow high-pressure sodium illumination. A total of 686 separate trials were carried out. The movement of the pattern on the special board was random. If it moved away from the road the correct response was to accelerate, and if it moved towards the road the driver was expected to brake. The mean response times are shown in figure 9. The data in this figure are for equal illuminance of CosmoWhite and yellow high-pressure sodium.

The conclusion that can be drawn is that there is a statistically significant difference in response times between white and yellow light for braking and accelerating. In both cases, the response time with white light is lower.

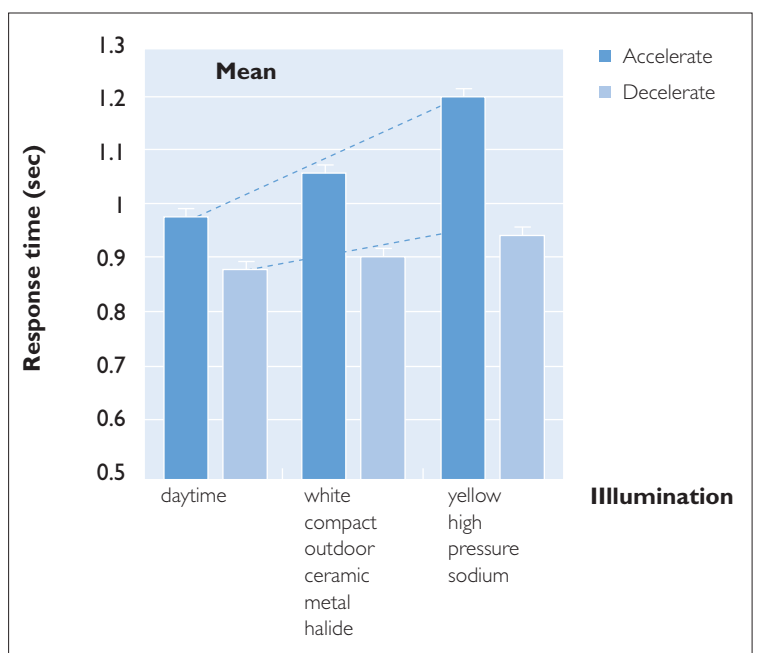


Figure 9: Response time with different light sources

Luminance contrast threshold experiment

The contrast detection threshold experiment was carried out on a group of people using three different types of lighting; SON-T, MASTER CosmoWhite and MASTERColour lamps. All three were used at the level required for road lighting.

In order to see an object, there has to be a certain luminance difference (i.e. contrast) between the object and its background. The contrast detection threshold is the minimum difference required so you can make out the object (without necessarily being able to perceive the colour or detail). A lower contrast threshold means that it is easier to detect an object.

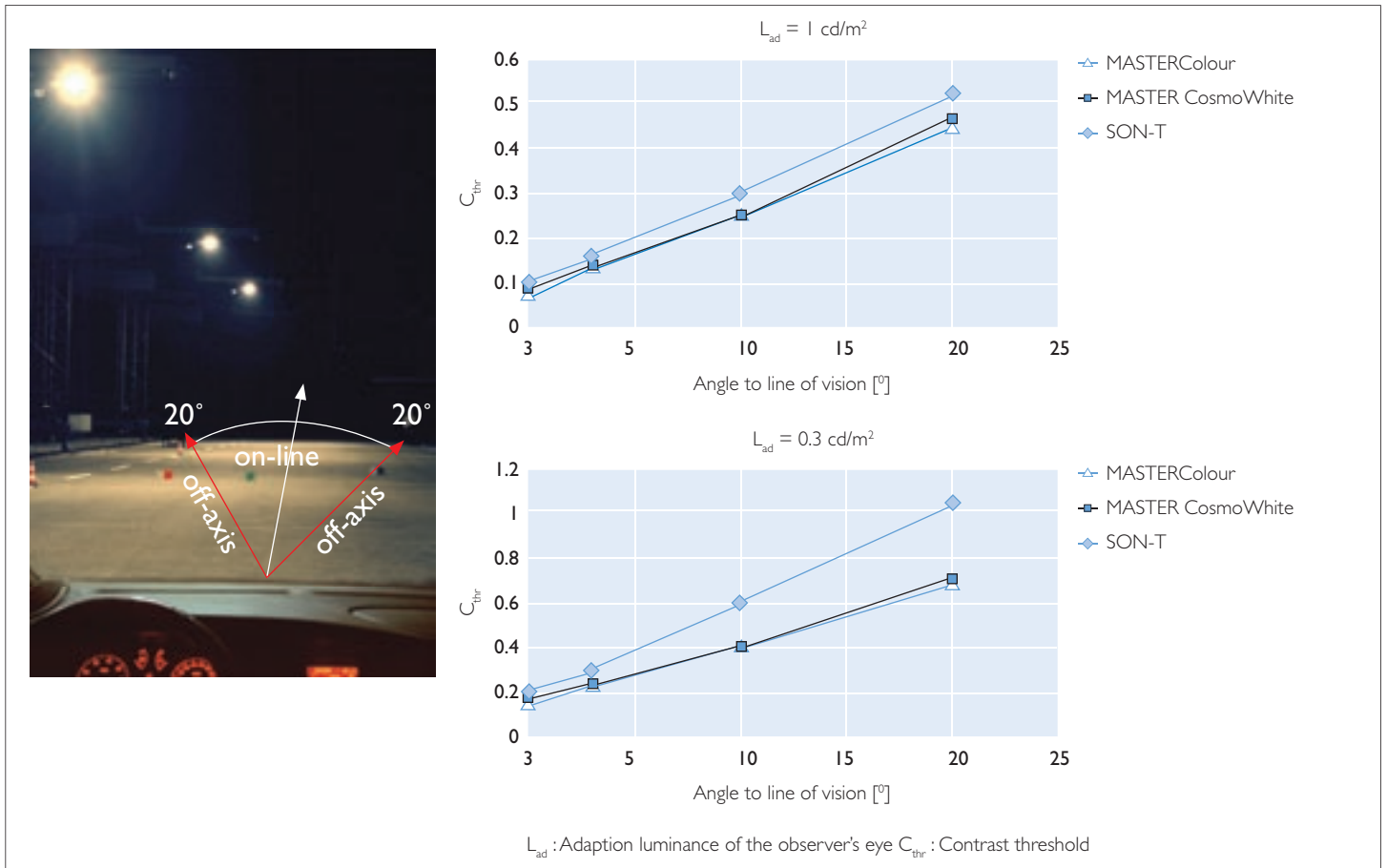


Figure 10: Contrast detection with 3 different types of lighting

The Technical University of Ilmenau, Germany conducted tests in which the contrast detection threshold of a 1mm spot of light was measured for 10 observers. The light spot was positioned at 4 different angles (0, 3, 10 and 20°) and three different light sources were used. For all of the light sources, the tests were carried out using a background luminance of 0.3, 1 and 2 cd/m^2 . The data collected for a background luminance of 0.3 and 1 are plotted in figure 10.

It was found that white light gives a lower luminance threshold than yellow light, especially at large off-axis angles and low luminance levels. This means that it is easier to see people or other objects with white light, which contributes to improved safety for the driver as well as for other road users. It will also be easier to see objects that have lower contrast relative to their background. The difference in contrast threshold between the white and yellow light sources was even more significant for targets in the peripheral field of view (10 – 20° from central field of view).

Energy efficiency

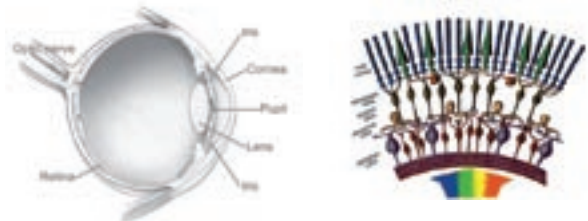
Ongoing performance improvements mean the latest white light sources (MASTER CosmoWhite) are more energy efficient than their high-pressure sodium counterparts. And because people experience white light as being brighter than it actually is, you can give the public what they expect while actually reducing the light output by as much as 30%.

Higher perceived brightness with white light explained

In order to properly understand the idea of higher perceived brightness, it is necessary to grasp what happens to our sight when lighting levels are low.

The retina in our eye is made up of rods and cones. The cones allow us to determine colours, while the rods enable us to see when it is dark and also help with peripheral vision. The vision associated with cones is known as photopic, and is typically associated with high light levels (daytime). The vision associated with rods, and with low light levels (nighttime), is known as scotopic. The area in between, the transition phase if you like when both rods and cones contribute, is known as mesopic vision. This corresponds to lighting levels that are much lower than daylight, but are still higher than out-and-out darkness. In other words, the kind of lighting conditions found on our city streets at night.

The sensitivity of our cones peaks at approximately 555 nm, which is towards the yellow end of the lighting spectrum. The sensitivity of our rods peaks at approximately 507 nm which is towards the blue end of the lighting spectrum. If a lighting source therefore has higher levels of blue light emission, it will be picked up more readily by our rods, which are more active in low lighting (mesopic) conditions. This is what is effectively meant by higher perceived brightness. The light source is not necessarily giving out more light overall, but it is giving out high levels of a frequency of light that can be picked up by our eye. This is what white light does.



Lower lighting levels - and therefore reduced energy consumption - can be just as effective

Testing carried out by the Lighting Research Center in Troy, New York* evaluated how people experience the effect of street lighting at night.

One of the most interesting conclusions from an energy efficiency point of view was that, when a much higher level of high-pressure sodium (15 Lux) was compared to 5 Lux of MASTER CosmoWhite (white light) illumination, the majority of participants still preferred MASTER CosmoWhite in four of the seven questions.

In particular, the naturalness of the scene under these conditions was judged to be better with MASTER CosmoWhite by more than 70% of respondents. And perception of safety was the same even when the light level of the MASTER CosmoWhite lamps was approximately 30% lower than that of high-pressure sodium.

This shows that reducing lighting levels while using white light can give people the perceived level of brightness (and the various associated benefits) they expect, while cutting power consumption.

* See page 18 for more information about this research.

The British way - legislation that permits lighting levels to be reduced in residential areas if the colour rendering is superior

In the United Kingdom, there is already a practice of reducing the required lighting level when using light sources with good colour rendering (i.e. $R_a > 60$). The lighting classes are based on the European standard I3201, where the average minimum luminance or illuminance level is described. The British standard BS5489-1:2003 defines which of these classes should be used on a given road or area depending on the crime rate, traffic flow etc. The standard permits a reduction of one lighting class on subsidiary roads (access

roads, residential roads and pedestrian or cycle paths) if a light source with a colour rendering of 60 or more is used, which is the case with white light (but not with high-pressure sodium). The consequences for the required horizontal illuminance are shown in the table below. As can be seen, the illuminance level can be reduced by -30% in subsidiary roads when light sources with a colour rendering index of over 60 (CRI > 60) are used. This, coupled with very efficient white light sources, can lead to substantial energy savings.

Crime Rate	R_a value	Minimum Maintained horizontal illuminance (Lux)		
		Low Traffic Flow	Normal Traffic Flow	High Traffic Flow
Low	$R_a < 60$	5	7.5	10
	$R_a > 60$	3	5	7.5
Medium	$R_a < 60$	7.5	10	15
	$R_a > 60$	5	7.5	10
High	$R_a < 60$	10	15	15
	$R_a > 60$	7.5	10	10

Figure 11: Excerpt from BS5489-1 for residential roads, footpaths and cycle ways

Note: Although this standard is already in force, there is still ongoing discussion on the validity of this trade-off between lighting levels and colour rendering.

Comparing the energy consumption of MASTER CosmoWhite and MASTER SON PIA

The table below shows three examples of the kind of CO₂ savings that are possible with MASTER CosmoWhite. The examples given are of real-life installations.

	Project	Previous installation	New installation	Energy reduction/ CO ₂ emission reduction
Installation upgrade	Böblingen, Germany. 200 lighting points	2 x SON 70W in a single luminaire	1 x MASTER CosmoWhite 60W	-43%
Installation refurbishment	Somosaguas, Spain. 300 lighting points	SON 250W at 9m height	MASTER CosmoWhite 140W at 6m height	-47%
New installation with higher perceived brightness	Leeds, UK. 80,000 lighting points	SON 70W at 30m spacing	MASTER CosmoWhite 45W at 40m spacing	-56%

Figure 12: Examples of energy savings with MASTER CosmoWhite

Somogaguas, Spain



Before: yellow high-pressure sodium



After: MASTER CosmoWhite

As shown in figure 12, even just by upgrading a lighting installation it is possible to reduce energy consumption by as much as 43%, and with a new installation the savings rise to 56%.

High quality white light is therefore the 'green switch' solution for outdoor installations, reducing CO₂ emissions to a level that was previously considered impossible, while simultaneously cutting energy bills by a significant amount.



Den Bosch,
the Netherlands

Product overview lamps

Key characteristics of yellow and white light - Positioning of Philips Outdoor light sources

On the spread you will find a comparison between the various types of Philips lamps available for outdoor lighting applications. They have been judged on four key parameters; colour temperature, colour rendering, lamp

efficacy and service lifetime. The diagrams give you a good overall impression of how each different lamp type measures up in these areas.

The lamps used in the comparisons are:

CPO = MASTER CosmoWhite - Outdoor compact ceramic metal halide

CDO = MASTER CityWhite - Outdoor ceramic metal halide

CDM = MASTERColour (Elite) - Compact ceramic metal halide

HPI / MHN = Quartz metal halide

SON = High-pressure sodium

SON Comfort = High-pressure sodium with a more comfortable colour impression and higher colour rendering

PL = Compact fluorescent

HPL = High-pressure mercury

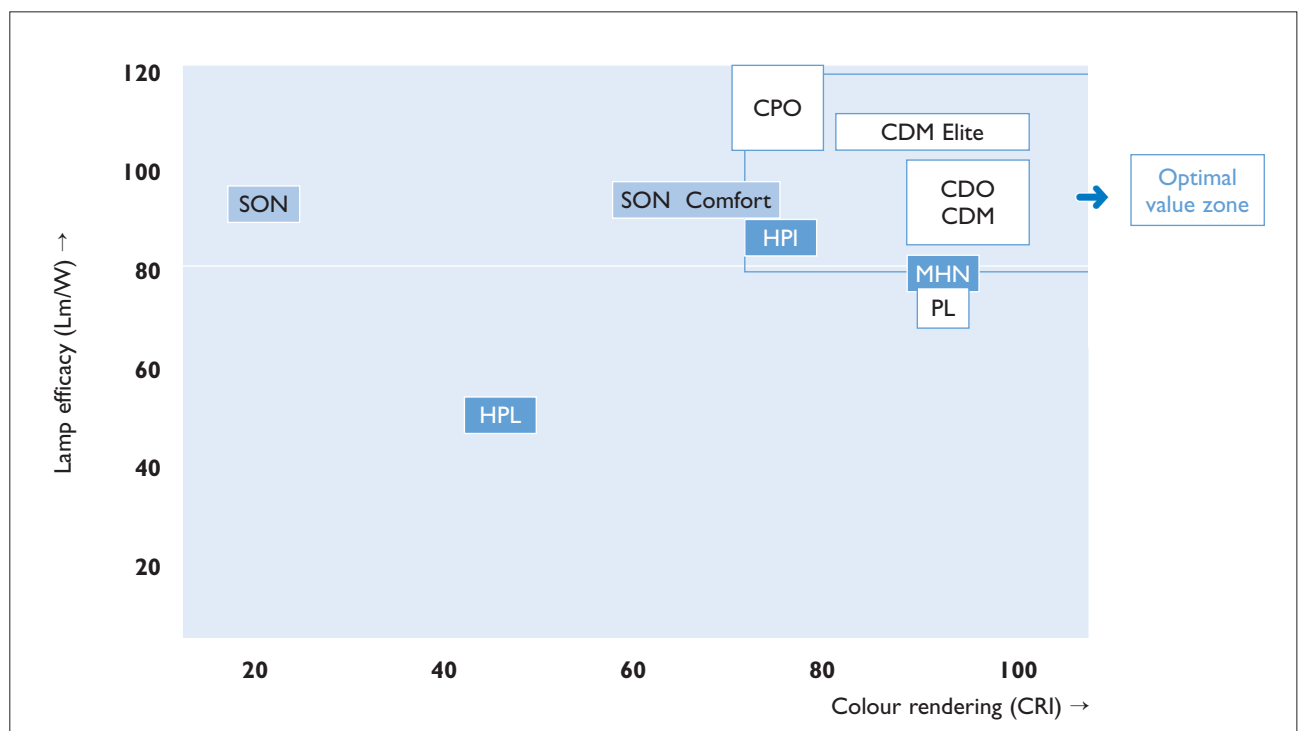


Figure 13: Colour rendering vs. lamp efficacy

The lamp efficacy is a measure of the amount of light produced per watt of lamp power, expressed in lumen per watt. The energy costs of installations, as well as the environmental impact, are directly related to the lamp efficacy. But lamp efficacy should not be at the expense of colour rendering, which is always important. The diagram above therefore shows how each of the different lamp types combines the two.

The colour rendering index (CRI) is an indicator of the extent to which colours are faithfully reproduced. For outdoor lighting, a CRI greater than 65 is usually sufficient to produce the kind of ambiance people are looking

for. Research has also shown that a colour temperature of 2800-3000° K is most suitable for urban lighting applications. The diagram below shows that several Philips light sources meet both criteria.

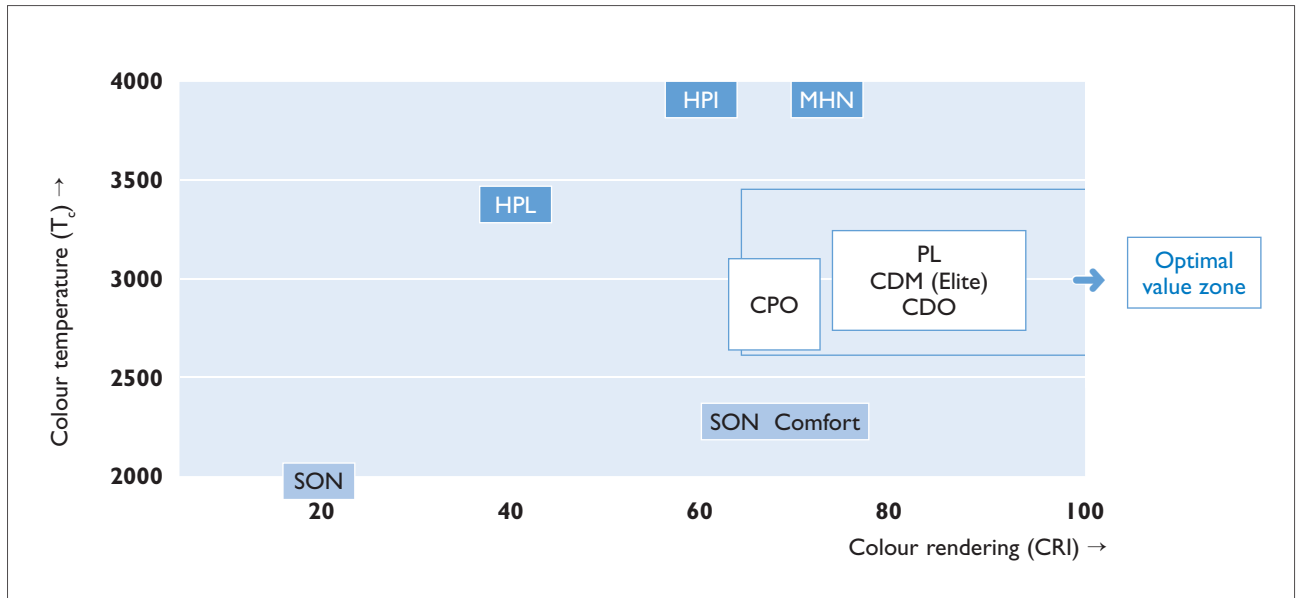


Figure 14: Colour temperature vs. colour rendering

White light solutions from Philips

CosmoPolis - MASTER CosmoWhite (CPO)

New generation of compact ceramic metal halide lamps for outdoor public lighting in city centres, residential areas and roads. High-quality, warm white light, improved service life, plus the highest lamp & system efficiency available.*The best option for new installations; uses 50% less energy than mercury vapour lighting, which equates to a saving of more than 100kg CO₂ per lamp on an annual basis. Even greater energy savings can be achieved through automatic dimming.



MASTER CityWhite (CDO)

Ceramic metal halide lamps used in the same application areas as MASTER CosmoWhite. The best option for replacements, as they directly retrofit on high-pressure sodium SON installations (E27/40base) to upgrade from yellow to white light. A comfortable, warm white light which remained stable during the long service lifetime. Even greater energy savings can be achieved through dimming with controllable electronic gear.



*with dedicated electronic drivers only

BeneKit

Energy saving conversion kit for upgrading existing mercury vapour HPL installations using a MASTER CityWhite lamp and a new driver (electronic or electromagnetic). Ideal for luminaires that do not yet need replacement (typically 10 to 20 years old), 'heritage' luminaires or those with a particularly noteworthy design.



MASTERColour CDM (Elite)

Compact ceramic metal halide lamps suitable for flood- & decorative lighting in city beautification. MASTERColour lamps, with their crisp white light, excellent colour rendering and stable colour temperature, and already the lamp of choice in many different indoor applications. The new generation MASTERColour Elite takes these qualities one step further with increased light output and even better colour rendering.



MASTER HPI Plus

Quartz metal halide lamps that offer a cooler white light for outdoor floodlighting. Often used in city beautification projects, as well as for lighting of sports stadiums and arenas.



(White) LEDs

The use of LEDs is becoming ever more widespread because ongoing technological improvements allow them to produce high lighting levels than ever before. LEDs are popular because they have many advantages over conventional lamp technologies such as far longer lifespan, colour changing possibilities, dimming and substantially lower energy consumption.

Although they are becoming popular in outdoor decorative installations, LEDs have not yet been able to make a serious impact in street lighting. However, it seems inevitable that, as improvements continue, LEDs will one day be able to meet the requirements of such outdoor applications. For the time being, the most recent high-intensity discharge sources like MASTER CosmoWhite offer the very high light output and optical performances needed for outdoor general lighting applications - as well as an attractively low total cost of ownership.

MASTERColour CDM Elite MW

(to be released in 2009)

The Philips MASTERColour CDM Elite MW system offers an unrivalled level of light quality and performance. The lamp's sparkling white light creates a more natural ambience and really brings out the best in all different types of colour. This performance remains stable over the long lifetime of the lamp. In addition, the high efficiency of the lamp and driver together means reduced energy use and a lower cost of ownership.



Product overview luminaires

All the most advanced outdoor luminaires are equipped with the CosmoPolis system or use the MASTER CityWhite. These luminaires are equipped with an extended range of optics that deliver the optimal solution for all kinds of applications.

Smart



Itinera



Trend



City



Garden



Veto



Vios



Viata



Urban



Mach 3



Mach 4



Mach 5







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