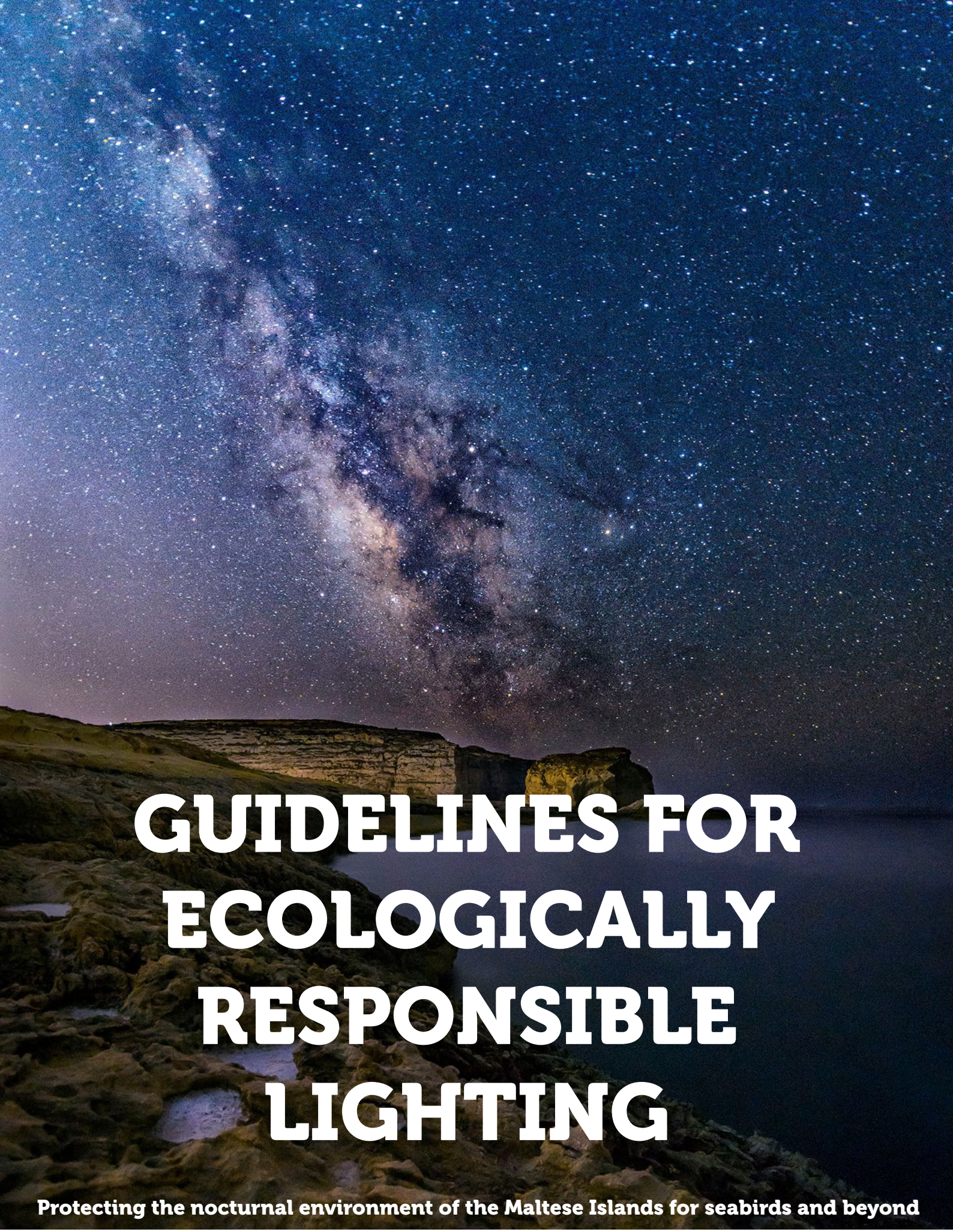


GUIDELINES FOR ECOLOGICALLY RESPONSIBLE LIGHTING

Protecting the nocturnal environment of the Maltese Islands for seabirds and beyond

LIFE Arċipelagu Garnija (LIFE14 NAT/MT/991) Securing the Maltese Islands for the Yelkouan Shearwater *Puffinus yelkouan*

PROJECT PARTNERS

CO-FUNDED BY

IN COLLABORATION WITH

PART 1.

HOW TO USE THIS GUIDELINE

Contents

This document is part of the requirements of Action C2 Address and reduce current light pollution affecting *P. yelkouan* colonies utilising policy and legislation

Author: James Crymble – LIFE Arċipelagu Garnija Project Warden and Light Pollution Officer (BirdLife Malta)

Illustrations by: Jose Luque and Victor Falzon – Field teacher (BirdLife Malta)

In collaboration with the Light Pollution Awareness Group and Nature Trust Malta

Cover photo: The Milky Way as observed from Dwejra ©Joseph Caruana

BirdLife Malta's LIFE Arċipelagu Garnija team conducting research in a seabird colony © James Crymble

PART 1.

PART 1.

Introduction

Natural darkness has substantial conservation value. A majority of life on earth has evolved with the natural day and night cycle, a cycle which is now being disrupted by increasing levels of artificial light at night [1]. Light pollution can be defined as the inappropriate or excessive use of light arising from poorly designed outdoor lighting schemes. It is a manifestation of wasted energy and can be a significant financial burden for local councils, organizations and businesses.

Light pollution is a fast growing threat of global concern, the negative impacts of which go far beyond being an economic drain. Across the world, many communities and ecosystems are affected by increasingly bright night skies as a result of urbanisation and the development of associated infrastructure. The effects of light pollution are felt most strongly in small countries with a high population density, like Malta.

Our understanding of how light pollution affects human health and the natural environment is growing. For humans, our quality of life is negatively affected in light polluted areas as stray light enters our homes, disturbing our sleep and carrying serious implications for our long term health, including mental wellbeing and increased prevalence of certain cancers [2].

Many aspects of the natural environment are highly sensitive to increasing levels of artificial light at night. Most commonly observed is the disruption of normal behaviours and biological processes in individual organisms but evidence now reveals the ecosystem-scale effects of light pollution [1].

Light pollution in Europe is increasing by 5-10% annually in Europe and 99% of the European population lives under light polluted skies [3]. This trend is evident in the Maltese Islands as a direct result of poorly designed lighting schemes and an over-use of bright-white LEDs.

Light pollution has severe consequences for the natural environment, especially for breeding shearwaters and storm-petrels. As darkness is a key environmental component for these species, light pollution reduces the areas in which these species are able to breed. Every year their fledglings are found stranded in our towns and villages, having been drawn to land by bright coastal lights rather than leaving their nests for the open sea.

Fortunately, the negative effects of light pollution are easily addressed. In some cases, it is as simple as flicking a switch. A number of mitigation measures can be applied to poorly-designed lighting schemes and light pollution can be greatly diminished. Prevention costs less than intervention. As such, these measures should be incorporated at concept stage. With increasing awareness on the issues surrounding artificial light at night, new developments are subject to more stringent regulations addressing not only energy consumption but also the impact on the natural environment.

Mitigating light pollution is beneficial for everyone. Outdoor lighting is a key component to the essential infrastructure of our urban environment but any artificial light at night will produce light pollution. A well-designed outdoor lighting scheme meets the requirements of human needs whilst using energy efficiently and minimising any light pollution.

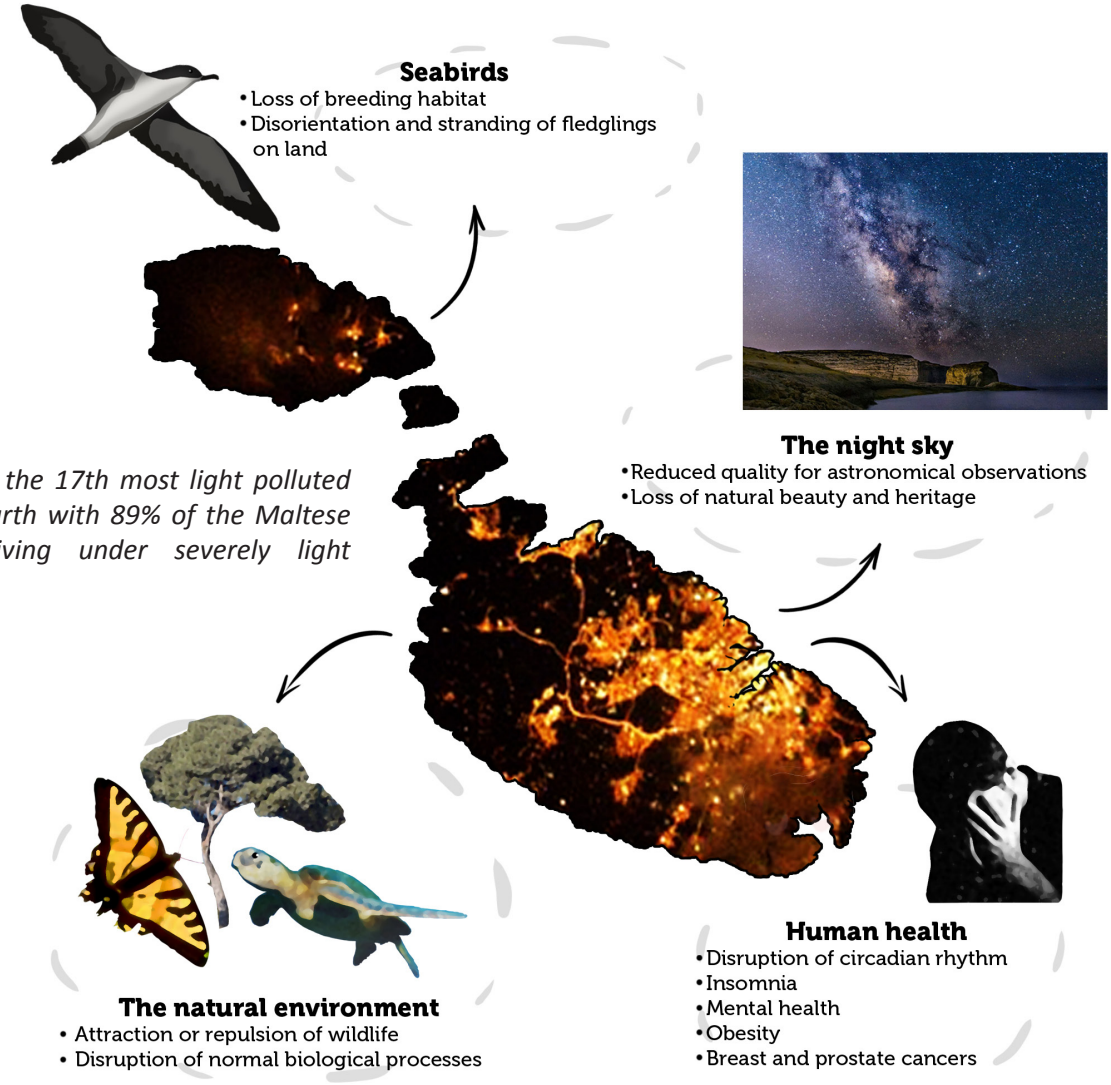
Malta as observed from the International Space Station
©Earth Science and Remote Sensing Unit, NASA Johnson Space Center, ISS025-E-10429

[1] Rich, C., & Longcore, T. (Eds.). (2013). Ecological consequences of artificial night lighting. Island Press.

[2] Cho, Y., Ryu, S. H., Lee, B. R., Kim, K. H., Lee, E., & Choi, J. (2015). Effects of artificial light at night on human health: A literature review of observational and experimental studies applied to exposure assessment. Chronobiology international, 32(9), 1294-1310.

[3] Falchi, F., Cinzano, P., Duriscoe, D., Kyba, C. C., Elvidge, C. D., Baugh, K., ... & Furgoni, R. (2016). The new world atlas of artificial night sky brightness. Science advances, 2(6), e1600377.

Impacts of light pollution



Malta is now the 17th most light polluted country on Earth with 89% of the Maltese population living under severely light polluted skies.

Aim

This Guideline aims to provide local councils, architects and developers with best practice guidelines for the design and assessment of sustainable, cost-effective and seabird friendly lighting.

The major aim of this Guideline is to promote the ecologically responsible use of outdoor lighting. With a primary focus on seabirds preventing the disruption or displacement from their natural habitats or light-induced mortality.

This Guideline is designed to complement current EU standards and national legislation regarding outdoor lighting. Key principles in light pollution mitigation are described in this document. The appendices contain technical information and sources for additional information.

Policy context and guidance documents

The specifications of best practice lighting described in this document adhere to the existing Maltese legislation regarding light pollution (ANNEX 1)

Areas where light pollution mitigation measures are required for flora and fauna can be found in the Management Plans for Natura 2000 sites in the Maltese Islands.
https://era.org.mt/en/Pages/Natura-2000-Management-Planning.aspx

Guidance documents are referred to in this document. A full list of these documents can be found in ANNEX 2

PART 2.

WHAT IS LIGHT

T POLLUTION?

Valletta by night - Malta © Giuseppe Milo

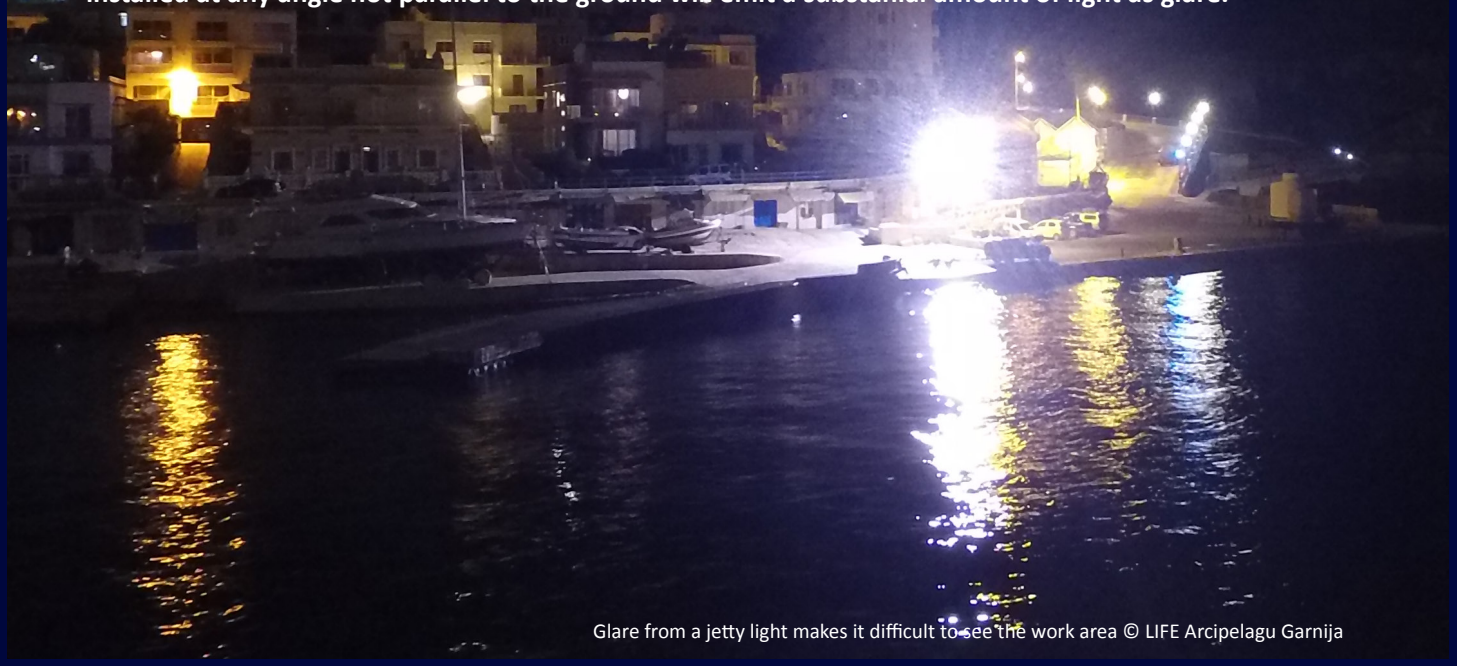
PART 2.

PART 2.

The four characteristics of light pollution

1. Glare

Glare is visual discomfort from poorly angled or unshielded lights. Exposure to glare reduces the eye's ability to distinguish between different levels of brightness, making it difficult to navigate or identify oncoming traffic and obstacles in the way. Glare can even lead to vision being disabled. Luminaires installed at any angle not parallel to the ground will emit a substanial amount of light as glare.



Glare from a jetty light makes it difficult to see the work area © LIFE Arcipelagu Garnija

2. Light trespass

Light trespass is the term given to any light that intrudes into an area where it is not required, such as private properties or ecologically sensitive areas. So-called "nuisance-lights" can negatively impact our quality of life. Light trespass is commonly seen in overly-illuminated areas. Any light falling on a private property is unacceptable.

Street lighting enters into a private residence © LIFE Arcipelagu Garnija

Light trespass onto a private property © LIFE Arcipelagu Garnija

3. Over-illumination

Over-illumination of an area is the presence of lighting in excess of what is necessary. European standards provide guidance on the minimum illuminance required for safe working conditions in a given area. The minimum illuminance required depends on the main use of the area and should be seen as a target, not exceeded.

Cirkewwa ferry terminal © LIFE Arċipelagu Garnija

4. Sky glow

Sky-glow is the result of stray light from luminaires being emitted directly into the sky or light being reflected by structures and roads. Sky glow not only reduces our ability to see the night sky, but also interferes with natural processes including photosynthesis and animal migration.

Sky glow in North-East Malta is at similar intensity to the rising full moon © LIFE Arċipelagu Garnija

PART 2.

Energy wasted by light pollution

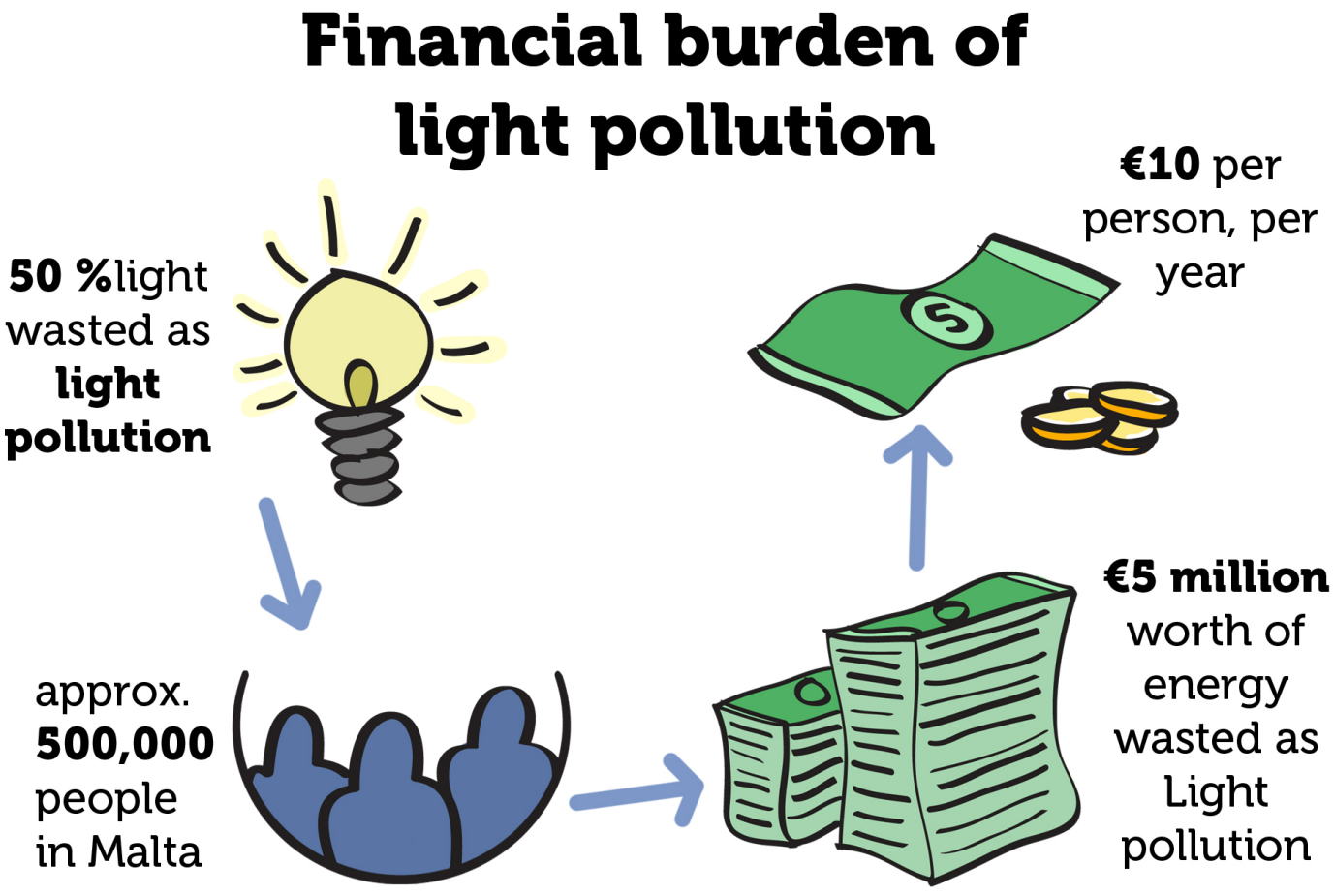
Light pollution wastes a vast amount of energy. A large proportion of energy generated for outdoor lighting is wasted as a result of poorly designed outdoor lighting. Wasted energy equates to wasted money. The financial burden of light pollution is signficant and is certainly a cost that can be easily avoided.

Energy wasted as light pollution costs the European Union approximately €5.2 billion every year. This equates to €10 for every man, woman and child living in the EU.

To put this into a Maltese context: Assuming that the same proportion of energy is wasted as light pollution at a similar cost per person, approximately €10, the total financial burden of light pollution in the Maltese Islands is €5 million.

Considering the Maltese Islands are more light polluted than most other EU countries [1], the true financial cost of light pollution is likely far higher.

Installing quality well-designed lighting is proven to reduce energy use by 60-70%, saving millions of Euros annually.



*figures are based on data from the Urban Lighting, Light Pollution and Society (2014)

[1]. Falchi, F., Cinzano, P., Duriscoe, D., Kyba, C. C., Elvidge, C. D., Baugh, K., ... & Furgoni, R. (2016). The new world atlas of artificial night sky brightness. Science advances, 2(6), e1600377.

LED technology

LED technology is the future of outdoor lighting. Not only are LEDs vastly more energy efficient, they have a longer life-span and are easier to control than older lighting types. However, as older technologies, such as high-pressure sodium lamps are phased out and replaced with LEDs, we may expect to see an increase in light pollution should these LEDs continue to be installed without considering their impacts on light pollution.

Until now, white-light LEDs have been the most popular choice due to their lower costs, higher energy efficiency and luminance. However, the phyiscal properties of the light emitted by bright-white LEDs actually increases the four characteristics of light pollution (glare, light trespass, over illumination and sky glow) as they emit a large amount of short wavelength blue light. These shorter wavelengths are scattered more in the atmosphere and therefore have a greater impact on astronomical and ecological light pollution.

The negative impacts of bright white-light LEDs are not only limited to our environment. They also represent a growing threat for human health. Extended exposure to artifical lighting with a large amount of blue-light has been reliably shown to negatively impact human health from mental health to increased prevalence of certain cancers [1].

LEDs, if used responsibly, are a key tool in mitigating light pollution. Not only are they more energy efficient, they are also easier to control and can be used in a diverse range of applications.

LED use in Malta. The popularity of LEDs has resulted in our coastline being overly-illuminated with bright-white lights.

LEDs at Qawra point © LIFE Arċipelagu Garnija

[1] Falchi, F., et al., (2011) *Limiting the impact of light pollution on human health, environment and stellar visibility,* Journal of Environmental Management

PART 3.

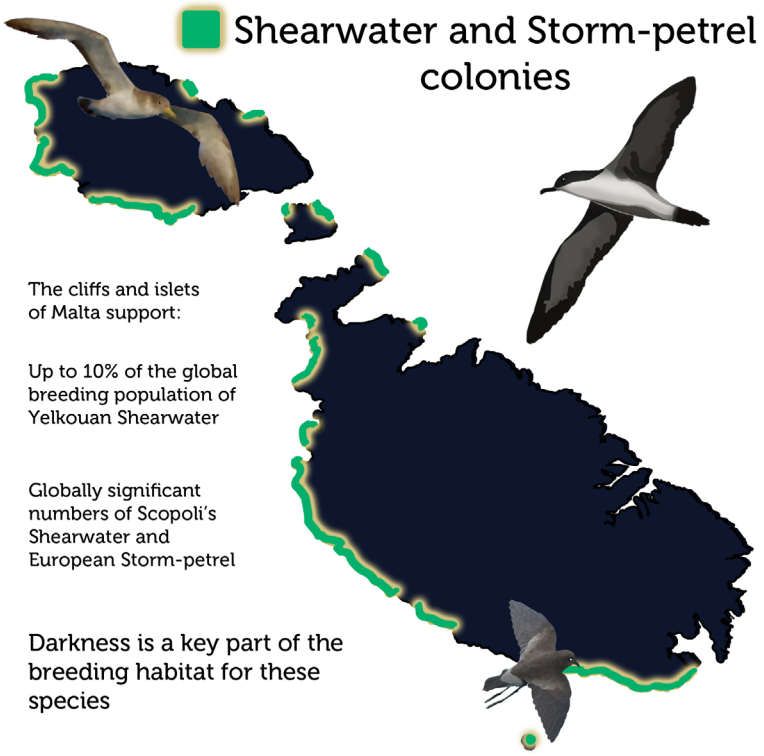
LIGHT POLLUTION AND SEABIRDS

Overview

The Maltese Islands have supported important breeding populations of seabirds for thousands of years. They currently hold between 1795 to 2635 pairs of Yelkouan shearwater *Puffinus yelkouan* [1] - up to 10% of the global population of this IUCN red-listed species endemic to the Mediterranean. Approximately 3000 - 4000 pairs of Scopoli's shearwater *Calonectris diomedea* and 5000 - 8000 pairs of European Storm-petrel *Hydrobates pelagicus* also breed in the Maltese Islands[2].

These species belong to a group of seabirds called the Procellariiforms, that have evolved to exploit the nocturnal environment. Their activity peaks during the darkest periods of night when adult birds return to attend their nests.

Light pollution is responsible for direct mortality of these species, causing birds to become disorientated and stuck on land. Artificial light at night is also repsonsible for a number of sub-lethal effects.
Only by improving the way we use artifical light at night can we hope to mitigate these effects.



[1] Austad, M., et al., (2019). *Site assessment report for Yelkouan shearwater population in the Maltese Islands. LIFE Arċipelagu Garnija [LIFE14 NAT/MT/991]* Report for Action A1 and A3

[2] Sultana, J., et al., (2011). The Breeding Birds of Malta. Malta: BirdLife Malta.

Breeding behaviour

Shearwaters and storm-petrels are long-lived seabirds that take up to five years to reach sexual maturity. Their breeding habitat is carefully selected according to various parameters, including darkness. They lay a single egg each year, a reflection of a large investment of resources. Incubation and chick rearing occurs over the course of several months and should the nest fail at any stage, they will not be able to lay a second egg as the cost to adult condition is too high. Due to their life-histories, any increase in the natural mortality rate of young birds and the degradation of breeding habitat can have serious consequences on their populations.

A Yelkouan Shearwater chick in its burrow © Ben Metzger

PART 3.

The effects of light pollution on shearwaters and storm-petrels

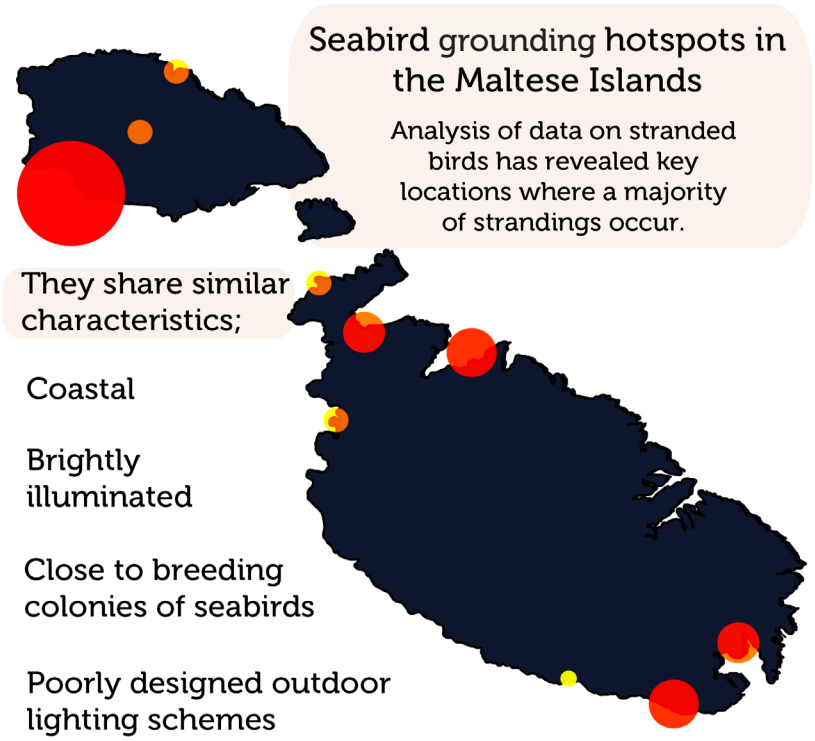
Since 1979, BirdLife Malta has kept a database on shearwaters and storm-petrels found grounded on land as a result of light pollution. Analysis of these data has identified light-induced grounding hotspots in the Maltese Islands. These hotspots share similar characteristics: they are brightly lit coastal areas situated close to large colonies of shearwaters and storm-petrels.

The number of grounded birds recovered each year is increasing at an exponential rate, with a particularly worrying increase after 2006 when LED use became widespread. LEDs may be more energy efficient but their physical aspects of light, emission spectra (wavelength) and intensity (brightness) that have the greatest effects on seabirds.

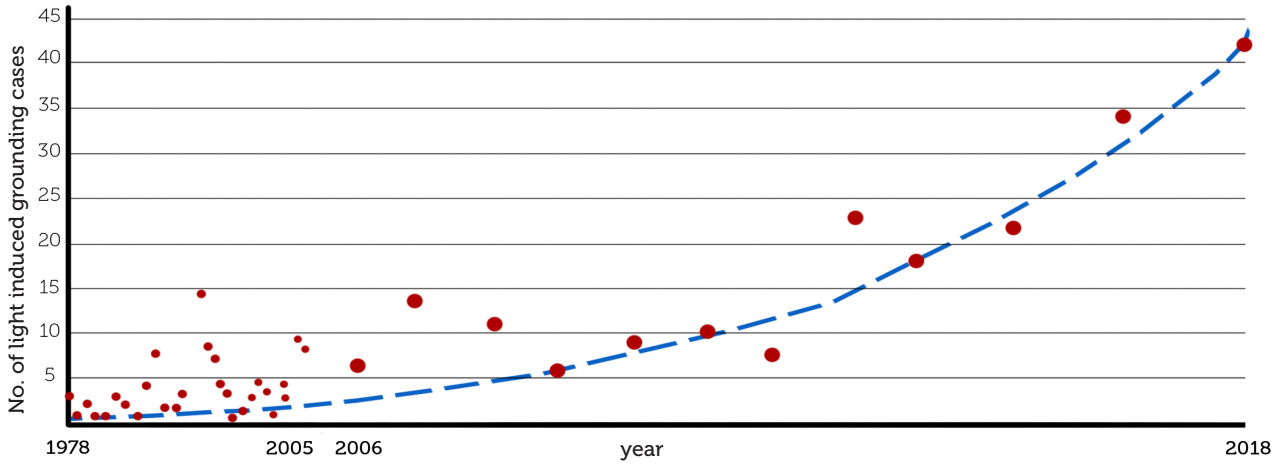
If this situation is left unchecked, the number of stranded fledglings is expected to rise. BirdLife Malta has also recorded the abandonment of historic shearwater breeding colonies. These areas were once unaffected by light pollution. However, development and poorly-designed outdoor lighting schemes led to large increases in the brightness of these sites.

The effects of light pollution can change according to the time of year, environmental conditions and stage of the breeding season.

It is now essential that we move towards more ecologically responsible outdoor lighting so that humans and the natural world can co-exist in the nocturnal natural environment.



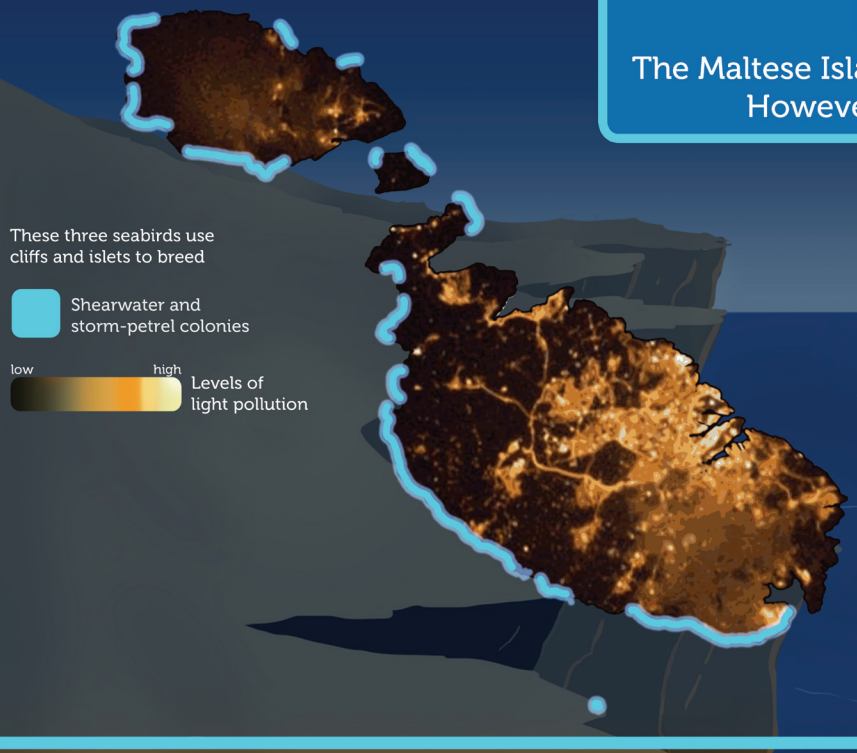
Graph showing the increase in number of grounded seabirds



DID YOU KNOW?

The Maltese Islands are an important location for breeding seabirds
However, light pollution is threatening their survival

BirdLife MALTA | L-Arċipelagu tal-Garnija



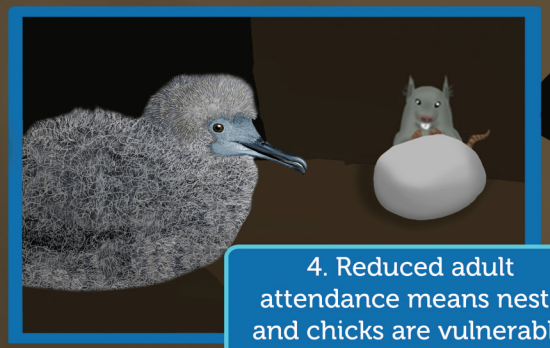
1. Fledglings are disoriented by bright lights and fly towards land instead of out to sea

Scopoli's Shearwater
Ciefa

Yelkouan Shearwater
Garnija

Mediterranean Storm-Petrel
Kangu ta' Filfla

3. The artificial illumination of breeding colonies stops adults from returning to their nests



4. Reduced adult attendance means nests and chicks are vulnerable to predation, exposure and may go without food

2. Whilst on land, grounded fledglings are vulnerable to predation, may be hit by vehicles or succumb to dehydration and starvation

PART 4.

Light pollution mitigation

Light pollution mitigation benefits

Environment:
The negative impacts of light pollution will be significantly reduced, increasing biodiversity and protecting nocturnal wildlife.

Tourism:
The Maltese Islands were once famed for their pristine dark skies. Dark sky areas are proven to attract tourists wanting to see the stars.

Shearwater colonies secured

Fledglings leave safely for sea

Energy costs:
Savings can be further increased if lights are switched off or dimmed at night

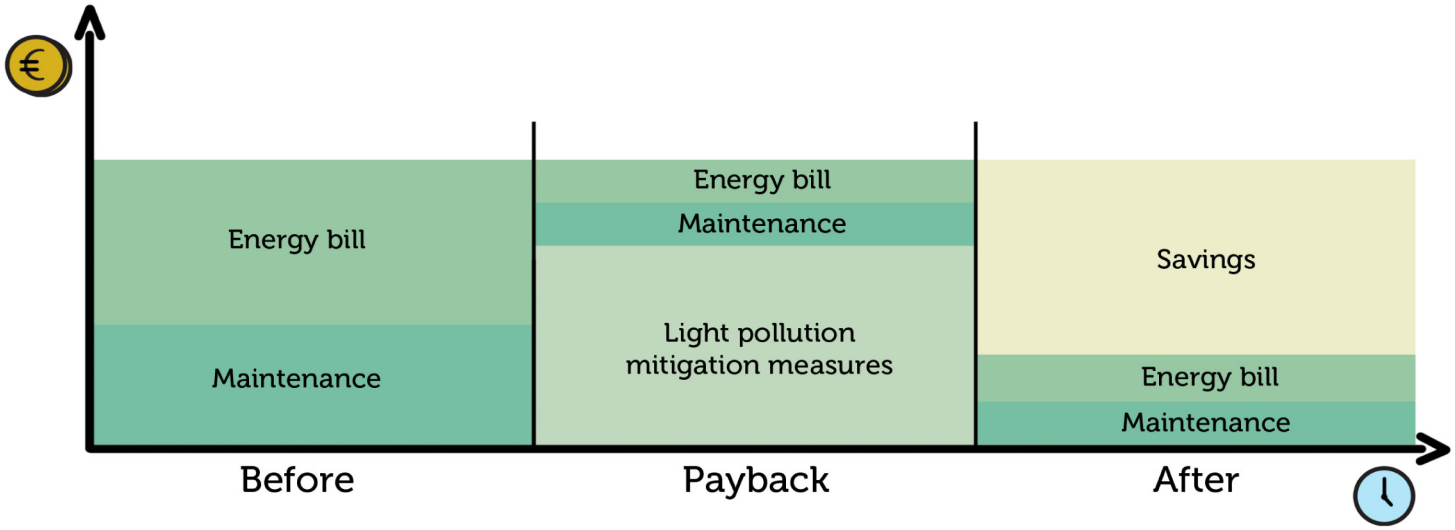
Energy use can be reduced substantially if energy efficient luminaires are used

Energy Reduction up to 60%

Street lights switched off when not in use

Quality of life:
Residents' lives are improved with reduced light trespass

PAYBACK is possible where out-dated or inefficient outdoor lighting schemes are replaced with energy-efficient and well-designed lighting. Once payback has been achieved, **substantial energy savings** can be enjoyed.



PART 4.

SECURITY BENEFITS OF MITIGATION

Light pollution from poorly-designed lighting schemes can make an area more dangerous.

These guidelines provide for lighting schemes that are low-impact and energy efficient without compromising public safety.

The primary goal of security lighting is to deter criminal activity by creating an environment where such activity is easily observable. However, many security lights often have the opposite effect. Security lighting is one of the major sources of glare and overlighting as bright lights are angled to illuminate as large an area as possible. Glare from these lights reduces visibility and makes it harder to see into darker areas. There is no evidence to suggest that increasing levels of lighting reduce crime [1].

Motion detectors should be installed to security lights. This has the added benefit of alerting the owner to the presence of an intruder each time the light is triggered. Outdoor lighting for public areas should provide the minimum illuminance required for safe use of that area. Intensely bright lights used excessively and poorly angled reduce visibility. To improve visibility in public areas, the minimum number of luminaires should be used. The aim should be to achieve the minimum safe level of illuminance with a good uniformity (see Part 5).

[1] Atkins, S., Husain, S., & Storey, A. (1991). *The influence of street lighting on crime and fear of crime*. London: Home Office.

Good lighting design

Milky Way over Filfla © Dorienne Grech

PART 5.

BEST PRACTICES FOR OUTDOOR LIGHTING

Any outdoor lighting will have an effect on the surrounding environment. However, through adopting good outdoor lighting design practice, it is possible to minimize the effects of light pollution. The following best practices should be taken into consideration at the earliest stage in the planning process:

Use full cut-off fixtures

Only full cut-off fixtures guarantee that light is directed only to where it is needed. They are the only fixture type to have an ULOR of 0%.

Keep intensity low

Use the minimum number of lights and the lowest intensity to provide appropriate illumination for the area.

Direct light to where it is needed

All luminaires should face downwards. Any light trespassing onto private properties, ecologically sensitive areas, or directed upwards is unacceptable.

Use lighting schedules

Outdoor lighting should be switched off when not required. Dimming and switching off lights reduces light pollution and energy costs.

Minimize blue light

Where possible, use outdoor lamps with a CCT <3000K or with a Spectral G-index of 1.5 in residential areas.

Reduce reflected light

Use non-reflective, dark-coloured surfaces for roads and infrastructure.

Promote good uniformity of illumination

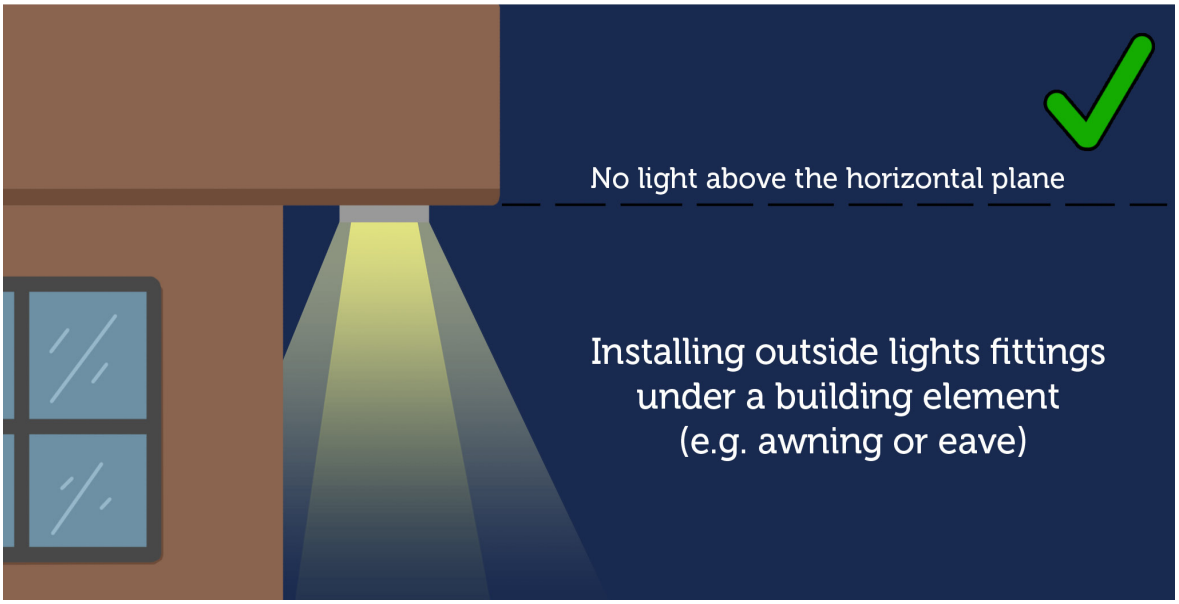
Outdoor lighting schemes should provide a constant average brightness across a given area. This aids human vision and increases our safety and security.

FULL CUT-OFF LUMINAIRES

All outdoor luminaires should be **full cut-off**. This helps to direct light to where it is needed, reducing light trespass.

Only full cut-off luminaires are guaranteed to emit no light above the horizon. This is known as the **Upward Light Ratio 0% (ULOR 0%).**

Full cut-off luminaires reduce light spill, optimize useful light and minimize glare.



PART 5.

REDUCING BLUE LIGHT

Correlated colour temperature

Correlated colour temperature (CCT) is the term given to how the human eye differentiates between different hues of white light. The scale is measured in Kelvin. Generally speaking, lamps with higher CCT often contain a higher proportion of blue light.

Blue light has the most negative impacts for both human health and the natural environment. Outdoor lighting must focus on reducing and excluding blue wavelengths entirely.

Only luminaires with a CCT ≤3000K are considered appropriate for outdoor use

Spectral G-index

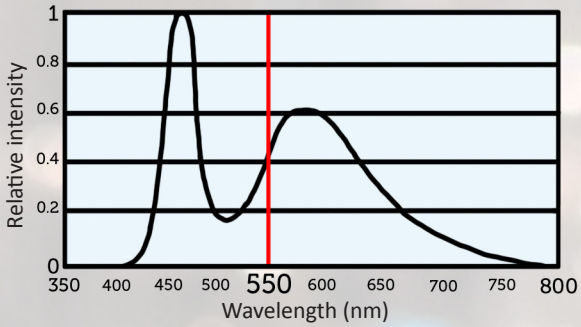
A new method of describing the spectra of lamps has been adopted. CCT does not adequately describe the spectrum of a lamp as CCT is not correlated with the amount of blue light. The Spectral G-index quantifies the amount of blue light per lumen from a light source. The smaller the G-index, the more blue light the spectrum contains.

Limit blue light emissions by using lamps with a high Spectral G-index

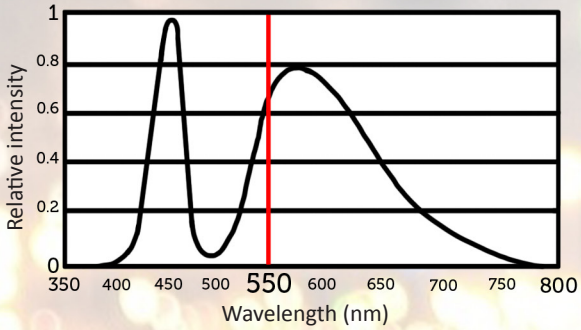
Colour temperature

Emission spectra of lamps with different CCT.
Note the spikes in blue-light at 400 - 500nm

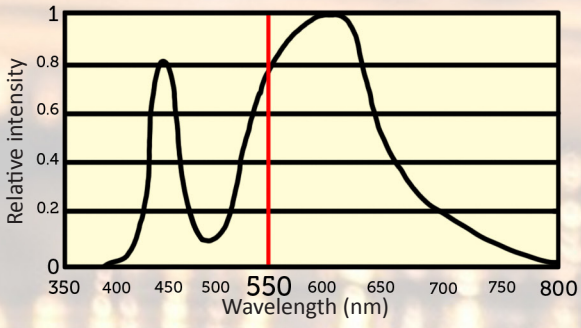
Cold white 5000K



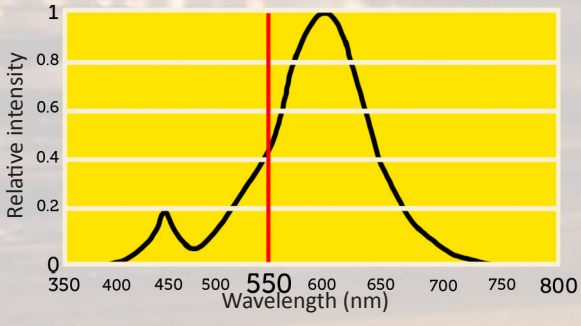
Neutral white 4000K



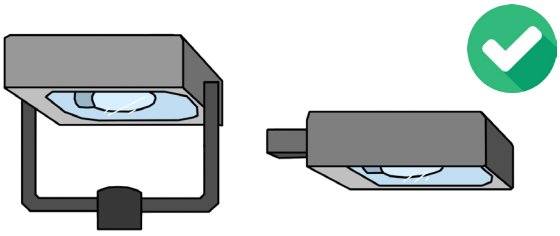
Warm white 3000K



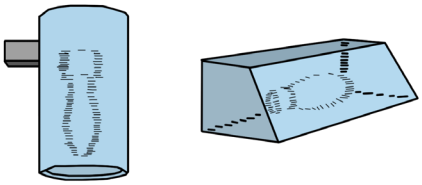
Amber white 2200K



APPROPRIATE LUMINAIRES

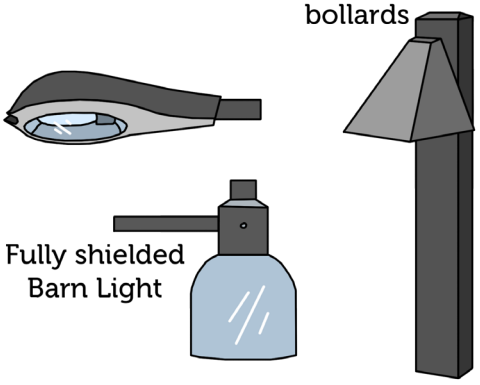


Full cut-off fixtures



Fully shielded fixtures

Fully shielded walkway bollards

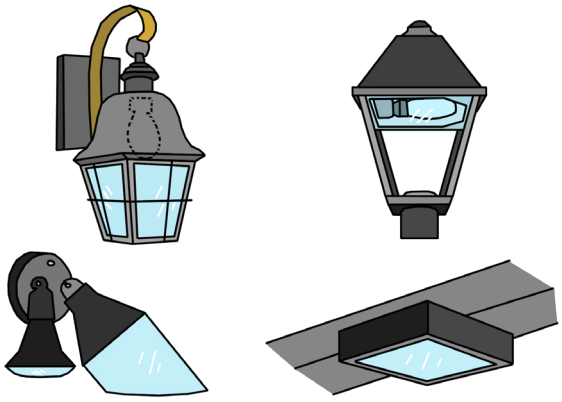


Fully shielded Barn Light

Fully shielded wallpack & wall mount fixtures

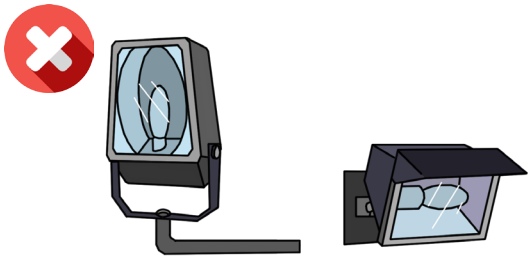
fully shielded decorative fixtures

fully shielded 'period' style fixtures

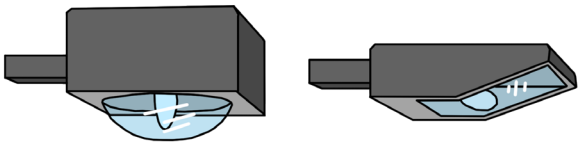


shielded / poorly-aimed PAR Floodlights

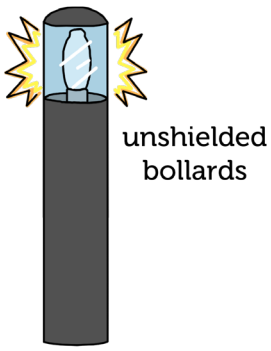
Flush mounted or side shielded under canopy fixture



unshielded floodlights or poorly-shielded floodlights

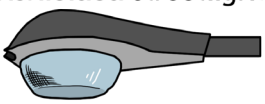


Drop-Lens & Sag-Lens fixtures w/ exposed bulb/ refractor lens

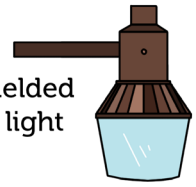


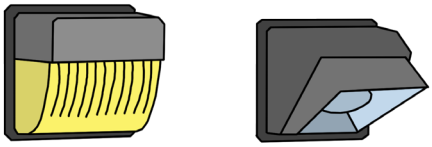
unshielded bollards

Unshielded streetlight



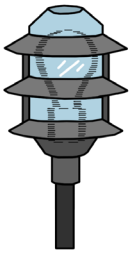
Unshielded barn light





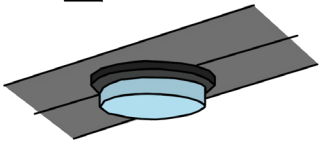
unshielded wallpacks & unshielded or poorly-shielded wall mount fixtures

Louvered 'Marine' Style Fixtures



Unshielded 'period' style fixtures

Unshielded PAR Floodlights



Drop-Lens Canopy Fixtures

PART 5.

PART 5.

APPROPRIATE ILLUMINATION

The minimum level of lighting required to create a safe and secure environment for human use should be used in all instances. Over illumination with many luminaires is wasteful both in capital investment and long term running costs.

The Environmental Zone classification of the surrounding area must be considered when designing outdoor lighting. Lighting appropriate for heavily urbanised areas would be unacceptable for use in protected sites. Guidance on Environmental Zone classification can be found in the table below.

Table 3 - Environmental Zones

Zone	Surrounding lighting	Environment	Examples
E0	Protected	Intrinsically dark	UNESCO Starlight Reserves, IDA Dark Sky Parks
E1	Natural	Dark	Relatively uninhabited rural areas
E2	Rural	Low distict brightness areas	Sparsely inhabited rural areas
E3	Suburban	Medium district brightness areas	Well inhabited rural and urban settlements
E4	Urban	High district brightness areas	Town and city centres and other commercial areas

Source: Commission Internationale de l'Eclairage. "Guide on the Limitation of the Effects of Obstrusive Light from Outdoor Lighting

The minimum illuminance required for safe use of outdoor area depends on the tasks occurring. Tasks that demand high levels of safety need greater illumination. Minimnum required illuminance can be determined by following guidance documents:

EN12464-2:2014 "Light and lighting – Lighting of work places – Part 2: Outdoor work places"

Commission Internationale de l'Eclairage (CIE) "Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations", 2nd Edition (CIE 150:2017).

LIGHTING SCHEDULES

One of the easiest methods of mitigating light pollution is to implement lighting schedules. Outdoor lighting is often left on throughout the whole night. Lighting schedules dictate the times at which outdoor lighting is permitted. The benefits of a lighting schedule are many, ranging from reduced costs and enhanced fixture lifespan to complete elimination of light pollution when lights are turned off. There are many ways to design a lighting schedule; what is best for a locality is dependent on the demands of human activity.

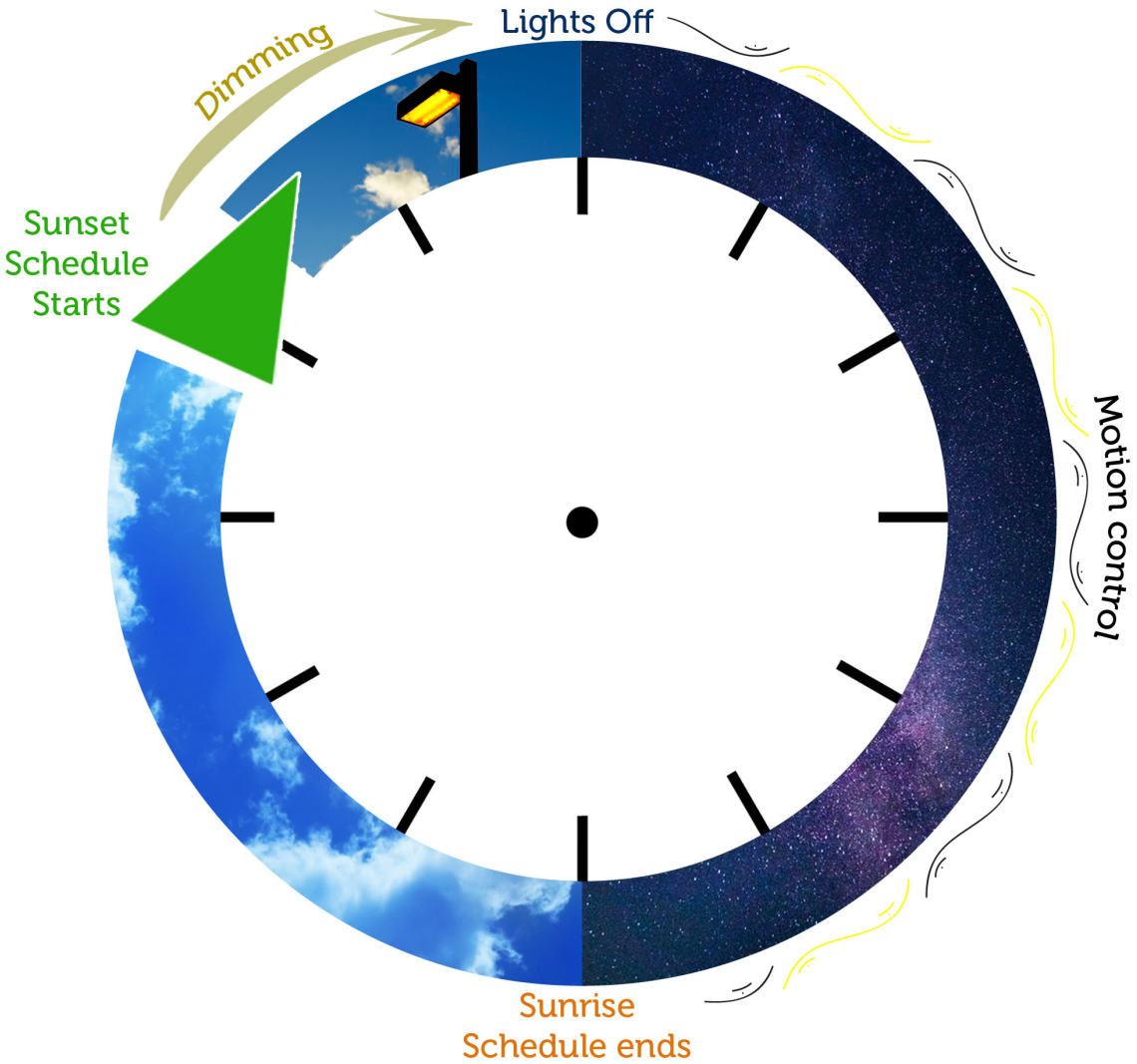
The most basic and perhaps easiest of lighting schedules is a curfew. In this case, all outdoor lights are turned off during certain times. Other options include smart-lighting systems and dimming. Smart-Lighting systems have been implemented in major cities worldwide. These systems use control systems that govern at what times and intensities lights are switched-on.

Technology enables us to control outdoor lighting according to demand. Installation of motion detectors will help ensure that only the area required to be illuminated remains lit for the duration of activity.

LED lighting allows a finer degree of control opposed to HPS or metal-halide lamps. Compatible LEDs can be easily dimmed when not in use or during times of low demand. The human eye is more than capable of adapting to lower levels of light when lighting is dimmed.

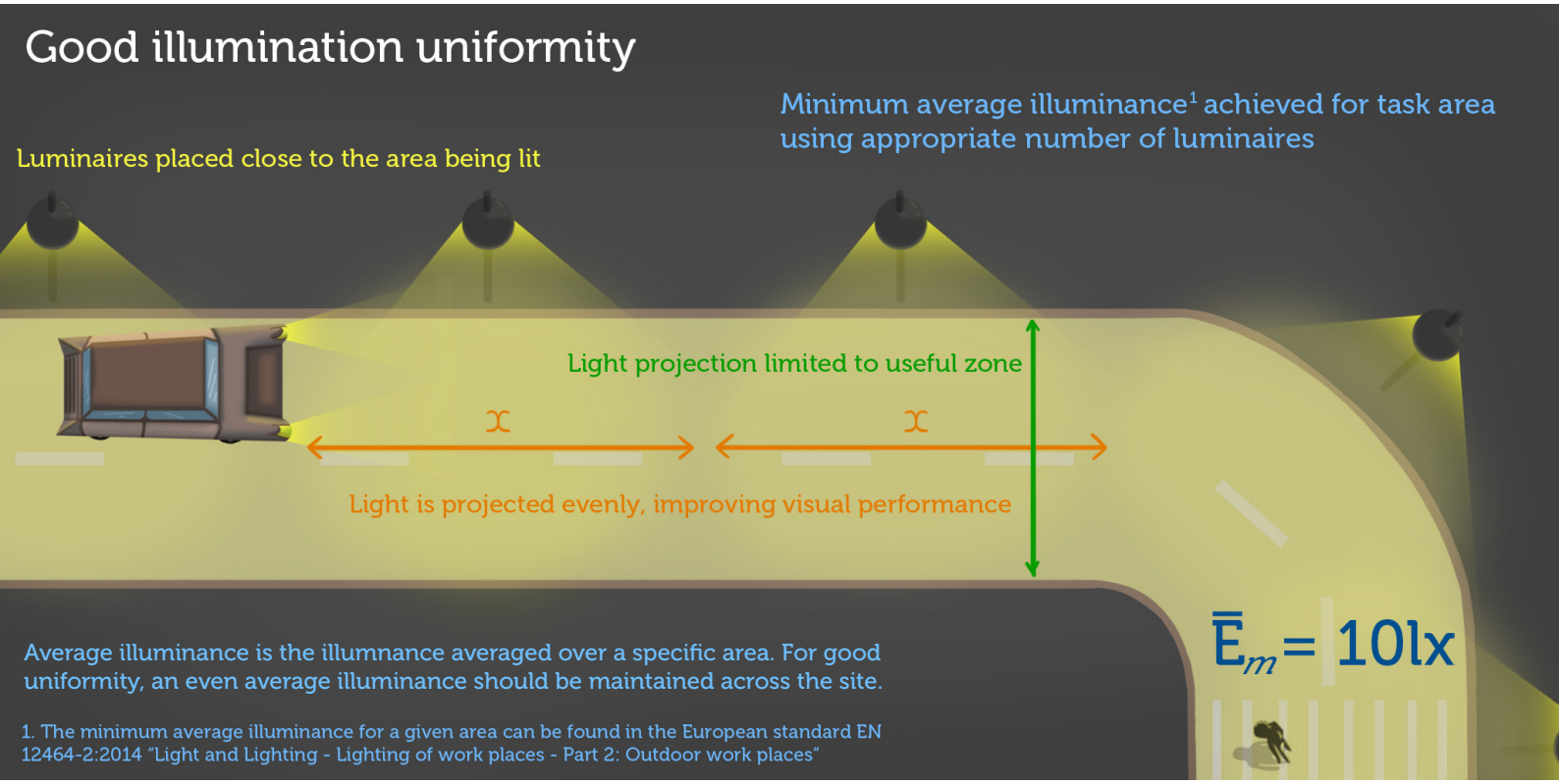
Energy and operational costs are substantially reduced.

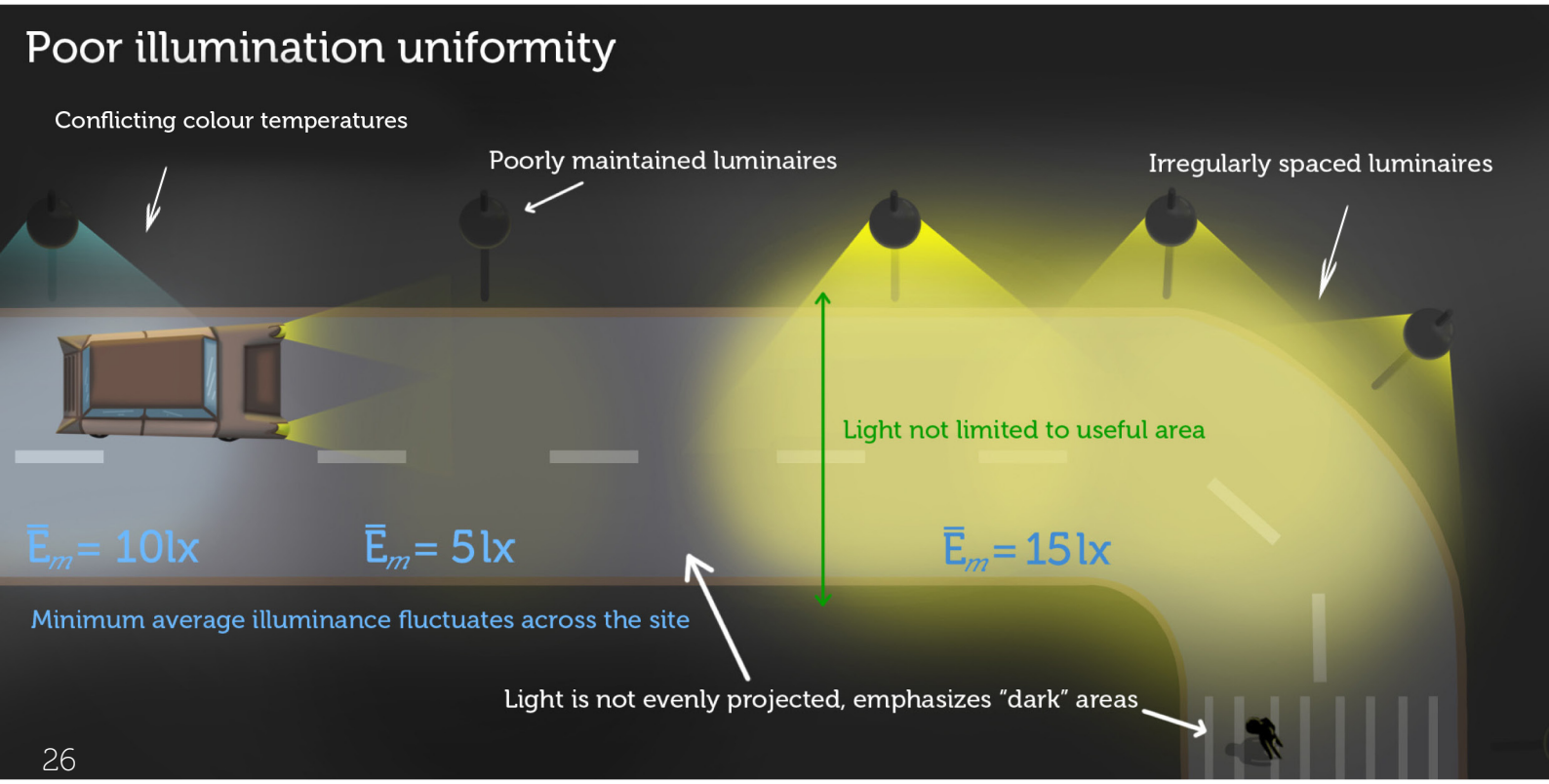
A good lighting schedule promotes appropriate lighting, increases energy efficiency and reduces maintenance costs.



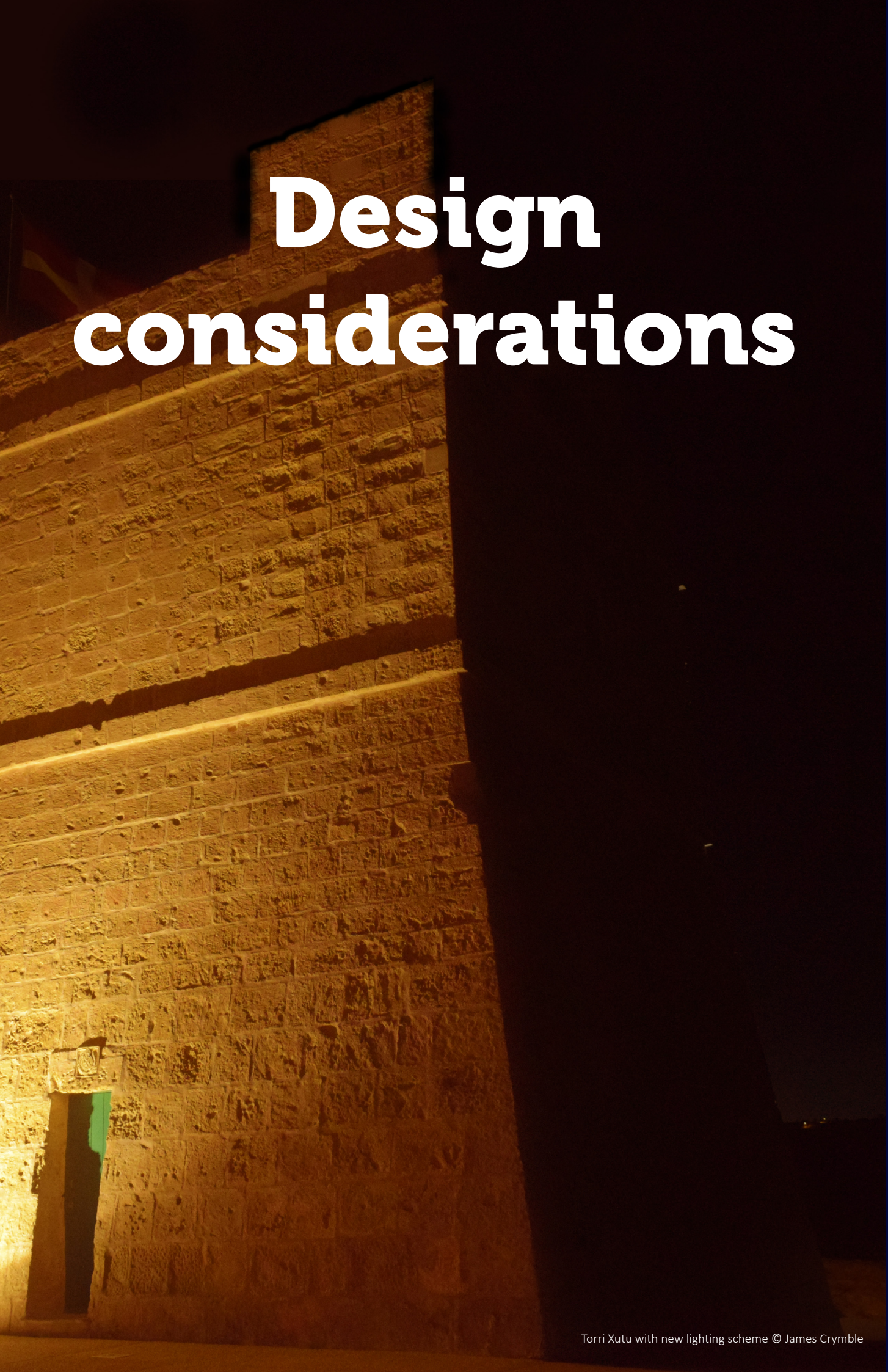
UNIFORMITY OF ILLUMINATION

Uniformity of illumination is an important part of outdoor lighting design. The more uniform outdoor lighting is, the better we are able to perceive our environment and navigate it safely. Sudden breaks in lighting or changes in light intensity creates a visually confusing scene, making it harder to see obstacles or dangers. Good uniformity of illuminance should apply in all settings, from roads and streets to public gardens and other leisure areas.





Design considerations



Torri Xutu with new lighting scheme © James Crymble

PART 6.

PART 6.

SEABIRD FRIENDLY OUTDOOR LIGHTING

Extra consideration must be given to seabirds when planning or upgrading outdoor lighting. Due to their high sensitivity to artificial light at night and its potentially lethal impacts, all outdoor lighting likely to affect seabirds must be planned in an ecologically responsible manner. This can easily be achieved if the environmental impacts of outdoor lighting are considered at the earliest planning stages.

Mitigating light pollution for seabirds benefits everyone. Using fewer, less intense lights not only reduces initial costs but also reduces long-term running costs. As this Guideline describes, it is possible to design outdoor lighting in an ecologically responsilbe way whilst providing a safe and secure environment for human use.

Legal framework

Seabirds in the Maltese Islands are listed as an Annex 1 species and are afforded protection under various items of legislation. It is illegal to hunt, take or deliberately disturb seabirds during their breeding and rearing periods. Light pollution is a major source of disturbance for these birds and disturbance arising from poorly-designed outdoor lighting schemes could be considered as a deliberate act if no Environmental Impact Assessment or mitigation measures are carried out.

Development close to breeding colonies

Historic seabird breeding colonies have already been abandoned as a direct result of development and resulting light pollution. The gradual degradation of habitat by artificial lighting will continue to restrict the areas where seabirds can breed. This could lead to a substantial long-term population decline if the problem is not addressed.

Seabirds must feautre prominently in the Enviornmental Impact Assessment of any development occurring within 3 km or in direct line of sight of a seabird breeding colony. These developments should have the absolute minimum level of outdoor lighting. All lighting should be downward facing, full cut-off and face inland. The intensity of light used should meet the minimum level described by relevant guidance documents (ANNEX 2).

Safeguarding the darkness of breeding colonies is a priority. Without daarkness we risk losing our seabird populations for good. Following our recommendations for seabird friendly lighting on page 30 will help to protect our breeding colonies of seabirds.

Scopoli's Shearwaters at sea © Aron Tanti

Outdoor lighting within grounding hotspots

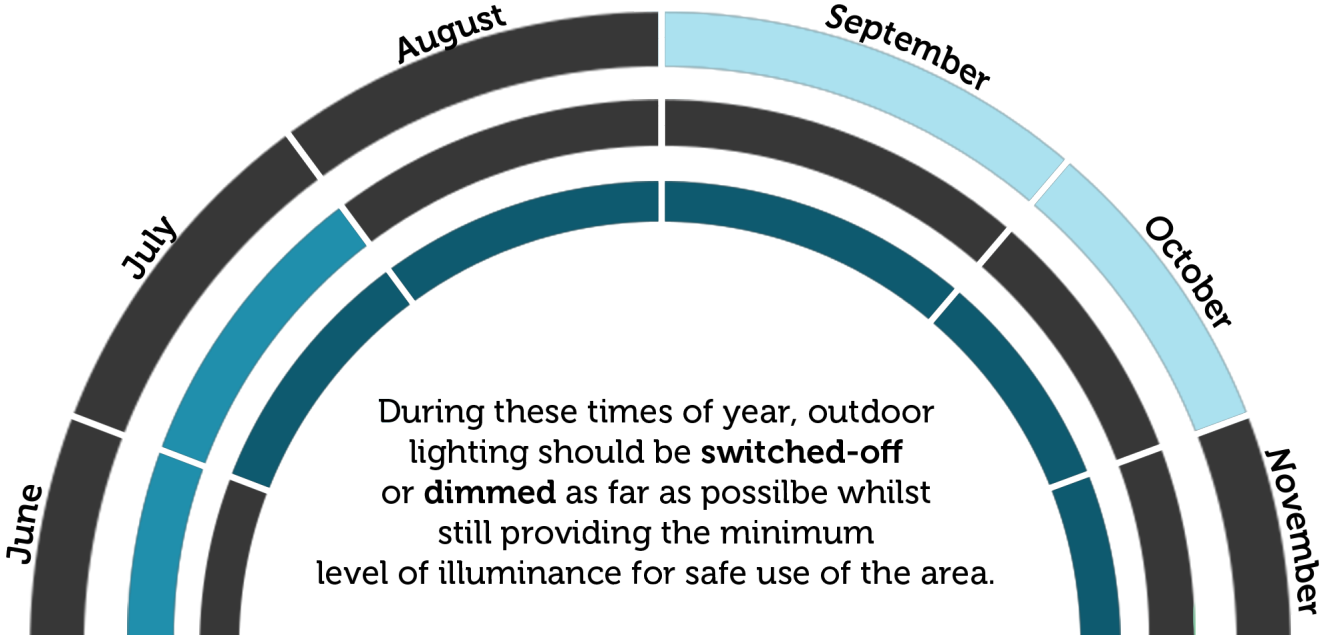
Seabirds are attracted to light sources from as far away as 15 km. Therefore, outdoor lighting schemes within light-induced grounding hotspots aand other coastal areas must be designed with particular attention to seabirds. To limit any increase in light pollution at these areas, new developments or upgrading of lighting schemes should adhere to the best practices described in this document.

Extra consideration should be given to any light likely to affect the marine environment. Any light shining directly out to sea is unacceptable unless required for safe passage or the loading and unloading boats within designated landing sites.

Fledging periods

- Scopoli's Shearwater
- Yelkouan Shearwater
- European Storm-petrel

Outdoor lighting should be restricted as far as possible during the critical **fledging periods** for shearwaters and storm-petrels.



Suitability for use near seabird habitat	
Low Pressure Sodium Vapour	White LED
High Pressure Sodium Vapour	Metal halide
Filtered* LED	White fluorescent
Filtered* metal halide	Halogen
Filtered* white LED	Mercury vapour

Suitable Not suitable

'Filtered' means this type of luminaire can be used only if a filter is applied to remove the short wavelength light.

Adapted from 'National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds, Commonwealth of Australia 2019'.

Management action	Detail
Implement management actions during breeding season.	Seabirds in the Maltese Islands nest from Spring to Autumn. Extra consideration must be given at these time of year: June-July | Yelkouan Shearwater. Late-September-November | Scopoli's Shearwater. July-November | European Storm-petrel.
Maintain a dark zone between breeding colonies and the light sources.	Install only lighting essential for infrastructure within 3 km of a breeding colony. Avoiding the installation of lights in this zone would reduce the number of grounded birds substantially.
Turn off lights during fledging seasons.	If possible, switch off all lights during the fledging seasons. If this is not possible consider curfews, dimming options, or changes on light spectra (preferably towards lights with low blue emissions).
Use lighting schedules to manage lighting.	Switch off lights around the breeding colony or in stranding hotspots during the fledging period by 22.00 pm.
Aim lights downwards and direct them away from nesting areas.	Aim light onto only to where it is needed. Any light with an ULOR > 0% is unacceptable. Use shielding to prevent light spill into the air or sea and outside the footprint of the target area.
Use motion sensors to turn lights on only when needed.	Pedestrian or street lighting within 3 km of a breeding colony or within a grounding hotspot should be controlled using motion detectors. This guarantees that lights are only switched-on when required.
Manage artificial light on jetties, wharves, marinas, etc.	Fledglings and adults may be attracted to lights on marine facilities and become stranded or collide with infrastructure.
Avoid lights containing short wavelength violet/blue light.	Do not use lights rich in blue light, i.e. metal halides, fluorescent, halogens, mercury vapour and white LEDs in or near seabird breeding colonies. LEDs with CCT <3000K are preferred.
Avoid white LEDs.	Ask your supplier for an LED light with little or no blue in it, or only use LEDs filtered to block blue light. Relative wavelength content can be visualised through a spectral power curve.
Avoid high intensity light of any colour.	Keep light intensity as low as possible in the vicinity of seabird breeding colonies and within grounding hotspots.
In facilities requiring intermittent night-time inspections, turn on lights only during the time operators are moving around the facility.	Use LEDs with CCT <3000K with smart lighting controls and/or motion sensors. LEDs have no warmup or cool down limitations so can remain off until needed and provide instant light when required for routine nightly inspections or in the event of an emergency.
Supplement facility perimeter security lighting with computer monitored infrared detection systems.	Perimeter lighting can be operated when night-time illumination is necessary but otherwise remain off.
Design and implement a rescue program for stranded birds.	This will not prevent birds from becoming grounded, but it is an important management action in the absence of appropriate light design. Rescue programs have proven useful to reducing mortality of seabirds. The program should include documentation and reporting of data about the number and location of rescued birds to regulatory authorities.

Adapted from © National Light Pollution Guidelines for Wildlife: Including Marine Turtles, Seabirds and Migratory Shorebirds, Commonwealth of Australia 2019.

STREET AND ROAD LIGHTING

The purpose of street lighting is to illuminate essential infrastructure, allowing for safe passage of all road-users and pedestrians alike. All too often, street lighting is poorly designed and may even reduce road safety by creating a confusing visual landscape of different colour temperatures, dark areas and glare.

Street lighting contributes as much as 30% to total sky glow. Street lights are also a source of stray light that often falls on private properties, impacting on the quality of life of residents.

Better lighting uniformity will reduce the negative perception of “darker” areas between street lights – these areas are in fact brighter than unlit areas but the human eye cannot adjust fast enough to the rapid changes in brightness.

The best option is to eliminate road lighting in areas with low traffic entirely. In some European countries, major arterial roads have no road lighting, instead they enforce lower speed limits and use reflective signs and road markings. Studies show that reducing street lighting through dimming, part-night lighting and switch-off do not increase road traffic collisions [1].

If road lighting is deemed absolutely necessary, it should provide the minimum illuminance depending on the environment zone classification, traffic level, and pedestrian usage at a given time.

[1] Steinbach, R., et al., (2015). *The effect of reduced street lighting on road casualties and crime in England and Wales: controlled interrupted time series analysis*. J Epidemiol Community Health, 69(11), 1118-1124.

Differences in road lighting CCT © LIFE Arċipelagu Garnija

HOTELS

The Maltese coast has many large hotels in prominent locations. Hotels are brightly lit and the numerous balcony lights are left on for long periods of the night. Hotels are easily distinguishable as they appear as large blocks of bright lights, even from afar. This kind of lighting is unnecessary as many hotel guests will have chosen the hotel prior to their holiday.

As such, hotel owners and operators must take action to move away from using lights for advertising reasons and should begin to compete in environmental responsibility. Decorative lighting should be kept to the absolute minimum. Balcony lights should be switched off as default and given to the control of the room's occupants using a timer switch.

Hotel guests can be informed upon arrival of the steps taken by the hotel owner or operator to reduce light pollution and the reasons why they are being implemented.

Hotels situated close to ecologically sensitive areas should take particular care during critical times of year for the local wildlife. Nesting turtles, fledgling seabirds and various other species are strongly influenced by artificial lights at night.

Switch-off or dim outdoor lighting as far as possible during critical fledging periods

Radisson Blu Resort & Spa, Malta Golden Sands © LIFE Arċipelagu Garnija

Promenade extending from Buġibba to Qawra © LIFE Arċipelagu Garnija

COASTAL PROMENADES

Many coastal settlements in the Maltese Islands have extensive promenades running the length of their seafronts. These areas are important features for enjoyment and leisure opportunities. However, they are often over-illuminated by an excessive number of lights that remain on throughout the whole night.

The styles of luminaire chosen for promenades are often inappropriate. In many cases these luminaires are unshielded on their seaward facing side, resulting in a large amount of stray light cast out to sea. Not only does this contribute to light pollution, it also creates a large visual impact when viewed from afar. Luminaires that cast light in one direction only should be used to illuminate promenades. These luminaires should be installed so that the lamp faces inland.

Limit light spill by using full cut-off, downward facing fixtures.

Coastal lights would benefit greatly from a lighting schedule. They should be controlled using motion detectors, ensuring that only the area of promenade being used would be illuminated when required. Alternatively, these lights can be dimmed during times of low use.

Promenade lighting should be switched-off or dimmed during periods of low-use.

Aerial view of Marfa jetty at night © LIFE Arčipelagu Garnija

HARBOURS, MARINAS AND JETTIES

Almost every coastal settlement has at least on dedicated harbour, jetty or slipway for the launching and landing of watercraft. Launching and landing of boats at night undoubtedly requires adequate provision of light.

In many places, jetties and slipways are currently illuminated using a single bright metal-halide or LED light that is angled in such a way that it produces a large amount of glare and a substantial amount of stray light shines out to sea. These lights are left on throughout the whole night.

Harbours, jetties and slipways should be illuminated only when necessary and controlled by motion detector. Any lights installed should be full cut-off and downward facing so that only the area required is illuminated whilst keeping glare and stray light to a minimum.

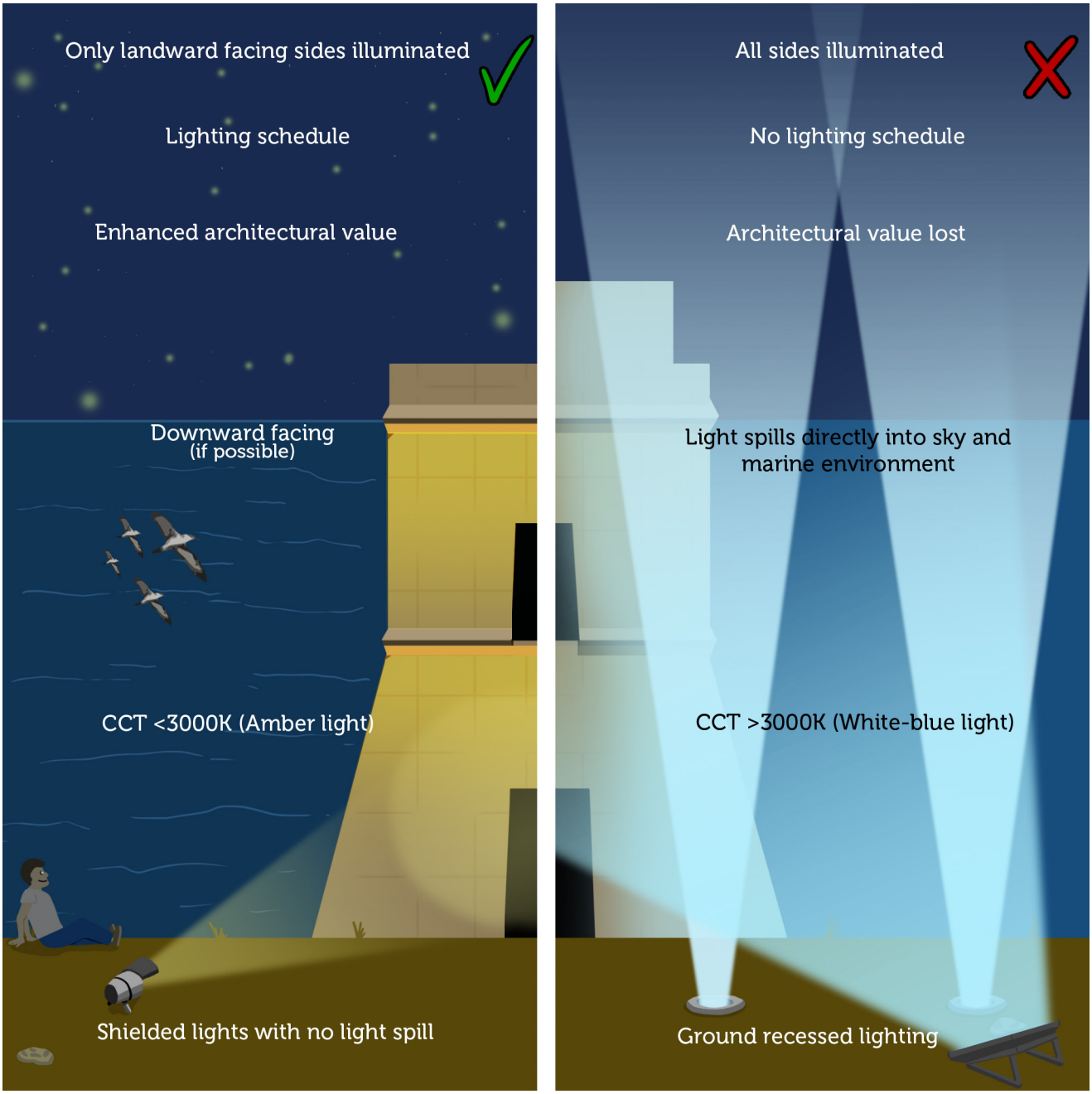
Use motion detectors to reduce light pollution and energy costs

BUILDINGS OF CULTURAL SIGNIFICANCE

Malta and Gozo have a wealth of culturally and historically significant buildings. Many of these buildings, such as the towers and fortifications, are illuminated using indiscriminate lighting, for example uptilted flood lights or ground-recessed spotlights which cause a large amount of stray light to be cast directly into the sky. The number and brightness of the lights used contributes to a harsh lighting effect on the building, reducing their architectural value as fine detail features are lost.

These structures should have lighting schemes tailored to enhance their unique architectural characteristics. They should only be illuminated on their landward side. Spotlights and floodlights should be positioned so that all their light enters the target area. It is unacceptable that any stray light results from the illumination of these structures. Specific shades can be applied to floodlights, thereby reducing the amount of stray light.

Use the minimum number of full cut-off and downward facing (where possible) with a CCT <2700K (amber-light).
All lights should be switched-off overnight



PART 6.

ECOLOGICALLY SENSITIVE AREAS

Special consideration must be given to areas of high ecological sensitivity – areas include all sites of the Maltese Natura 2000 network and other designated protected sites.

Various rare and threatened endemic species live in the Maltese Islands

Outdoor lighting in ecologically sensitive areas should be eliminated or kept to the absolute minimum. Blue light must be reduced to its lowest possible level. For best results, all best-practice guidelines in this document should be followed.

Where outdoor lighting is necessary, laws pertaining to protected sites demand that all outdoor lighting within 30 m of a Natura 2000 site must be vetted by ERA prior to installation.

To keep blue light to a minimum, only lamps with a CCT <3000K or spectral G-Index > 2 should be used.

Natura 2000 sites are protected by law under the Environment Protection Act (CAP, 549)

NATURA 2000

Ta Ċenc Cliffs © Paulo Lago

MARINE TURTLES AND LIGHT POLLUTION

Three marine turtle species regularly occur in the Mediterranean Sea – The Loggerhead turtle *Caretta caretta*, the Green turtle *Chelonia mydas* and the Leatherback turtle *Dermochelys coriacea*.

The Maltese islands play an important role, as they hold various foraging grounds for turtle species common to the Mediterranean. The Loggerhead turtle has even been recorded as visiting the Maltese Islands during nesting season in 2012, 2016 and 2018, in the northern part of Malta.

Even though we are more aware of the impact of threats such as plastic pollution on sea turtles, turtles are endangered as their nesting sites become threatened due to human disturbance, recreational beach use and coastal development. One growing disturbance that is adversely impacting turtle nesting sites and hatchling mortality rates is artificial lighting.

Light pollution is exacerbated near coastal destinations, not just by urbanization, but also increased tourism. In Malta, as the tourism sector grows and investment is made to develop its coastal infrastructure, this will become an increasing problem for its endangered turtle population. This is compounded by the fact that turtle hatching season corresponds with peak tourist season in summer.

But how is this a problem?
Light is used as a mode of navigation for sea turtles where the sea is often considered the brightest source of light, as it reflects the moonlight. This is particularly important for nesting mother sea turtles as well as hatchlings. However, artificial light produced by growing coastal developments pose two significant problems for future turtle conservation efforts in the region.

Firstly, nesting female turtles look for quiet, dark beaches on which to nest. Artificial lights deters females from using those areas as nesting grounds and if she fails to nest after several false crawls she will resort to depositing her eggs in less-than-optimal locations, which might result into an unsuccessful nest. This invariably leads to marginal survival rates for hatchlings of an already endangered species.
Artificial light also poses a risk to hatchlings who emerge at night and can easily become disoriented and are inadvertently drawn inland towards the light. As a result, they are likely to die of injury, dehydration or predation as they are unable to reach the sea.
Research to identify further important nesting hotspots around the world is being implemented. Conservation organizations globally are making efforts to control light pollution in these ecological hot-spots, with local governments implementing enforcement with regards to human activities on hotspot nesting beaches during the nesting season.

The adoption of light control as part of coastal management efforts, would make significant difference in the protection of such species. Countries around the world, have adopted multiple ways to tackle the problem such as the mitigation of glow of nearby artificial lighting.

Such efforts can be adopted by both private and public sectors to ensure improved coastal management. This will help in the long term conservation goals being the increase of nesting turtles in our beaches.

By Oriana Balzan, Nature Reserves Manager

Loggerhead turtle nest 2018 © Nature Trust Malta


Turtle hatchling © Nature Trust Malta

GLOSSARY

Correlated Colour Temperature – A measurement, in Kelvin (K), of how the colour of light is perceived by the human eye. Lights with CCT > 4000K emit light containing a high proportion of blue light. Lights with CCT <3000K significantly reduce the amount of blue light emitted in their spectrum

Cut-off - A method of describing the output direction of light from a source.

Dark sky tourism – Tourism based on the attraction of good night sky visibility.

Ecologically sensitive area – An area identified as requiring increased protection due to its landscape, wildlife or historical value.

Glare – The vision disabling effect of viewing a light source that is far brighter than its surrounds.

Illuminance – A measurement of the amount of light falling in a particular area. Is used to describe the effectiveness of lighting illumination. Measured in lux. See lux

Kelvin – A unit of temperature measurement based on the absolute thermodynamic temperature scale where 0 Kelvin is absolute zero.

LED Light Emitting Diode – A semiconductor light source that emits light when a current is passed through it.

Light-induced grounding – The result of a shearwater becoming grounded on land due to being attracted by artificial lights at night

Light Trespass – Light falling where it is not needed or intended e.g. private property.

Lumen – A measurement of the total quantity of visible light emitted by a source.

Luminaire – A complete electric light unit (lamp, post, shade etc.)

Luminance – The intensity of light emitted from a surface per unit area in a given direction.

Luminous Efficacy – The measure of a light source's effectiveness in producing light, for a given input electrical power. Unit is lumens per Watt (lm/W).

Lux – The metric unit for measuring the level of illuminance.

Ornamental lighting – A light fixture that is predominantly for decorative purposes. Design is often based on the classical look of light fixtures.

Overlighting – Light levels exceeding those necessary for human vision.

Shielding – A descriptive term used to indicate the extent at which light emitted from a luminaire is directed and shielded from contributing to glare, light trespass and sky glow.

Smart lighting – Outdoor lighting that is enabled to be switched off or dimmed when it is not needed.

Uniformity – The relationship between the average luminance value and the lowest. Substantial and/or sudden differences in luminance can be disturbing.

Uptilt – An upward angle of tilt that a luminaire is installed at.

Annex 1 - Maltese legislation concerning outdoor lighting and light pollution

i. The Marine Policy Framework Regulations (SL 549.62)

ii. The Strategic Plan for the Environment and Development, 2015

iii. The Environment Protection Act, 2015 Part VII, Article 58

iv. The National Environment Policy and the National Strategy for the Environment

v. The National Biodiversity Strategy and Action Plan 2012-2020

vi. The Flora, Fauna and Natural Habitats Protection Regulations, 2006 (SL 549.44)

vii. Environmental Impact Assessment Regulations, 2007 (SL 549.46)

viii. Development Control Design Policy, Guidance and Standards, 2015 (DC, 2015)

ix. The Development Notification Order (Legal Notice 211/16)

x. Gozo and Comino Local Plan (2006)

Annex 2 - Guidance documents

i. Commision Internationale de l'Eclairage (CIE) "Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations", 2nd Edition (CIE 150:2017).

ii. EN 12464-2:2014 "Light and Lighting - Lighting of work places - Part 2: Outdoor work places".

iii. The Institution of Lighting Professionals (ILP) "Guidance Notes for the Reduction of Obtrusive light"