



Conférence Européenne
des Directeurs des Routes
Conference of European
Directors of Roads

WG Environment

Lighting and light pollution on major road infrastructure

INTRODUCTION

Light pollution is an environmental issue that has received much attention in the last years due to its negative impact on insects, birds, bats and other species. The change to LED-lights has increased light pollution in Europe resulting in very worrying situation; more than 60 % of Europeans can't see the Milky way from their homes (Falchi, 2016).

As an answer to the above, in March 2022, CEDR launched a survey on the topic of lighting and light pollution on major road infrastructure.

NRAs were asked the following questions:

- 1. Do you have a strategy for mitigating the impacts of light pollution from your network?***
- 2. What measures have you undertaken to mitigate light pollution?***
- 3. What are the most important considerations for you when it comes to mitigating light pollution?***
- 4. Have you undertaken any research or innovation projects on the impacts of light pollution?***
- 5. What changes e.g., limitation of lumen output, colour temperature, tilt angle, lighting times etc., have you made to your national guidelines/standards to mitigate the impacts of lighting?***

Ten different NRAs participated in the survey and their answers can be found below:

COUNTRY FEEDBACK

AUSTRIA

1. Do you have a strategy for mitigating the impacts of light pollution from your network?

The ASFINAG has no over-all strategy for the impacts of light pollution. However, the increasing number of (technical) restrictions and specifications (eg defined lumen, restrictions of the lighting times for the mitigation of the impacts of light pollution) in nature conservation approvals shows the growing importance of this topic.

2. What measures have you undertaken to mitigate light pollution?

The current measures are closely linked to renovation works and the planning and construction of new schemes and projects. ASFINAG forces the adaption and re-

equipping of old lighting systems to LED lighting systems alongside an adequate light management on existing roads. The goal of light management is to optimise tilt angles and directions of the lighting to mitigate light pollution (especially usage of full-cut lighting). Moreover, an adequate light management is mostly part of official permits.

In addition, measures such as noise barriers can and partially do function as a slight mitigator of light pollution.

3.What are the most important considerations for you when it comes to mitigating light pollution?

The use of the state of the art (eg full-cut lighting) and the technical standards (eg ISO-Norm, ÖNORM).

4.Have you undertaken any research or innovation projects on the impacts of light pollution?

There was no need, respectively a strong driver for research in this field in the past.

5.What changes e.g., limitation of lumen output, colour temperature, tilt angle, lighting times etc., have you made to your national guidelines/standards to mitigate the impacts of lighting?"

Aside the requirements and standards defined in national guidelines/standards or other technical guidelines no changes are made.

DENMARK

1.Do you have a strategy for mitigating the impacts of light pollution from your network?

No

2.What measures have you undertaken to mitigate light pollution?

Nothing in particular

3.What are the most important considerations for you when it comes to mitigating light pollution?

Traffic safety and bats

4.Have you undertaken any research or innovation projects on the impacts of light pollution?

No

5. What changes e.g., limitation of lumen output, colour temperature, tilt angle, lighting times etc., have you made to your national guidelines/standards to mitigate the impacts of lighting?"

Nothing

GERMANY

1. Do you have a strategy for mitigating the impacts of light pollution from your network?

The aim is to develop a technical set of regulations for protection against light emissions including light pollution, to finally provide technical instructions for protection against light as a general administrative regulation ("TA-Licht"). For this purpose, a national working group has been established, which will first record the status quo in the area of light emissions and on the basis of which the necessary technical regulations will then be defined in a second step. In order to clarify open questions on the topic of light emissions including light pollution, corresponding research projects will be tendered and carried out. In addition, there will be an intensified exchange with experts in European and international committees (CEN, CIE, ISO).

The development of technical regulations is supported by the adaptation of corresponding laws, e.g. §41a was added to the Federal Nature Conservation Act. This states that in future, lighting systems must be designed in such a way that animals (especially in-sects) and plants are protected by reduced light emissions.

2. What measures have you undertaken to mitigate light pollution?

- Addition of §41a to the Federal Nature Conservation Act (BNatSchG) (see above).
- Establishment of a national working group to develop uniform technical regulations.
- Existing important national notes and recommendations:
- LAI notes on the measurement, assessment and reduction of light emissions ("LAI-Hinweise zur Messung, Beurteilung und Minderung von Lichtimmissionen")
- BfN-Skripten 543: Notes on the measurement, assessment and reduction of light emissions ("Hinweise zur Messung, Beurteilung und Minderung von Lichtimmissionen")
- LiTG-Schrift 12.3: Recommendations for the measurement, assessment and reduction of light emissions from artificial light sources ("Empfehlungen für die Messung, Beurteilung und Minderung von Lichtimmissionen künstlicher Lichtquellen")

3. What are the most important considerations for you when it comes to mitigating light pollution?

It is particularly important to fully assess the totality of all disturbance functions and to comply with the present emission values. I.e. all aspects for the protection of people, flora and fauna must be considered together.

The assessment and reduction of light emissions should already be carried out during professional lighting design and not only after a lighting system has been installed, i.e. when the lighting is already in place.

The majority of existing lighting installations in Germany have been built without a full assessment of light emission. In order to improve their light emission quality, auditable conversions and retrofits of these old installations should be carried out (see e.g. BNatSchG).

4. Have you undertaken any research or innovation projects on the impacts of light pollution?

The following research project has been started:

- Glare assessment for the reduction of light immissions caused by road traffic-related light immissions (Blendungsbewertung zur Minderung von straßenverkehrsbedingten Lichtimmissionen, FE 03.619/2021/GGB)

The following research projects are planned:

- Climate and immission protection through intelligent and sustainable control of lighting systems
- (Klima- und Immissionsschutz durch intelligente und nachhaltige Steuerung von Beleuchtungsanlagen, FE03.623/2022/GRB)
- Quality assurance of lighting in the case of conversion and retrofitting required under species protection law
- (Qualitätssicherung der Beleuchtung bei artenschutzrechtlich gebotener Um- und Nachrüstung, 77.0605)
- Limitation of immissions caused by street lighting - Limitation of illumination on surrounding properties (Begrenzung der Straßenbeleuchtungsbedingten Immissionen - Begrenzung der Raumaufhellung, 77.0604)
- Optimisation of street lighting for speed 30 zones and fast cycling traffic (Optimierung der Straßenbeleuchtung für Tempo 30-Zonen und Radschnellverkehr, 77.0603)

5. What changes e.g., limitation of lumen output, colour temperature, tilt angle, lighting times etc., have you made to your national guidelines/standards to mitigate the impacts of lighting?

Germany has published a relevant LAI document.

HUNGARY

1. Do you have a strategy for mitigating the impacts of light pollution from your network?

We do not have any strategy yet for mitigating the impacts of light pollution.

2. What measures have you undertaken to mitigate light pollution?

Our environmental authority has not imposed yet any obligation on our Company and we do not have any measures in force yet to mitigate light pollution. We note, however, that the last section of the M3 motorway towards the border is currently being designed by NIF Zrt. In relation to this project, the authority issued a construction regulation as part of its environmental permit with provisions on the light, the operating temperature, the location and the height of luminaires and on the lighting of non-illuminated areas in order to protect light-flying insects, birds and nocturnal small mammals.

4. Have you undertaken any research or innovation projects on the impacts of light pollution?

In 2019, a special blue light trap was installed downstream on the two pillars of the Little Danube Bridge in Tahitótfalu, operated by our Company. The aim was to protect the Danube Mayflies (*Ephoron virgo*) swarming on the surface of the water by keeping the insects above the water. The lighting of the bridge consists of 5 lamp posts, each with a warm white 85 W LED lamp. Between 15 August and 15 September, during the period of mayflies flying, the brightness of the blue light is automatically reduced by 30% in the nightfall period.

ICELAND

1. Do you have a strategy for mitigating the impacts of light pollution from your network?

No IRCA has not.

2. What measures have you undertaken to mitigate light pollution?

Not other than we do not put up light in rural roads except on intersections with high traffic flow and are systematically replacing older light sources to LED lamps which offers wider opportunities to adjust lighting in the future.

3. What are the most important considerations for you when it comes to mitigating light pollution?

We try to minimize lighting but first priority is always traffic safety and security of road users.

4. Have you undertaken any research or innovation projects on the impacts of light pollution?

Not in particular, but in 2009 a research project led to a publishing of guidelines for road lighting in rural areas where light pollution was an issue taken into consideration. The guidelines have become outdated and will be reviewed in the near future.

5. What changes e.g., limitation of lumen output, colour temperature, tilt angle, lighting times etc., have you made to your national guidelines/standards to mitigate the impacts of lighting?"

We do not have guidelines that cover all street and road lighting, other than those who are outdated mentioned in answer to question 4.

A working group within IRCA is however currently working with these matters, among other things with the aim of making guidelines that covers all this.

IRELAND

1. Do you have a strategy for mitigating the impacts of light pollution from your network?

TII's strategy in relation to public lighting can be summed up as:

- remove
- reduce
- replace

TII's strategy for mitigating the impacts of light pollution is set out in the published Standard DN-LHT-03038 Design of Road Lighting for the National Road Network in August 2018.

The right light in the right place at the right time underpins the strategy and in particular the Standard clearly defines the areas of the National Road Network that do not need to be lit (e.g., the mainline between junctions). Where lighting is to be provided, the extents of the lighting (e.g. at junctions) has been carefully considered and restricted to the immediate confines of the junction/conflict area and any extension of the lighting extents is subject to a risk assessment and only applied on a case by case basis.

The Standard includes lighting assessment tools to ensure that careful consideration is made when consideration is given to implementing lighting that do not form part of any mandatory requirements both in terms of quantifiable and non-quantifiable benefits/dis-benefits and these areas are subject to TII's Departure from Standard process.

The Standard adopts best practice guidance such as the external guidance document published by the Institute of Lighting Professionals GN01 Guidance Notes for the Reduction of Obtrusive Light.

2. What measures have you undertaken to mitigate light pollution?

DN-LHT-03038 Design of Road Lighting for the National Road Network sets out a number of requirements to ensure light pollution is mitigated. The Standard stipulates that the lighting designer shall:

- undertake an analysis and risk assessment of the lighting class to allow the opportunity to reduce the intensity of light.
- apply a 1 step dimming regime as a minimum in order to reduce the intensity of lighting during hours of darkness when roads are lightly used.
- limit the switch on-switch off Lux levels in order to trim the burning hours of lighting units.
- ensure that all luminaires are fitted with an industry standard 7-pin NEMA or system ready socket to facilitate future connection to a CMS that permits additional variable control and can support a further reduction in lighting at a future date.
- apply constant light output for LEDs to reduce unnecessary light output during the earlier years of a lighting installation.
- ensure lanterns are at 0° tilt and consider higher G rating classes to minimise light spill on surroundings and not just solely rely on threshold increment which is a metric used to limit glare for motorists.
- meet design requirements for environmental zones based on ILP guidance note GN01.

TII has reviewed existing lighting levels at motorway/dual carriageway junctions and removed significant numbers of lights at twenty-seven of these junctions on the network while still providing a safe level of lighting in accordance with DN-LHT-03038 Design of Road Lighting for the National Road Network. Investigations are underway to establish the potential for a similar removal of lights at another twenty seven motorway/dual carriageway junctions.

TII has replaced less efficient lighting with more efficient technology so less energy is used while still achieving the required lighting levels in DN-LHT-03038 Design of Road Lighting for the National Road Network.

3. What are the most important considerations for you when it comes to mitigating light pollution?

TII considers that mitigating light pollution forms an important part of road lighting design and as such the lighting design standard identifies the need to address lighting at concept, preliminary and detailed design stages. This should be evidenced through the development of a lighting design file that ensures light pollution is considered as the design is being developed and also provides a record of key decisions made.

As part of the lighting design file, designers must derive an assessment to demonstrate power density indicators and annual energy consumption figures in order to show that options and the selected design achieve an efficient energy design.

There is a balance to be struck between lighting provided for road users (including vulnerable road users) and mitigating the effects of lighting on local flora and fauna. The TII standard is considered to cater for all and takes a balanced approach when assessing the needs and impacts of lighting.

The TII lighting design standard was rewritten fully and published in 2018. It is recognised that road lighting using LED technology is advancing at a rapid rate and TII considers it important that the standard is reviewed (and updated if required) on a regular basis as the impacts of LED lighting such as science of light, colour temperature etc are better understood.

4. Have you undertaken any research or innovation projects on the impacts of light pollution?

TII has undertaken a number of pilot studies and trials associated with dimming and trimming of LED light sources. Research has been undertaken into the retrofit of LEDs on high mast lighting which are prominent on the TII network. As part of the assessment, lighting impact analysis was undertaken to better understand the impacts of light pollution on nearby receptors e.g. residential properties. The extents of lighting at junctions have also been part of a pilot study to understand impact on road safety and support the key initiative TII has been undertaking in order to support the initiative in reducing energy and reducing light pollution.

5. What changes e.g., limitation of lumen output, colour temperature, tilt angle, lighting times etc., have you made to your national guidelines/standards to mitigate the impacts of lighting?

When the TII Standard was developed in 2018, a number of changes were made to ensure light pollution is mitigated on the national highway network. These changes include but are not limited to the following.

The Standard limits correlated colour temperature (CCT) to no greater than 4,000K. CCT above the 4000K is subject to a Departure from Standard. An informative Annex was compiled to guide the designer in considering a warmer colour temperature given the additional benefits such as negating impact on flora and fauna. Previously, the availability of warmer colour temperatures was limited however, an increasing number of manufacturers are now developing products that can provide a warmer colour temperature without significantly increasing energy consumption. Future updates to the standard are expected in line with the direction of technology developments and as a greater understanding is being developed through research and best practice.

The Standard also stipulates all lights must have a 0° tilt together with the application of luminous intensity classes (G2 to G6) depending on the surrounding environmental zone.

Mitigating the impacts of lighting needs to be considered prior to product selection and TII has set clear guidance on how to light roundabouts, junctions and interchanges to ensure that the lighting designers understand the extents of lighting to be applied and ensure greater consistence in approach. TII is explicit on areas that do not require lighting.

NETHERLANDS

1. Do you have a strategy for mitigating the impacts of light pollution from your network?

Yes, we have.

2. What measures have you undertaken to mitigate light pollution?

For the illumination of the Dutch main road network, an upper limit for the EIR (Edge Illuminance Ratio) is applied. For the roads in the direct vicinity of Natura 2000 areas, the light fixtures are shielded or the artificial lighting is limited in an other way. Locally extra mitigation is executed by means of adaptations in distances between light masts, tilt angles, light colour and height of the light masts.

3. What are the most important considerations for you when it comes to mitigating light pollution?

The most important consideration is that the function of illumination of the roads, road safety, should not be hampered. Of major importance and a legal requirement is whether illumination may hamper favorable conservation statuses of protected species. Following the duty of care in the nature conservation law, adverse effects on fauna through artificial light should be avoided when feasible. Replacement by low-energy LEDs is not a mitigation measure in itself, but is a window of opportunity for implementing mitigation measures (see question and answer 5).

4. Have you undertaken any research or innovation projects on the impacts of light pollution?

Rijkswaterstaat participates in the multi-annual Light on Landscape programme from the Netherlands Institute of Ecology, following the Light on Nature programme. Main goal for the current programme from the Rijkswaterstaat perspective is to develop threshold values for effects of artificial lighting on protected fauna, depending on light spectra. In 2011 Rijkswaterstaat also initiated a field trial to develop the world's first led lamps with a spectrum to mitigate effects on bats.

5. What changes e.g., limitation of lumen output, colour temperature, tilt angle, lighting times etc., have you made to your national guidelines/standards to mitigate the impacts of lighting?"

Rijkswaterstaat guidelines limit artificial lighting on national roads near N2000 areas (i.e., no artificial lighting) and limits colour temperature of new illumination to 4000 Kelvin elsewhere. Additional measures (e.g., limitation of lumen output, colour temperature, tilt angle, lighting times, light pole height, spectrum) are case-specifically used and increasingly applied. Examples are adjusted tilt angle at highway A7 Afsluitdijk, reduced pole height at highway A74, red spectrum at highway A29, etc.

NORWAY

1. Do you have a strategy for mitigating the impacts of light pollution from your network?

No, but we are working to know more about the impacts of road lights on nature in Norway. We are also mapping the information about all state-owned road lightning to make it easier to implement national measures.

2. What measures have you undertaken to mitigate light pollution?

Some areas with special landscape and vulnerable nature have been built without road lights due to the risk of light pollution.

Several road sections are built with motion sensors. See links here:

<https://www.vegvesen.no/fag/fokusomrader/miljo-og-omgivelser/forurensning/lysforurensning/>

3. What are the most important considerations for you when it comes to mitigating light pollution?

Energy efficiency and the impacts on nature and especially insects.

4. Have you undertaken any research or innovation projects on the impacts of light pollution?

We have two early phase ongoing research projects.

One is about the impact of Norwegian road lights on insects. So far, the research program has focused on the relevance of international research and on GIS-analyses of in which part of the country insects is most vulnerable.

The second is about environmental lightning design. So far the research program has focused on zoning and the development of a road lightning program.

5. What changes e.g., limitation of lumen output, colour temperature, tilt angle, lighting times etc., have you made to your national guidelines/standards to mitigate the impacts of lighting?

So far we have changed requirement for colour temperature from 4000 to 3000 Kelvin, required midpoint dimming as a minimum and recommended use of motion sensor with dimming down to 20 % of the required level where it is suitable.

POLAND

1. Do you have a strategy for mitigating the impacts of light pollution from your network?

In general, such a strategy has not been formally developed, but the technical requirements indicated in the tender specifications (e.g. Description of the Subject of the Contract) prevent light pollution in the upper half-space (sky).

2. What measures have you undertaken to mitigate light pollution?

Technical requirements have been introduced in the Description of the Subject of the Contract (regarding public procurement - new investments) in terms of materials and technology, which are in line with the provisions of the international agreement called the "dark sky convention".

At the same time, we would like to point out that this applies only to new investments and GDDKiA does not carry out any activities aimed at mitigating light pollution on the existing infrastructure.

3. What are the most important considerations for you when it comes to mitigating light pollution?

In the context of the above replies, the main issues in terms of reducing light pollution are not identified. Nevertheless, the implementation of the international agreement called the "dark sky convention" remains important.

4. Have you undertaken any research or innovation projects on the impacts of light pollution?

No.

5. What changes e.g., limitation of lumen output, colour temperature, tilt angle, lighting times etc., have you made to your national guidelines/standards to mitigate the impacts of lighting?

The current GDDKiA standards in terms of materials and technology are consistent with the provisions of the international agreement called the "dark sky convention" and these include the following requirements:

- use only road luminaires (lighting fixtures) made in LED technology (hereinafter: LED fixtures), i.e. directional fittings;
- for the total inclination angle of the boom with the luminaire in relation to the illuminated surface, e.g. the main road, at the level not exceeding 5 °;
- limiting the light emitted above the horizon (ULOR), i.e. 0.0% for the inclination angle of the luminaire relative to the illuminated surface of 0 ° [ULOR for a complete luminaire optimally mounted on a pole position, at a level no higher than indicated in the "Commission Regulation (EC) No. 245/2009 of 18 March 2009... "];
- color temperature of the light emitted from the LED source up to 4000 ° K (neutral white) outside the luminaire;

In addition, in the situation of the location of the designed road lighting in the area of animal crossings, and in particular within the range of impact on overpasses for animals, at least 100 m in both directions from the border of the crossing, luminaire used should be equipped with a solutions/dedicated system of optical ensuring, first of all, the limitation of the light flux dispersion outside the illuminated area and the concentration of the emitted light flux outside the luminaire only in the area of the road's crown.

At the same time, LED road luminaires must ensure that no luminous flux is emitted outside the luminaire into the upper half-space ("to the rear").

SWITZERLAND

1. Do you have a strategy for mitigating the impacts of light pollution from your network?

Highways are not illuminated in Switzerland with the exception of tunnels and junctions. This being said we have little or no experience with mitigation.

2. What measures have you undertaken to mitigate light pollution?

Our strategy is to limit light pollution.

3. What are the most important considerations for you when it comes to mitigating light pollution?

Limitation of light pollution.

4. Have you undertaken any research or innovation projects on the impacts of light pollution?

No.

SUMMARY OF FINDINGS

In Ireland and Switzerland, main lines between junctions are not illuminated. In Ireland, the illumination of junctions is restricted to the immediate confines of the junction and careful considerations must be given when implementing lighting that do not form part of mandatory requirements. Netherlands, Ireland and Poland have an upper limit of 4000 kelvin, while Norway has an upper limit of 3000 kelvin. In Norway, midpoint dimming is required and the use of motion sensors is recommended. In most countries the light must be angled down. In Ireland, the luminous intensity classes depend on the surrounding environmental zone. In Netherlands, no artificial lighting is allowed near nature protection areas. In Germany, a technical set of regulations is under development, supported by a paragraph in the Federal Nature Conservation Act saying that lighting systems must be designed in such a way that animals and plants are protected by reduced light emissions.

Germany has started a research project about reduction of light emissions and is planning many other research projects on the topic. Ireland has been researching on dimming of LED-light sources and the impact of light pollution on nearby receptors. Netherlands is part of a program called Light on Landscape finding out threshold values for effects of artificial lighting on protected fauna, depending on light spectra. Norway has started research projects about light pollution effects on insects and environmental lighting design. Hungary have installed blue light traps on a bridge to protect Danube Mayflies.