

## **House of Lords Science and Technology Committee inquiry: Effects of artificial light and noise on human health**

1. This is the official response from the Royal Astronomical Society (RAS) to the House of Lords Science and Technology Committee inquiry into the effects of artificial light and noise on human health.
2. The RAS represents more than 4,000 astronomers and geophysicists, in the UK and around the world, in occupations in academia, industry, education and public engagement, and journalism, as well as others in the wider economy. Our members are described as ‘Fellows’.
3. This written evidence was shaped by input from our governing Council and other dark-sky related organisations we cooperate with.
4. The Society took over the secretariat role for the All-Party Parliamentary Group for Dark Skies in 2022. Our response is independent of the APPG, though we support many of its policy positions.
5. We do not believe there are any prejudicial conflicts of interest to declare. The Society itself has no financial relationship with health organisations or lighting companies. While many of our Fellows would welcome a reduction in light pollution to conduct amateur astronomy, the majority make use of observing facilities abroad for science purposes. International observatories are also under threat, however; a recent study in our MNRAS journal shows that three quarters of professional optical observatories are affected by light pollution<sup>1</sup>.
6. As an organisation dedicated to astronomy and geophysics, we are primarily responding to the questions relating to the sources of and approaches to the mitigation of light pollution. Our responses also focus on outdoor artificial illumination, as opposed to indoor artificial lighting.
7. We are happy to assist the Committee with its work in this area, and are able to give oral evidence on this topic if required.

### **Executive Summary**

8. In general there is little awareness of light pollution and its associated harms on human health, as well as wider ecological impacts. This lack of awareness is systemic within local government and delegated authorities, with many planners, environmental health officers and councillors lacking sufficient knowledge of the issue. At the same time, there is little legislation in place dedicated to removing unnecessary light pollution, which not only be beneficial for human health and wellbeing and the environment, but would also help the UK to reach its Net Zero targets.
9. Our main recommendations include:

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<sup>1</sup> <https://ras.ac.uk/news-and-press/research-highlights/three-quarters-major-observatories-affected-light-pollution>

- a. Governmental organisations like UKRI, the UK Space Agency, NPL, DEFRA, and Natural England should invest in cross-disciplinary light pollution research, involving the monitoring of artificial light as well as its impacts on society.
- b. The establishment of a new independent regulator of light pollution, with powers to propose legislation and hold the government to account.
- c. Highway and local authorities should conduct research on lighting, especially in relation to crime and safety, so that future lighting decisions are evidence-based.

## **Responses to specific points from the Select Committee**

### **What are the primary sources of light pollution and how well do we understand them?**

10. There are many sources of light pollution, including but not limited to: street lighting; commercial and security lighting (e.g. factories, ports, sports facilities); floodlights used for stadiums or heritage buildings; advertising; car headlamps; office buildings; and residential lighting.
11. Street lighting used to be one of the main primary sources of artificial light at night, however with the introduction of LEDs and significant reductions in energy costs, other sources of lighting have become much more dominant (residential lighting, for example).
12. Some studies have been able to estimate the relative contributions of streetlights as a percentage of total light pollution in a specific city. They demonstrate that streetlights are less significant than expected:
  - a. In Ribeira (Spain), public streetlights account for 44.68% of total light pollution emissions<sup>2</sup>.
  - b. In Tucson (USA), public streetlights account for 13% (after midnight) and 18% (before midnight) of total light pollution emissions<sup>3</sup>. It should be noted that Tucson is an exceptional case as the city has a long-standing commitment to best lighting practices to try and protect nearby observational facilities.
13. Overall, it is very difficult to measure the relative contributions between different sources of lighting<sup>4</sup>. There are many factors in how the use of lighting changes, depending on location (e.g. rural versus urban), time (e.g. evening versus early morning), and the angle at which the lighting is being observed (e.g. vertically, from space or horizontally, from the ground)<sup>5</sup>.

### **Is there evidence that light pollution is worsening – for example, with the introduction of LEDs and cheaper forms of lighting, or lighting with a different wavelength spectrum?**

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<sup>2</sup> Bará et al. (2023). Quantitative evaluation of outdoor artificial light emissions using low Earth orbit radiometers. <https://doi.org/10.1016/j.jqsrt.2022.108405>

<sup>3</sup> Kyba et al. (2020). Direct measurement of the contribution of street lighting to satellite observations of nighttime light emissions from urban areas. <https://doi.org/10.1177/1477153520958463>

<sup>4</sup> Bará et al. (2018). Estimating the relative contribution of streetlights, vehicles, and residential lighting to the urban night sky brightness. <https://doi.org/10.1177/1477153518808337>

<sup>5</sup> Kyba et al. (2022). Multiple Angle Observations Would Benefit Visible Band Remote Sensing Using Night Lights. <https://doi.org/10.1029/2021JD036382>

14. Light pollution is worsening significantly, a recent 11-year citizen science study shows that it is increasing at a rate of 9.6% per year<sup>6</sup>.
15. Previous studies measuring light pollution from space found annual increases of ~2%. This demonstrates the challenges in measuring light pollution from space, with only one instrument to hand, namely the Visible Infrared Imaging Radiometer Suite (VIIRS<sup>7</sup>). VIIRS cannot measure light at blue wavelengths, nor light being emitted at non-vertical angles (e.g. horizontal light emissions from cars or advertisements). This is a possible explanation for the differences between space- and ground-based studies. We recommend that the UK Space Agency supports work toward putting an instrument in space which can measure blue-light emissions.
16. The uptake of LEDs is increasing rapidly. The International Energy Agency (IEA) finds that LEDs made up 48% of global lighting sales in 2021, compared to 7% in 2014<sup>8</sup>.
17. It would be useful to understand the makeup of LED sales in more detail, particularly regarding the correlated colour temperature (CCT) of lighting units sold, and so more data is needed in this area. Higher CCTs (above 3000 Kelvin) appear more white-blue in colour and are known to cause significantly more harm than lower CCTs<sup>9</sup>.

**How reliable is our evidence base for these impacts – are there areas where we are less confident or additional studies that are needed?**

18. The difficulty in disentangling the effects of light pollution from other influences (e.g. air pollution and socioeconomic factors) makes conducting research into its effect on human health very challenging.
19. Several studies claim that outdoor light at night causes cancer, for example, but the link is tenuous and further epidemiological studies are needed<sup>10,11</sup>.
20. Studies also seem to agree that light pollution increases a risk of depressive disorders<sup>12</sup>, but again more evidence is needed to understand this effect.
21. Conversely, spending time under dark skies offers wellbeing benefits. A study on Sark found that observing the night sky with others facilitates community connections, and results in positive feelings and a universal fearlessness of the dark<sup>13</sup>. Additionally, Care for

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<sup>6</sup> Kyba et al. (2023) Citizen scientists report global rapid reductions in the visibility of stars from 2011 to 2022 <https://doi.org/10.1126/science.abq7781>

<sup>7</sup> [www.nesdis.noaa.gov/current-satellite-missions/currently-flying/joint-polar-satellite-system/visible-infrared-imaging](http://www.nesdis.noaa.gov/current-satellite-missions/currently-flying/joint-polar-satellite-system/visible-infrared-imaging)

<sup>8</sup> IEA (2022) Lighting <https://www.iea.org/reports/lighting>

<sup>9</sup> <https://www.royalsociety.org.nz/assets/Uploads/Blue-light-Aotearoa-evidence-summary.pdf>

<sup>10</sup> Sweeney et al. (2022) Light at night and the risk of breast cancer: Findings from the Sister study <https://doi.org/10.1016/j.envint.2022.107495>

<sup>11</sup> Bożejko et al. (2022) Outdoor artificial light at night and human health: A review of epidemiological studies <https://doi.org/10.1016/j.envres.2022.115049>

<sup>12</sup> Tancredi et al. (2022) Artificial light at night and risk of mental disorders: A systematic review <https://doi.org/10.1016/j.scitotenv.2022.155185>

<sup>13</sup> Blair (2017) An Exploration of the Role that the Night Sky Plays in the Lives of the Dark Sky Island Community of Sark, <https://doi.org/10.1558/jsa.34689>

Carers found that their dark sky experiences (an RAS funded programme taking carers to the island of Coll for short breaks) boosted well-being and confidence for participants<sup>14</sup>.

**Does the UK have a sufficient research base? Who are the main organisations conducting research into light pollution and how are they funded?**

22. There is very little research on light pollution in the UK. As far as we are aware, the main contribution to research on health impacts is from Russell Foster's research group at the University of Oxford<sup>15</sup>. His work specialises in circadian neuroscience.
23. Additional studies would be very welcome in other related research fields, such as environmental and ecological studies (particularly biodiversity), sociology (e.g. social inequalities around the use of lighting, and crime and safety), and the measurement and economic cost of light pollution itself. Notable UK experts include:
- a. Kevin Gaston, professor of Biodiversity & Conservation at the University of Exeter.
  - b. Davide Dominoni, lecturer in Urban Ecology at the University of Glasgow.
  - c. Herman Wijnen, associate professor at the University of Southampton interested in environmental impacts of artificial light.
  - d. Gareth Jones, professor of biological science at the University of Bristol.
  - e. Nick Dunn, founder of University of Lancaster's Dark Design Lab which focuses on the impact of light pollution on human health and nature.
  - f. Rob Shaw, lecturer at Newcastle University who researches the relationship between the 'night' and society.
  - g. Martin Morgan-Taylor, associate professor at the Leicester De Montfort Law School who researches the legal impact of light pollution.
24. Based on the above, the main organisations conducting research into light pollution are individual researchers based at universities, and so research is quite disjointed. We recommend that an interdisciplinary research group in the UK should be established, alongside a Masters programme, dedicated to "night studies"<sup>16</sup>. This could be supported by UKRI.
25. The European Commission has recently launched a Horizon fund worth 7 million EUR, under the call: "Impact of light and noise pollution on biodiversity"<sup>17</sup>. We recommend that the UKRI becomes equally proactive in funding light pollution research, and funds this on an individual or cross-disciplinary basis across NERC, MRC, BBSRC, AHRC, and STFC.
26. There is also little-to-no research into light pollution being conducted by relevant governmental departments, such as DEFRA and DLUHC, and the advisory bodies NPL and

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<sup>14</sup> Bowler (2018) RAS 200 grant helps carers 'Stepping Out', <https://doi.org/10.1093/astrogeo/aty269>

<sup>15</sup> <https://www.seni.ox.ac.uk/team/russell-foster>

<sup>16</sup> Kyba et al. (2020) Night Matters—Why the Interdisciplinary Field of "Night Studies" Is Needed, <https://doi.org/10.3390/j3010001>

<sup>17</sup> <https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl6-2023-biodiv-01-2>

Natural England, so contributions from these and other relevant organisations would be very welcome.

**Are the Government agencies, departments, or local authorities currently responsible for monitoring and regulating light pollution appropriately resourced? Is there sufficient expertise within organisations charged with regulating or enforcing regulations on artificial light?**

27. Currently, there is very little monitoring and regulating of light pollution. The APPG for Dark Skies's "Ten Dark Sky Policies for the Government" summarises the existing legal framework regulating light pollution<sup>18</sup>.
28. Local Planning Authorities can develop planning policies that reduce light pollution<sup>19</sup> and local authority environmental health departments are responsible for investigating causes of light nuisance. However, local authorities often lack the technical expertise and resources required to assess statutory nuisances or lighting proposals for planning applications.
29. We support the Dark Skies APPG proposal for the establishment of a new independent regulator of light pollution, with powers to propose legislation and hold the government to account. These responsibilities could be integrated into existing organisations (e.g. the Environment Agency or the Office for Environmental Protection), or they could form a stand-alone non-ministerial public body.

**Have there been any changes to Government policy following the Royal Commission on Environmental Pollution's 2009 report into artificial light in the environment? Have these been adequate?**

30. There have been little-to-no changes, as far as we are aware.

**What role should planning authorities play in determining plans or restrictions on light pollution? Are the current guidelines on light pollution set under the Government's advice for planning authorities adequate?**

31. Planning authorities should have an important role to play in restricting light pollution to safeguard human health and biodiversity, as well as for energy savings and the reduction of carbon emissions.
32. The National Planning Policy Framework (NPPF) 2021 makes a small reference to lighting with regard to the control of obtrusive light. Paragraph 180 section c states that planning policies and decisions should ensure that new development should "limit the impact of light pollution from artificial light on local amenity, intrinsically dark landscapes and nature conservation"<sup>20</sup>. Despite this, development proposals are typically not assessed against light pollution, and thus, this current guidance is inadequate.

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<sup>18</sup> <https://appgdarkskies.co.uk/policy-plan>

<sup>19</sup> see e.g. the Dumfries and Galloway Local Development Plan [www.dumgal.gov.uk/media/22619/Dark-Skies-Friendly-Lighting/pdf/Dark\\_Skies\\_Friendly\\_Lighting\\_SG\\_LDP2\\_Adopted.pdf](http://www.dumgal.gov.uk/media/22619/Dark-Skies-Friendly-Lighting/pdf/Dark_Skies_Friendly_Lighting_SG_LDP2_Adopted.pdf)

<sup>20</sup> [www.gov.uk/government/publications/national-planning-policy-framework--2](http://www.gov.uk/government/publications/national-planning-policy-framework--2)

33. The lack of impact by the NPPF policy to control light pollution is reinforced by a CPRE survey<sup>21</sup>. 49 out of 76 local authorities who responded to the survey question on lighting policies had a lighting policy: 41 of 47 local authorities already had lighting policies in place, compared to six who introduced an entirely new policy due to the NPPF. 16 had adapted the lighting policy to comply with the NPPF whereas over two thirds (34) had not adapted their policy.

**What recommendations would you make for changing Government policy on light pollution?**

34. We agree with the following recommendations made by the APPG for Dark Skies:

- a. The NPPF text on light pollution should be expanded to allow local planning authorities to impose specific planning conditions related to external lighting, including curfew hours, standards for brightness and CCT, as well as the direction and density of lighting.
- b. Regulations for exterior lighting similar to the advertisement regulations in the Town and Country Planning Act 1990<sup>22</sup> should be introduced. Currently, the installation of any lighting inside and outside a building does not amount to “development” and therefore does not require planning permission.
- c. Section 102 of the Clean Neighbourhoods and Environment Act 2005<sup>23</sup> states that “artificial light emitted from premises so as to be prejudicial to health or a nuisance” is a statutory nuisance, yet this is difficult to uphold as “health and nuisance” are subjective and difficult to prove. Moreover, many exceptions are listed where statutory nuisances do not apply, and this should be reviewed.
- d. A nuisance should be defined as lighting that does not conform to established guidance, legislation or standards. If the light is not conformant, it is automatically classed as a nuisance unless a deviation from guidance, legislation or standards is agreed with the local authority.

35. We also agree with the recommendations in the Royal Commission on Environmental Pollution’s 2009 report on “Artificial Light in the Environment”:

- a. Highways authorities and local authorities should reassess the lighting of roads against potential road safety and crime reduction benefits (paragraph 3.5). Additionally, we believe that they should go further and evaluate the effectiveness of their lighting and determine whether or not more lighting improves safety and reduces crime.
- b. Planning guidance should include a presumption against the provision of artificial light in areas where it has a negative impact on species of concern. Guidance should

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<sup>21</sup> <https://www.cpre.org.uk/resources/shedding-light/>

<sup>22</sup> [www.legislation.gov.uk/ukpga/1990/8/part/VIII/chapter/III/crossheading/advertisement-regulations](http://www.legislation.gov.uk/ukpga/1990/8/part/VIII/chapter/III/crossheading/advertisement-regulations)

<sup>23</sup> <https://www.legislation.gov.uk/ukpga/2005/16/part/9/crossheading/statutory-nuisances>

enable local authorities to assess the ecological impacts of changes to the amount and quality of artificial light (paragraph 3.10).

### **What are the possible interventions that could be deployed to mitigate the effects of light pollution and how well understood are their effects?**

36. The choice of appropriate illumination has to balance several needs: optimal visibility, human health and wellbeing, and environmental conservation. There exist several interventions that can mitigate the effects of light pollution which are readily available, inexpensive, and easy to implement (e.g. light orientation, proper shielding on light installations, turning lights off when not needed, dimming to intended use, using blinds or curtains, and using filters or changing the spectral colour)<sup>24</sup>.
37. It is also possible to implement more advanced technology, using intelligent lighting with motion sensors<sup>25</sup>, or smart lighting which can adapt to the weather and changing road conditions, for example.
38. The use of blue-rich light at shorter wavelengths is known to suppress melatonin and disrupt circadian rhythms. It also increases the glare for elderly people, decreasing visibility. Since cold-white LEDs are more energy efficient than warm-white LEDs, filters can be used to change the spectral power distribution and create warm-white light. We also recommend that incentives are provided to encourage industry to focus on developing LEDs which are warmer in colour but just as efficient as their bluer counterparts.
39. More research is needed in several areas. The efficiency of illuminants is measured using photopic vision, but more knowledge is needed to create measurements for mesopic or scotopic vision, which humans predominantly use at night time<sup>26</sup>.
40. We also need to rethink the required brightness of street lighting. There is little justification for the ranges of illuminance specified in guidance documents nor for the criteria by which a particular light level is selected<sup>27</sup>. Illuminance recommendations are not based on visual needs alone but are subject to practical, financial and emotional forces<sup>28</sup>. There is also little evidence that more lighting reduces crime or improves safety<sup>29,30</sup>. Outdoor lighting policies should consider the entire makeup of urban lighting (for example advertising, architectural lighting, and sports lighting), rather than focus solely on road lights.

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<sup>24</sup> Schroer and Hölker. (2014). Light Pollution Reduction. [https://doi.org/10.1007/978-3-319-00295-8\\_43-1](https://doi.org/10.1007/978-3-319-00295-8_43-1)

<sup>25</sup> Juntunen et al. (2013). A smart LED luminaire for energy savings in pedestrian road lighting. <https://doi.org/10.1177/1477153513510015>

<sup>26</sup> Fotios and Goodman. (2012). Proposed UK guidance for lighting in residential roads. <https://doi.org/10.1177/1477153511432678>

<sup>27</sup> Fotios and Gibbons. (2017). Road lighting research for drivers and pedestrians: The basis of luminance and illuminance recommendations. <https://doi.org/10.1177/1477153517739055>

<sup>28</sup> Boyce. (1996). Illuminance Selection Based on Visual Performance—and other Fairy Stories. <https://doi.org/10.1080/00994480.1996.10748146>

<sup>29</sup> Steinbach et al. (2015). The effect of reduced street lighting on road casualties and crime in England and Wales: controlled interrupted time series analysis. <http://dx.doi.org/10.1136/jech-2015-206012>

<sup>30</sup> Tompson et al. (2022). Absence of Street Lighting May Prevent Vehicle Crime, but Spatial and Temporal Displacement Remains a Concern. <https://doi.org/10.1007/s10940-022-09539-8>

41. Planning and provision of lighting also often fails to consider the environment. The effect of variable spectral power distribution (brightness of lights at different colours) needs to be considered and adapted to protect sensitive species. In addition we still need a better understanding of at what times which species need protection and how to create adequate dark refuges<sup>31</sup>.

**Are there any interventions that have been pursued effectively in other countries that could be replicated in the UK?**

42. The Czech Presidency aims to encourage the adoption of a Europe-wide coordinated solution to light pollution. In doing so they published a document which maps light pollution reduction measures in individual European countries (including the UK)<sup>32</sup>.
43. Notable interventions include the Federal Nature Conservation Act (2021)<sup>33</sup> in Germany, specifying that general regulations are to be applied, according to which any significant adverse effects on nature and landscape shall primarily be avoided. Unavoidable effects are to be offset via compensation or substitution measures or, where this is not possible, via monetary substitution. In addition, species protection law must also be observed in the context of adverse effects of lighting.
44. In 2018, France adopted a decree relating to the “prevention, reduction and limitation of light pollution”<sup>34</sup>. The law specifies requirements for the design and operation of outdoor lighting installations and regulations for public and private property owners, such as curfews for outdoor lighting. It also sets global restrictions such as restrictions on brightness and CCT usage, and light trespass into dwellings, and the use of skybeams, lasers and similar high-intensity light are prohibited.
45. To protect the natural environment and human health from the effects of light pollution, the Society believes that the UK should now consider similar measures.

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<sup>31</sup> Holker et al. (2021). 11 Pressing Research Questions on How Light Pollution Affects Biodiversity. <https://doi.org/10.3389/fevo.2021.767177>

<sup>32</sup> <https://czech-presidency.consilium.europa.eu/media/005cwlmn/light-pollution-reduction-measures-in-europe.pdf>

<sup>33</sup> <https://leap.unep.org/countries/de/national-legislation/act-protection-insect-diversity-germany-and-amendment-other>

<sup>34</sup> <https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000037864346>