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POLLUTANTS

Light and Noise Pollution

A GETTING STARTED GUIDE

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ABOUT THIS SERIES

This guide is part of our series of Getting Started Guides that supports your company to develop an embedded sustainability strategy. Each guide tackles a specific sustainability sub-issue and explores what your company needs to do to support the resilience of the environmental and social systems around you.

In each guide, we address relevant trends, system thresholds, key concepts, key actors, and key resources. We also offer guidance on how to address the impacts of decisions and activities in your operations and value chains as well as developing credible goals and outlining key corporate actions and internal targets that can help to provide clarity on the work ahead.

We recommend you read the first guide in the series, Getting Started Guides: An Introduction, which explains our overall approach and the value of setting a clear strategy anchored in your company's most material issues. It also explains how you can leverage process-based interim targets to clearly outline and track the specific actions that your company needs to take to achieve its high-level goals.

A complete list of focus areas and sub-issues can be found in our guide Scan: A Comprehensive List of Sustainability Issues for Companies.

This guidebook addresses **Light Pollution** and **Noise Pollution**, part of the broader sustainability issue of **Pollutants**.

1 SETTING THE STAGE – A LOUD AND BRIGHT WORLD

Light and noise pollution are on the rise. Just as leachate can unintentionally filter into surrounding areas and affect local ecology and communities, so too can light and noise. Instead of chemicals, the pollutants are photons and soundwaves. Unmanaged and improperly managed light and noise pollution can have a dire impact on human health, contribute to the climate and nature loss crises, and exacerbate social inequities.

LIGHT POLLUTION

Just as clean water, air, and soil have intrinsic conservation value, so too does natural darkness. Humans and wildlife need the right amount and type of light in the right place at the right time for the proper regulation of a broad range of natural processes and behaviours.

Yet, the occurrence of light pollution in the environment is of growing global concern. Light pollution disrupts wildlife, impacts human well-being, wastes money and energy, contributes to climate change, and blocks our view of the universe. It is now among the most chronic and pervasive environmental disturbances on Earth and is increasingly recognised as an emerging issue for the conservation of nature, human health, and astronomy.

Light pollution is the human-caused alteration of outdoor light levels from those occurring naturally, as well as the unintended consequences of excessive and inappropriate use of artificial light. This excess illumination can take many forms, including glare (excessive and disruptive brightness that shines horizontally), light trespass (stray light shining where it is not needed), sky glow (the scattering of light particles that drowns out the night sky over inhabited areas), and light clutter (confusing and distracting groups of bright light sources).

Part of the problem has been the transition to new lighting technology – shifting from conventional incandescent bulbs to cheaper, more energy-efficient, brighter alternatives, such as compact fluorescents and light-emitting diodes (LEDs). Although this transition supports a dramatic drop in energy consumption, these much brighter light sources are often overused and can cast large amounts of wasted light without proper shielding. Further, animals perceive light differently from humans; the ultra-violet (UV), violet, and blue-white LED lights that are most commonly used today emit light at a temperature that affects animals – including humans – more dramatically than lights emitting in other parts of the spectrum.

Globally, artificial light is increasing by as little as 2% and as much as 10% per year. 83% of the world's human population – including more than 99% of the people in Europe and the United States – live under night skies that have been artificially brightened. More broadly, research suggests that more than one-tenth of the planet's total land area experiences artificial light at night, and that figure rises to 23% when accounting for skyglow.

Excess light threatens the resilience of ecosystems by harming wildlife whose life cycles and biochemical equilibria depend on the normal ebb and flow of natural light levels. In particular, disruption of darkness can disrupt the behaviour

of millions of nocturnal species, which comprise approximately 30% of all vertebrates and 60% of all invertebrates. Research indicates that disappearing darkness has notably harmful impacts on sea turtles, birds, insects, plants, fish, marine invertebrates (including corals), bats, and primates.

NOISE POLLUTION

Unlike light pollution, noise pollution is an invisible danger, both on land and under the sea. Noise pollution refers to any unwanted or disturbing sound that disrupts natural balance, affects the health of humans and other organisms, or otherwise disrupts or diminishes one's quality of life.

As populations and cities grow, so too does the need and potential for activities – traffic, construction, industry, and more – that emit excess noise into the local environment. In particular, traffic noise has been classified as the second worst environmental stressor affecting human health, exceeded only by air pollution. As of 2020, and in Europe alone, an estimated 113 million people are affected by long-term road traffic noise levels above 55 decibels, the threshold at which the World Health Organisation classifies noise as becoming harmful to human health.

Excess sound from industrial and urban activities is leading to a broad range of physical and psychological effects on humans, from hearing damage and sleep disruption to increased stress and higher levels of disease. Like light pollution, it is also disrupting normal wildlife behaviour.

For instance, there has been a recent surge in complaints, protests, and lawsuits against hyperscale computing facilities, such as data centers, server farms, and cryptocurrency mining operations, related to the noise they produce from on-site power generation (such as from natural gas-powered turbines and diesel generators), whirring fans, and the hum of cooling systems.

Noise is also a growing problem in our oceans. For many marine organisms, sound is their primary means of learning about their environment. Many species of marine mammals and fish depend on sound for navigating, communicating, finding mates, and feeding. Unfortunately, ocean noise pollution has doubled in many marine areas every decade since the 1960s.

Maritime traffic has significantly increased in recent decades; approximately 80% of the volume of internationally traded goods are transported by sea, from approximately 4 billion tons in 1970 to 13 billion tons in 2023. The number of fishing ships alone has more than doubled from 1950 to 2015, growing to 3.7 million vessels. Researchers predict that this increase in maritime traffic coincides with a doubling of global ship noise every 11.5 years; noise levels in European waters, specifically, doubled within just 5 years, between 2014 and 2019.

UNDERSTANDING THE KEY SOURCES OF LIGHT AND NOISE POLLUTION

Light and noise pollution are pervasive, and as human communities grow and expand, so does our light and noise pollution footprint.

Light pollution is largely driven by growing reliance on outdoor electrical lighting. Cities have the most unshielded and improperly coloured lighting, and account for most of the global light pollution. Key sources of excess light include streetlights, unshielded pathway lighting, electronic advertising, illuminated signs, and lighting from factories, industrial facilities, greenhouses, and commercial and residential buildings.

Common sources of acute and chronic noise pollution include transportation, such as road traffic, railway traffic, and air traffic; construction and industrial activity, such as noise from heavy machinery, drilling, grinding, hammering, pile

driving, generators, and air compressors; and from equipment used in services and maintenance, such as lawn mowers, leaf blowers, and from waste collection. Improper noise control measures can also allow for noise from inside of buildings to emit into the external environment.

A rapidly emerging area of focus on noise pollution is from anthropogenic marine activities.

Marine noise emissions can be acute and continuous, and can originate from cavitation generated by ship propellers; pile driving during offshore construction; construction and operation of ports; oil and gas drilling platform construction; the use of naval sonar devices; air guns, seismic surveys, multibeam echo sounders, and other technologies used in deep-sea mining; drilling and excavation; fisheries and the use of acoustic devices to ward off marine mammals from nets; and military technologies and activities such as active sonar systems and detonations during weapon tests, material tests, and training manoeuvres.

These technologies generate sound waves that travel hundreds – or even thousands – of meters through the water column of the ocean before penetrating the seabed, and these activities can drive away or even kill marine animals and increase normal levels of background noise one hundred-fold over a radius of up to 300,000 km^2. Sonar can emit signals with an intensity of up to 240 decibels for the purposes of detecting submarines and structures. These noises and others can produce a type of "acoustic fog" that may mask sounds, such as those from prey, predators, and mates that are vital to marine animals.

UNDERSTANDING THE IMPACTS OF LIGHT AND NOISE POLLUTION

Light and sound are critical cues for humans and wildlife. They help us to orient ourselves in the environment, to communicate, avoid danger, and more. Yet, light and noise pollution are often overlooked as environmental issues. Urban communities – and natural spaces adjacent to them – are commonly awash in sound and artificial lighting. Many people seldom (if ever) have the opportunity to experience nature away from such pollution.

Though often overshadowed by air or water pollution, these pollutants nonetheless can result in acute and chronic harm to humans and wildlife alike. These pollutants are exerting pervasive, long-term stress on ecosystems, many of which are already suffering from other, more well-known forms of pollution.

THE IMPACTS OF LIGHT POLLUTION

For the vast majority of organisms, the cycle of light and dark is an influential regulator of behaviour. Countless species have evolved to develop biological cues triggered by the predictable and rhythmic shift between day and night, which helps humans and wildlife to regulate appetite, metabolic reactions, and body temperature, among other natural processes. In turn, this helps to mediate natural behaviours and activities, such as sleeping, feeding, courtship, reproduction, and migration.

Artificial light is known to have a broad range of adverse effects on nature, and especially on threatened, migratory, and/or nocturnal species. It can change behaviour and physiology, reducing survivorship and reproductive outcomes; reduce the availability of habitat and food resources; and attract predators and invasive pests.

Behavioural changes in wildlife due to exposure to artificial light have been well documented for some species.

Bright lights can disorient baby sea turtles. Baby turtles are drawn to light, and seek out the lowest, brightest light on the horizon (such as the moon's reflection on the ocean) when they emerge from their eggshells. This can cause them to travel away from the water (and to wander into roads and onto

commercial and residential properties) in large numbers, resulting in greater vulnerability and high mortality due to exhaustion, dehydration, and predation. Sea turtles may also avoid nesting on beaches that are artificially lit.

Light can affect the migratory patterns of birds, which may misinterpret excess light as a continuation of daylight. This can result in exhaustion, elevated risk of predation, and lethal collision with buildings and other structures; in the US alone, it is estimated that hundreds of millions of birds – and perhaps as many as 1 billion or more – die from crashing into buildings. Birds may use less preferable roosting sites to avoid lights, and lighting can expose birds to increased predation by making them more visible. Light pollution can also cause birds to leave their wintering sites earlier than appropriate, resulting in migration mistiming, bringing them into regions where the resources and conditions along their migratory path are not suitable.

Artificial light severely impacts insects, of which approximately half are nocturnal. Artificial lighting attracts insects and distracts them from carrying out other necessary behaviours and actions, and can disrupt bioluminescent communication, light-based navigation, plant pollination, and limit the range of locations for egg-laying. Insects also face lethal consequences from light pollution: research from 2006 estimated that street lamps in Germany killed 60 billion insects over a single summer, with insects burning or collapsing after hours of circling the light sources.

Bright lights can also mask the phases of the moon and interfere with coral spawning cycles, disrupting or preventing reproduction; disrupt the feeding cycle of zooplankton, potentially leading to algae blooms that overwhelm other life in marine and freshwater bodies; displace and reduce habitat space for light-shy bat species; and alter plant physiology and result in changes to leaf colouring and to growth and timing of flowering.

Although some of these may seem like isolated impacts, they have a compounding effect across countless interactions between affected species and organisms.

Humans have evolved within the context of a reliable cycle of bright light at day and darkness at night. Research indicates that certain types of lights can disturb our circadian rhythm by disrupting the normal ebb and flow of melatonin that helps to regulate our body's internal clock. This disruption has been linked to low levels of leptin and obesity. Low melatonin levels and circadian disruption are thought to play a role in fatigue, stress, heart disease, diabetes, depression, and cancer.

Light pollution is also a significant source of wasted energy. DarkSky International estimates that at least 30% of all outdoor lighting in the U.S. alone is wasted, mostly by lights that are not properly shielded. Estimates of the economic impact range, with billions of dollars in wasted energy and potentially trillions of dollars yearly when factoring in the annual loss of ecosystem service value.

It is also important to consider the psychological and cultural impact of losing the night sky, including the impact such loss can have on art, philosophy, individual and societal connection to nature, and positive human behaviours.

THE IMPACTS OF NOISE POLLUTION

Noise pollution can lead to sound masking, which can affect the wellbeing of wildlife and increase their risk of death by disrupting normal behaviours, including predator or prey detection and avoidance, interfering with communication, hindering echolocation and navigation, and more. Noise pollution can affect avian communities by reducing species diversity and abundance, reproductive success, and the ability to detect predators. It can also increase stress responses and reduce the availability of nesting areas. Many invertebrates

have evolved to emit and detect sounds and vibrations, such as for attracting or locating mates, and noise pollution can drown out their sensory capacity.

Similarly, underwater noise interferes with the key life functions of marine animals. Many species are highly dependent on sound for their survival; visibility through water is often low, whereas sound waves transmit extremely well. Noise pollution can result in a broad range of negative impacts on wildlife health, including temporary or permanent hearing loss; changes in individual and social behaviour; altered metabolisms; reduced reproduction outcomes; disorientation; decompression sickness and tissue damage in marine mammals that ascend too quickly to escape loud sounds; and even death. Noise pollution can lead to animals avoiding noisy areas and adjusting the natural cycle of necessary activities to better account for noise, which contributes to mass strandings of cetaceans and other extreme events. Marine noise can also affect marine invertebrates, including by reducing the embryonic development of mollusks and displacing and disrupting the behaviour of clams, crustaceans, and sea stars.

Within communities, noise pollution impacts millions of people daily. A key factor is that the human sympathetic nervous system maintains lighter stages of sleep when the body is exposed to noise, which prevents our blood pressure from following the normal rise and fall cycle of an undisturbed circadian rhythm.

Noise Induced Hearing Loss (NIHL) is the most common health problem associated with excess sound, but noise exposure can also cause hypertension; ischemic heart disease and other cardiovascular diseases; sleep disturbances; anxiety; nausea; stress; annoyance; changes in the immune system; and birth defects. Long-term exposure to transport noise has been specifically linked to elevated rates of mental illness, diabetes, and premature death. In children, noise pollution can cause stress and impairments in memory, attention level, and reading skill, and has been linked with obesity. Stress from exposure to elevated noise levels has also been associated with increased workplace accident rates, aggression, anti-social behaviours, and decreased mental health.

Research from the World Health Organisation (WHO) indicates that traffic-related noise accounts for more than 1 million healthy years of life lost annually in Europe, and that disability-adjusted life-years (DALYs) lost from environmental noise within the 33 nations of the European Environment Agency (excluding Turkey) include more than 155,000 years for ischemic heart disease; as many as 436,000 years for high annoyance; and as many as 453,000 years for high sleep disturbance. Research also indicates that traffic noise may increase the risk for other major diseases, including stroke and diabetes.

Noise pollution can also impact productivity. Research suggests that traffic noise alone imposes an aggregate economic burden of USD $110 billion on the United States, with low-income and minority households bearing a disproportionate share of the costs. In Europe, annual economic costs are estimated to be EUR €95.6 billion. These costs include lost workdays, healthcare treatment, impaired learning, and decreased productivity.

ADDRESSING THE IMPACTS OF LIGHT POLLUTION AND NOISE POLLUTION

To address the impacts of light and noise pollution, governments, industry leaders, and non-governmental organisations are collaborating and forming coalitions to drive action.

The United Nations Environment Programme (UNEP) signed the Convention on the Conservation of Migratory Species of Wild Animals in 1979, also known as the Convention on Migratory Species (CMS). In 2020, parties adopted light pollution guidelines – one of the only formal international policy frameworks to explicitly address light

pollution. Resolution 13.5 acknowledges that artificial light is increasing globally, that it is known to adversely affect many species and ecological communities, and endorses national light pollution guidelines for wildlife, with a specific emphasis on marine turtles, seabirds, and migratory shorebirds. It implores managing artificial light so that migratory species are not disrupted within, nor displaced from, important habitat, and are able to undertake critical behaviours such as foraging, reproduction and migration. It also recommends that non-parties and other stakeholders – including the business sector – use and promote the guidelines to facilitate uptake of processes that limit and prevent the harmful effects of artificial light on migratory species; recommends that stakeholders dedicate greater attention to night sky brightness and its monitoring including energy costs linked to nocturnal illuminations; and recommends greater scientific research on the impacts of artificial light on wildlife.

Although no binding global treaty yet exists on light pollution, there is strong bottom-up action from cities, non-governmental organisations, and the research community. Nations around the globe have implemented light pollution laws, and a growing body of evidence suggesting that intense LEDs are harmful to human and wildlife health has led to recommendations and support for communities to change streetlights and other public lighting to minimise and control the use of artificial lighting. Some cities, such as Chicago, Illinois, and Flagstaff, Arizona, have retrofitted their lighting to reduce energy waste and light pollution, and many others are exploring opportunities to do the same.

DarkSky International, a non-profit organisation committed to preserving and protecting the night-time environment and shared heritage of dark skies, has introduced a range of global initiatives to address light pollution, including the DarkSky Action fund that aims to provide immediate and direct support to projects addressing light pollution worldwide, and International Dark Sky Week, an annual event encouraging community engagement, such as stargazing events, education, and light audits.

In regard to noise pollution, the International Labour Organisation's Maritime Labour Convention (MLC 2006) set out requirements to prevent the risk of exposure to hazardous levels of noise on board ships, and in 2012 the International Maritime Organisation (IMO) adopted a regulation in the International Convention for the Safety of Life at Sea (SOLAS) to require ships to be constructed to reduce on-board noise and to protect personnel from noise. The regulation was set in accordance with the Code on noise levels on board ships, which sets out mandatory maximum noise level limits for machinery spaces, control rooms, workshops, accommodations, and other spaces on vessels.

The Global Partnership for Mitigation of Underwater Noise from Shipping (GloNoise Partnership) project was launched in 2022 by the IMO to further address the impacts of underwater noise on marine life, in collaboration with the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF).

In 2023, IMO issued revised guidelines for the reduction of underwater radiated noise (URN) from shipping that recognise that commercial shipping is one of the main contributors to noise pollution and that such pollution can have significant impacts on a wide range of marine life, the likes of which many coastal communities – including Indigenous communities – depend on for food, livelihood, and culture. The guidelines also include updated technical knowledge; provide sample templates to assist shipowners with the development of underwater radiated noise management plans; and provide an overview of approaches applicable to designers, shipbuilders, and ship operators to reduce the underwater radiated noise of any given ship.

In 2024, the IMO approved the Underwater Radiated Noise (URN) Action Plan, aimed at addressing barriers to the uptake of the revised URN guidelines. The URN Action Plan outlines a range of tasks to be carried out by member states, such as establishing an experience-building phase (EBP) for sharing lessons learned and best practices that have emerged in the implementation of the revised guidelines; enhancing public awareness, education, and seafarer training; developing targets and policies for underwater noise reduction; developing tools to collect data and share information; and encouraging more research on underwater noise and its impacts on the marine environment.

The GloNoise project was created to establish a global partnership that could engage and assist developing countries to raise awareness, build capacity, define baselines, and promote international policy dialogue on the mitigation of underwater noise from shipping. This included creating a partnership of Lead Pilot Countries (LPCs) and supporting them – via engagement with the IMO, private sector, and strategic partners from developed countries – to tackle the issue of noise pollution from the shipping sector.

THE RISK TO BUSINESS

Light and noise pollution matter for business. Across a broad range of industries, businesses are facing credible and mounting risks from a decline in the societal acceptance of light and noise pollution, increased management costs, legislative and regulatory changes, and the growing risk of legal challenges and litigation from parties that have suffered harm, loss, or damage from excess noise or light pollution.

Chronic and long-term exposure to light and noise pollution also threatens the resilience of social and environmental systems, and therefore the resilience of local and regional economies. Without healthy communities, businesses risk losing access to talented employees and a healthy customer base, and the erosion of ecosystem integrity threatens supply chains and access to key resources and ecosystems services.

Light and noise pollution also threaten global health and economic stability, which presents material risks to business. This includes productivity losses, increased healthcare costs, and eroding the resilience of ecosystems and threatening the services that we depend on.

Businesses have a crucial role to play in protecting people and nature by eliminating light and noise pollution from their own operations and in their value chains. Companies need to understand how their operations and value chains may be directly or indirectly contributing to light and noise pollution and the cascading effects these impacts may have on their business, society, and the environment. They need to review and rethink their processes to limit, and ideally eliminate, excess noise and light from their operations and value chains; invest in innovation; and work with policymakers and peers to advance the resilience of key systems.

Note. Sustainability issues are generally systemic issues, because they are deeply interconnected and rooted in complex environmental, social, and economic systems. In these guides, a system threshold is defined as the point at which the resilience of an environmental, social, or economic system becomes compromised. This occurs when the total impacts imposed on the system exceed its capacity to assimilate those impacts.

SYSTEM THRESHOLD

There is a limit to the concentration and volume of pollutants that the Earth and particular ecosystems and communities can withstand before their resilience and well-being are significantly – and perhaps irreversibly – eroded.

In the pursuit of a corporate strategy that addresses the issues of light and noise pollution, it is important for your company to determine appropriate and defensible limits within which it must function. Identifying the limits above which light and noise pollution impact human health and nature – let alone threaten environmental, social, and/or economic collapse – is an urgent priority. For some species, there may be no safe level of exposure to light and noise pollution below which adverse effects do not occur.

Although artificial light is essential to safe communities, increased productivity, and amenity, these benefits must be considered within the context of social and ecological resilience and of balancing the needs of communities and nature.

Biological responses to artificial light vary by species, location, and environmental conditions, and the technology around lighting hardware, design, and control is changing rapidly. As such, it is not possible to set prescriptive limits on lighting. Instead, it is important to build theoretical, technical, and practical information and to assess whether the lighting your company employs is likely to affect wildlife and humans, and, if so, to minimise and mitigate that effect through best practice in lighting design.

Although there is no consensus on exposure limits to light, DarkSky and the Illuminating Engineering Society jointly published the Five Principles for Responsible Outdoor Lighting, which recommend that lighting is: useful, purposeful, and considerate of how it will impact the area, including wildlife and their habitats; targeted, so that direct light falls only where needed; no brighter than necessary; controlled and only used when necessary; and warm-coloured, with the shorter wavelength of light (blue-violet) being limited to the least amount needed.

Similarly, there is no consensus on a safe exposure limit to sound. Rather, the WHO provides noise level recommendations for multiple contexts.

KEY TOPICS ASSOCIATED WITH LIGHT AND NOISE POLLUTION

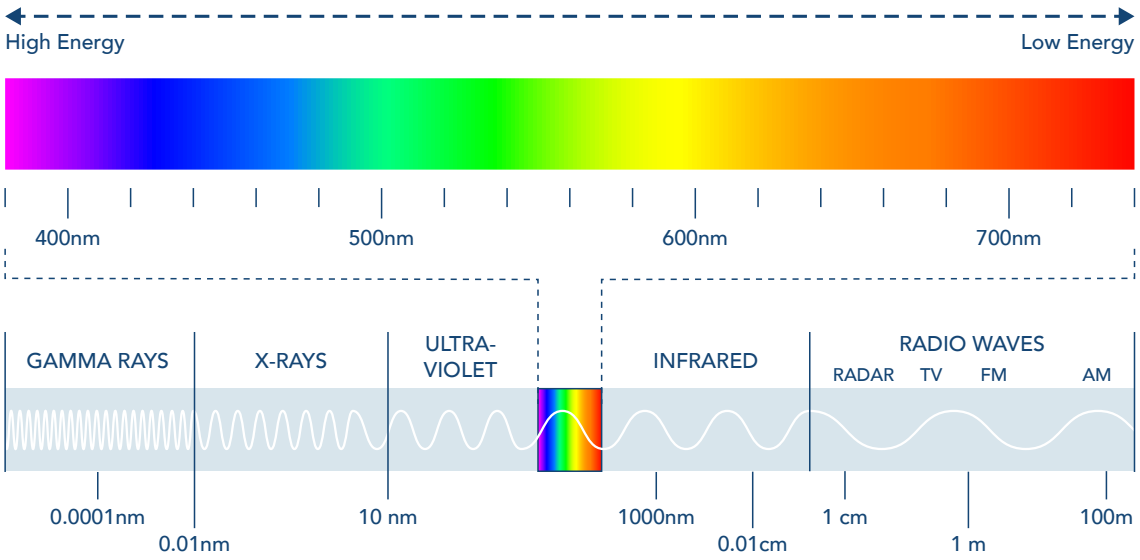
- Excessive light and inappropriate light placement, colour, intensity, wavelengths, timing of use, flicker frequency, and/or flashing.
- Unwanted, harmful, or disturbing sounds that affect people and animals.
- Vibrations from operating equipment; ground vibrations caused by explosions or blasting, construction and demolition work, transportation (railway, trucks, airplanes, and road traffic), and heavy equipment; seismic vibrations attributed to human interventions such as mining, dam construction, hydraulic fracturing ("fracking"), and wastewater injection; and structural damage due to vibrations.

2 KEY CONCEPTS

Light is a form of electromagnetic radiation that can be detected by human eyes and the eyes of millions of animal species. It is comprised of massless particles called photons, which travel in a wave-like fashion in a repeating pattern at a constant speed (the speed of light, which is 299,792,458 meters per second, or approximately 1 billion kilometers per hour) with a specific wavelength, frequency, and amplitude. Because light does not require matter to carry its energy, it can travel through a vacuum, such as the vacuum of space.

The frequency of light's wavelength determines its colour. The spectrum of light that can be perceived by the human eye corresponds to wavelengths between 380 and 750 nanometres. At each end of the visible spectrum – and imperceptible to the human eye – are the wavelengths corresponding to infrared light (from around 780 nm to 1 mm) and ultraviolet light (from around 100 nm to 400 nm). White light is understood as light that contains all the colours of the visible spectrum. Short-wavelength visible light – such as blue and violet – is more likely to cause harm to humans and animals, and can even be fatal.

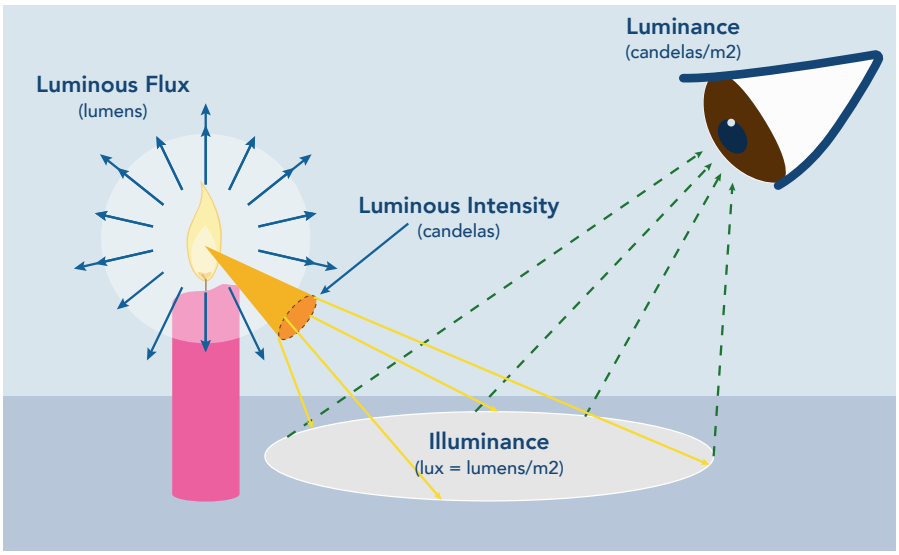
VISIBLE SPECTRUM



When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the material composition of the object and the frequency of the light.

There are three units of measurement of illumination: a lumen, a lux, and a candela. A **lumen (lm)** is the unit of luminous flux, or luminous power, which is the measure of the perceived power of

visible light emitted by a source. A **lux (lx)** is the measure of the **luminous flux** per unit area, and is the equivalent of one lumen per square metre. Referred to as **illuminance**, it can be thought of as a measure of how bright a surface is. A **candela (cd)** is the measure of **luminous intensity**. It is defined as the intensity of light in a specific direction, and is therefore related to the angle of aperture towards the light. For example, a lantern and a flashlight may have similar lumens, but the concentration of the light from the flashlight makes the light appear much more intense. There is also **luminance**, which refers to light leaving a surface or source in a particular direction. Luminance is related to how bright this light appears; it is measured in candelas per unit area, and is the equivalent of one candela per square meter.



Sound travels in waves, with pressure disturbances propagating through a material medium by causing particles to vibrate back and forth in the direct of the wave's travel. The speed of sound depends on the type of medium – the more dense the medium, the faster the sound waves travel. Sound will therefore travel faster through water or metal than through air.

The louder a sound, the greater the amplitude, or intensity, of the wave. Sound levels are measured in **decibels (db)**. The number of sound waves per second at any given point is referred to as the frequency, and it is measured in **Hertz (Hz)**. It corresponds to the "pitch" of a sound; the higher the frequency, the sharper the sound.

Noise can also be categorised as one of four types: continuous, intermittent, impulsive, or low-frequency. **Continuous** noise comes from objects or machines that run without interruption, such as the steady of thrum of a generator or the noise emanating from industrial machinery. **Intermittent** noise is infrequent but regular within daily life, and can be thought of as loud bursts that are noticeable but not surprising, such as the sound of a train leaving a station or airplanes flying overhead. **Impulsive noise**, by contrast, is neither regularly scheduled or readily recognised. These intense sounds can be surprising and frightening, such as sonar, detonations, and impact sounds. Finally, **low-frequency** sounds are common, ambient sounds that are often overlooked or unnoticed, and can include the hum of high voltage power lines, or the noise produced by heating or ventilation systems. Some sounds can also be conceived of as a combination of types, such as the deep rumble of a ship's engine.

3 KEY PLAYERS

A wide range of organisations play a role in measuring and managing light and noise pollution.

The **World Health Organisation (WHO)** provides guidance, monitoring, and reporting on global trends and changes in health outcomes associated with light and noise pollution (and related actions) at the national, regional, and global levels.

The **UN Environment Programme (UNEP)** promotes global action on pollution and health. They publish articles that highlight new research on noise and light pollution and have produced assessment reports on emerging environmental issues, such as urban soundscapes.

DarkSky International provides an array of information and resources on the causes and effects of light pollution, with themes specific to wildlife and ecosystems, energy waste, human health, and the intersection of lighting, crime, and safety. They participate as a stakeholder in multiple professional organisations that establish global lighting standards, including the International Commission on Illumination (CIE) and the Illuminating Engineering Society (IES).

DarkSky International also certifies and helps conserve starry sky parks, communities, and other places around the world; certify lighting products, designs, and installations that reduce light pollution; work with communities and professionals to establish lighting codes that reduce light pollution; and inform the public how excessive artificial light can harm humans, wildlife, and our climate.

The **International Maritime Organisation (IMO)** is a specialised agency of the United Nations that is responsible for measures to improve the safety and security of international shipping and to prevent pollution from ships, including noise pollution. The IMO provides guidelines, creates initiatives and action-oriented partnerships, and develops measures to protect particularly sensitive sea areas.

OceanCare, a marine conservation non-government organisation, also actively campaigns in numerous regional and international bodies to reduce noise emission in the ocean.

4 COMMITTING TO TAKE ACTION – MID- AND LONG-TERM GOALS

Committing to take action on **Light Pollution** and **Noise Pollution** can include addressing many of the key topics listed above. The mid- and long-term commitments that your organisation elects to make should be based on your identified priorities, areas of greatest impact, and your capacity to undertake the work required. It is important to note that this section does not provide all possible mid- and long-term goals related to this issue, but rather a sample of the goals that were most frequently adopted by companies in our research.

Common mid- and long-term goals and/or commitments on **Light Pollution** and **Noise Pollution** include variations of the following:

Long-term goal: Eliminate unnecessary light at all of our operations

- 100% of company-owned and operated sites will adhere to the Five Lighting Principles for Responsible Outdoor Lighting and ensure that lighting is useful, targeted, low-level, controlled, and warm-coloured.
- 100% of commercial lighting technology and infrastructure at company-owned and operated sites will meet the standards of the DarkSky Approved Luminaires program by 20[XX].
- We will assess and reduce – and seek to eliminate – measurable adverse impacts from company lighting on wildlife behaviour, human circadian health, and night-sky visibility.

Long-term goal: Eliminate unnecessary sound at all of our operations

- Achieve operational noise comparable to natural background sound – or better – at property boundaries at 100% of our facilities.
- Eliminate chronic noise exposure above health-protective levels for neighbouring communities and natural spaces.
- Reduce noise to levels that avoid measurable disruption to wildlife communication, feeding, breeding, migration, rest, and habitat use.

Long-term goal: Continuously reduce our [noise / light] impacts on the environment along our entire value chain

- Achieve 100% DarkSky-aligned lighting and processes at all strategic value chain facilities.
- Require key suppliers to engage with vendors and implement appropriate noise pollution mitigation practices.

5 HOW TO GET THERE – PROCESS-BASED INTERIM TARGETS

Note: The following proposed timelines are only for guidance and are based on the pace outlined by other companies. The timeframe for actions and work for each step needs to be embedded in your organisational context, which may require different time allocations.

The sequence outlined below assumes that your company has significant impacts on **Light Pollution** and/or **Noise Pollution** within its direct operations and that you will begin to engage with your value chain after learning and taking action to get your own house in order. Companies with greater impacts within their value chain may (and likely should) opt to engage with value chain partners at a much earlier stage.

YEAR 1: UNDERSTAND ISSUES RELATED TO LIGHT AND NOISE POLLUTION

Understand the safe thresholds for excess light and sound that derive from your operations and your value chain and clarify the legal requirements for compliance in the regions where you operate. Ideally, much of this work will have already been completed as a part of your organisation's regulatory compliance processes.

If you operate in regions or areas where regulations are lacking, aim to understand how your industry, your operations, and your value chain may impact the resilience of communities and nature through their production of noise and light polllution, as well as what action would be necessary to preserve and enhance the health and wellness of key social and environmental systems.

YEAR 1: GATHER DATA AND ESTABLISH BASELINES

Review your current polices and processes regarding environmental management and control with an eye to how they address light and sound. Aim to understand your current systems, narrative, and the culture that exists around managing excess light and sound to minimise the risk of harm to workers, communities, and the environment.

To the extent that you can, determine current light and sound levels by gathering data at your sites. Prioritise gathering data on sources with the greatest potential for harm, such as sources of intensely bright blue-white lights or loud sounds near residential areas or within or near natural areas. Establish light and noise baselines to support effective future decision-making related to excess light and sound. Depending on the scope and scale of potential light and sound pollution and their sources, your company may need to develop and implement a comprehensive process of continuous (and mobile) monitoring, using a combination of sensors, exposure calculators, and data processing and modelling tools. You will also want to assess for potential gaps in monitoring.

CASE STUDY: Newmont's noise monitoring system operates continuously at their Cadia Mine operations in New South Wales, Australia. The system captures real-time noise data, averaging the measurements over five-minute intervals, and this data can be accessed by the public through the Cadia Environmental Portal. The monitors record total environmental noise in all directions, including from mining operations, community noise from vehicles and aircraft, and other local noise sources.

For organisations whose products may emit harmful levels of light and sound into the environment, it is crucial to understand and quantify the impacts of these products at the point that they may enter environmental and social systems. Proper use and management may be outside of your company's direct control once these products are purchased by customers. It is therefore crucial that you identify, estimate, and document potential light and noise impacts to better understand and focus your efforts where they will be most relevant. If this information is not readily available, you may need to engage in relevant research.

Examples of process-based targets for Year 1:

- By 20[XX], we will gather data to assess the extent of excess light and/or noise generated at our sites and operations.
- By 20[XX], we will implement routine noise pollution monitoring and screening.
- By 20[XX] we will perform a review of the available government databases and scientific literature and perform field studies to determine whether listed or protected wildlife that is susceptible to the effects of artificial light could be present at our operations.
- By 20[XX], we will identify relevant best practices, including best available sound mitigating technologies, for reducing noise pollution from our facilities.
- By 20[XX], we will consult with experts to ensure that all our facilities adhere to noise regulations.

YEAR 2: UNDERSTAND LIGHT AND/OR NOISE-RELATED RISKS

Light and noise pollution have significant implications for businesses. Public awareness of environmental issues and expectations for action are growing, and companies are under increasing scrutiny. Noncompliance with regulations can result in legal action, fines, damage to reputation, and physical risks, such as impacts on employee health.

Unfortunately, when it comes to light and noise, regulations may lag, creating a risk of legal action. For instance, noise-related regulations often focus on decibel limits rather than frequency, which can result in the production of persistent hum, pressure waves, and vibrations, such as those produced by hyperscale data centers. Your company needs to understand these light- and noise-related risks.

CASE STUDY: Schréder, a designer and manufacturer of sustainable outdoor lighting, acknowledges that the preservation of dark skies is an essential aspect of environmental sustainability, wildlife protection, and human health, and that artificial lighting can have significant impacts on biodiversity and ecosystems. Their 2025 Sustainability Report – informed by a double materiality assessment – notes that poor lighting design can disrupt natural light cycles and the behaviour of nocturnal species, including insects, bats, and other wildlife. It also affirms that downstream value chain effects are both a responsibility and a financial opportunity, and that developing "environmentally conscious solutions" that integrate biodiversity-related considerations into product design and innovation processes would enable Schréder to mitigate ecological impacts while meeting the growing demand for "biodiversity-friendly infrastructure."

YEAR 2: IDENTIFY BEST PRACTICE AND AREAS OF IMPROVEMENT

Identify industry or regional guidance on best practices to reduce impacts from light and noise pollution in your operations. While this will look different for each industry, region, and environmental context, it can include aspects such as defining geographic boundaries for mapping; developing noise monitoring systems; identifying hot spots; integrating light and noise considerations into environmental planning and facilities design; including light and noise among pollution metrics; and using shielding and/or insulation to limit excess light and sound.

Examples of process-based targets for Year 2:

- By 20[XX] we will begin work with protected species researchers and managers to observe and understand changes in animal behaviour and population demographic parameters that can be attributed to light and/or noise pollution.
- By 20[XX], we will perform a comprehensive assessment to better understand how noise pollution is affecting the environment in the areas where we operate and how our activities are impacting this issue.
- By 20[XX], we will establish a measurement process to better understand and track impacts on whales and other cetaceans caused by excess noise from our direct operations and quantify baselines.
- By 20[XX] we will perform a comprehensive assessment to determine if there are Biologically Important Areas (BIAs) within 20 kilometres of our facilities and consider the species-specific impacts our activities have.
- By 20[XX] we will understand the existing light environment at all of our facilities and the potential changes required, such as alterations to the number and type of lights; their height, orientation, and hours of operation; site topography and proximity to wildlife and/or wildlife habitat; the distance over which this artificial light is likely to be perceptible; shielding or light controls used to minimise lighting; and spectral characteristics (wavelength) and intensity of lights.
- By 20[XX] we will understand the wildlife in the areas that may be affected by artificial lighting at our operations, including species type and their abundance, conservation status, ecological significance, and physiological sensitivity to wavelength and intensity, and its visual field.
- By 20[XX], we will undertake environmental impact assessments for effects of artificial light on listed species for which artificial light has been demonstrated to affect behaviour, survivorship, and reproduction.

YEAR 3: SET TARGETS

Set site-based targets that will help you to reduce the impact of light and noise pollution and ensure resilience and wellbeing – these should aim to bring your activities in line with national or local thresholds and goals for the region. At a minimum, these targets should be informed by WHO standards and/or align with WHO guidelines. Given the differences in safe limits for excess artificial light and sound between species, your targets should also be guided by the precautionary principle, meaning that where there is a risk of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

While there may be several actors contributing to light and noise pollution in the regions where you operate, leverage the social, economic, and technical information that is available to determine your 'fair share' of the effort.

YEAR 3: DEVELOP AN ACTION PLAN

Target your efforts to address light and noise pollution on sites and from processes where your research and risk analysis point to the greatest potential impacts on communities and nature. You may also want to prioritise the improvements that are the easiest to implement to jumpstart the process. Train employees on risks associated with light and noise pollution and emerging methods to measure these contaminants and assess their impacts on the local environment. Engage employees in the planning process to support the uptake of your action plan at the site level. Establish processes and methodology to effectively track and analyse impacts to evaluate your progress.

CASE STUDY: As part of their underwater radiated noise reduction (URN) plan, BC Ferries has set a target to reduce URN by 50%. Towards achieving this target, they have installed hydrophones to detect the noise levels that whales and other marine organisms are subjected to; established baselines for radiated noise levels for every BC Ferries vessel operating in the most frequented waters of southern resident killer whales, as well as vessels that may be deployed in this habitat; and have developed a multi-decade fleet replacement strategy that includes a contractual partnership with a URN specialist firm to support a noise control program for all new construction and retrofit projects.

Examples of process-based targets for Year 3:

- By 20[XX] our light management plans will be developed in partnership with and/or reviewed by qualified lighting practitioners in consultation with appropriately qualified wildlife biologists and ecologists.
- By 20[XX], we will ensure that all facilities exclusively employ external lighting that is shielded and downward-facing.
- By 20[XX], we will use adaptive lighting – such as through the use of motion sensors, dimming, and timed lighting – at all facilities.
- By 20[XX], 100% of our facilities will align with guidance from the WHO on long-term exposure thresholds linked to stress, sleep disruption, cardiovascular risk, and other effects related to light and noise pollution exposure.
- By 20[XX], we will install continuous noise monitoring systems at 100% of our facilities and provide publicly accessible dashboards showing compliance and trends.
- By 20[XX], 100% of our facilities will align external lighting systems with the DarkSky Commercial Luminaire criteria.
- By 20[XX], we will install sound barriers around our facilities to reduce the impact of noise pollution on residential areas and explore soundproofing options – such as sound enclosure panels – for on-site equipment.
- By 20[XX], we will apply a combination of motion sensors, dimmers, and timers on outdoor lighting.
- By 20[XX], we will ensure all outdoor fixtures use longer-wavelength LEDs rather than bright-white lights.
- By 20[XX], new guidelines will be introduced for reducing underwater vessel noise by reducing ship speeds.
- By 20[XX], all port berths will feature shore power systems, thereby allowing vessels to plug into the port electrical grid and reduce sound from auxiliary diesel engines while docked.

- By 20[XX], we will establish expanded slowdown zones at our ports and introduce enhanced vessel traffic measures to improve coordination and reduce the need for higher-speed operations.
- By 20[XX], we will introduce discounted harbour fees for quieter ships.
- By 20[XX], we will include light and sound considerations into our purchasing criteria when considering the replacement of machinery and equipment.
- By 20[XX], we will introduce real-time acoustic monitoring for improved adherence to determined noise thresholds.
- By 20[XX], we will introduce science-based measures for rerouting vessels away from biologically important areas.
- By 20[XX], we will reduce underwater radiated noise by [X]% within demarcated zones.
- By 20[XX], we will ensure zero night-time noise exceedances within residential boundaries.
- By 20[XX], we will integrate acoustic impacts into all infrastructure design.
- By 20[XX], noise mitigation technologies and processes, such as sound barriers and enhanced operational timing, will be introduced at 100% of our facilities.

YEAR 4: EXTEND YOUR LEARNINGS TO YOUR VALUE CHAIN

For many companies, the greatest source of excess light and sound resides within their value chain. Leverage what you have learned from your own efforts in your operations to reduce the impact of light and sound pollution to help bring about positive change in your value chain. Share your light and sound mitigation targets and insights with suppliers to encourage a greater understanding of impacts, the risks they pose to business, and the importance of action. Prioritise engagement with suppliers that have the greatest potential impacts and aim to co-develop solutions.

YEAR 4: SUPPORT SYSTEM-WIDE CHANGES

Explore where your organisation could play a broader role to raise awareness around light and noise pollution and to drive or support efforts to reduce such pollution in the areas where you operate, and especially in areas with vulnerable species and people. Identify industry and/or local initiatives related to light and noise pollution where your organisation's participation and contributions may help to foster greater impact. Much of the work related to reducing and eliminating light and noise pollution is underpinned by the availability of robust and accurate data, yet there remains limited data related to excess light and sound. Identifying whether and how your company can support improved data collection and monitoring can be an important pathway towards broader industry and system-wide changes.

CASE STUDY: In 2014 the Vancouver Fraser Port Authority launched its ECHO (Enhancing Cetacean and Habitat Observation) Program, a first-of-its-kind initiative developed to better understand and reduce the impacts of commercial shipping on at-risk whales off the southern coast of British Columbia, Canada. Guided by the advice and input of more than 100 advisors and partners across the marine transportation industry, Indigenous communities, and both Canadian and U.S. governments and environmental groups, the ECHO Program focuses on reducing acoustic and physical disturbances through voluntary, seasonal measures such as ship slowdowns and route alterations. The ECHO Program produces and provides public access to research studies, reports, and peer-reviewed papers, and over 80 marine transportation organisations voluntarily participate in ECHO Program initiatives.

Examples of process-based targets for Year 4:

- By 20[XX], we will identify industry, local, and/or international collaboration opportunities to support systemic change towards reducing and eliminating light and/or noise pollution.
- By 20[XX], we will establish a process for sponsoring scientific research to fill knowledge gaps to better understand and mitigate the risks of light and/or noise pollution.
- By 20[XX], we will organise technical sessions to promote education and information-sharing among stakeholders.
- By 20[XX], we will evaluate and act upon opportunities to support legislation that protects and restores natural darkness in communities and ecosystems.
- By 20[XX], we will assess the operations of our suppliers and, where appropriate, introduce requirements for compliance with DarkSky-aligned lighting standards.
- By 20[XX], we will integrate light pollution considerations into supplier evaluations and audits.
- By 20[XX], we will establish ongoing engagement with researchers and governments to inform best practices related to noise pollution.
- By 20[XX], we will ensure that 100% of value chain partners receive training and demonstrate competency on the effects of noise, hearing loss, how to recognise workplace noise hazards, and effective strategies for controlling noise.
- By 20[XX], we will engage with local governments and residents in setting acceptable light and/or sound thresholds and mitigation strategies.

RESOURCES

GUIDANCE

UNDERSTANDING THE EFFECTS OF LIGHT AND NOISE POLLUTION

This article from National Geographic can help you to better understand and appreciate the growing problem of light pollution, and the long-term effects it is having on humans and nature.

This article from National Geographic can help you to understand what noise pollution is, the effects it can have on wild species, and common sources of noise pollution.

This compendium of WHO and other UN guidance on health and environmental noise features a range of information on the effects of noise on human health and nature. It provides limits for acceptable noise exposure for humans and provides a table with guidance for addressing common sources of noise pollution.

This report from Ocean Care can help you to build your understanding of underwater noise emissions from deep-sea mining (DSM) activities. It provides an overview of human-caused underwater noise, explains the state of knowledge in regard to noise emissions from deep-sea mining activities, and explains their impact on marine life. It also provides an overview of legal and policy frameworks.

This report from Ocean Care provides a review of 115 primary studies encompassing various human-produced underwater noise sources on dozens of species of fish (including herring, tuna, halibut, rockfish, and bass) and invertebrates (including octopi, squid, jellyfish, shrimp, lobsters, and shellfish). It explains how noise can affect an individual's behaviour, physiology, anatomy, and development, with potentially significant impacts on reproduction, health, and mortality.

TAKING ACTION ON LIGHT AND NOISE POLLUTION

DarkSky International is a non-profit organisation committed to preserving and protecting the night-time environment and shared heritage of dark skies. Their website provides a wide array of information to grow your understanding of the causes and effects of light pollution, with themes specific to wildlife and ecosystems, energy waste, human health, and the intersection of lighting, crime, and safety. Their resources also include videos, infographics, and a research library.

This resource from Australia's Department of the Environment and Energy provides a framework that can help you to assess and manage the impact of artificial light on susceptible wildlife. It introduces a multi-step approach that explains how artificial light impacts wildlife; highlights the principles of best practice light design; explains how to determine biologically relevant luminance and perform artificial light auditing; and provides an artificial light management checklist. The guidance also features species-specific appendices and case studies.

The Revised Guidelines for the Reduction of Underwater Radiated Noise from Shipping to Address Adverse Impacts on Marine Life from the International Maritime Organisation were created to provide an overview of approaches applicable to designers, shipbuilders, and ship operators for reducing the underwater radiated noise (URN) of any given ship, as well as to assist relevant stakeholders in establishing mechanisms and programmes through which noise reduction efforts can be realised. It provides information on URN management planning, URN reduction approaches, evaluation and monitoring, and more.

This report from the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and Ocean Care provides a comprehensive overview of (current) best available techniques, technologies, and practices for preventing and reducing marine noise pollution from shipping, air guns, and pile driving.

Explore more curated resources on Noise Pollution and Light Pollution on our website.

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