OCEAN IMPACT INITIATIVE

Ocean Impact Initiative

UTILITIES INDUSTRY REVIEW

ONE OCEAN Foundation

SDA Bocconi SCHOOL OF MANAGEMENT SUSTAINABILITY LAB

McKinsey & Company

CSIC Consejo Superior de Investigaciones Científicas

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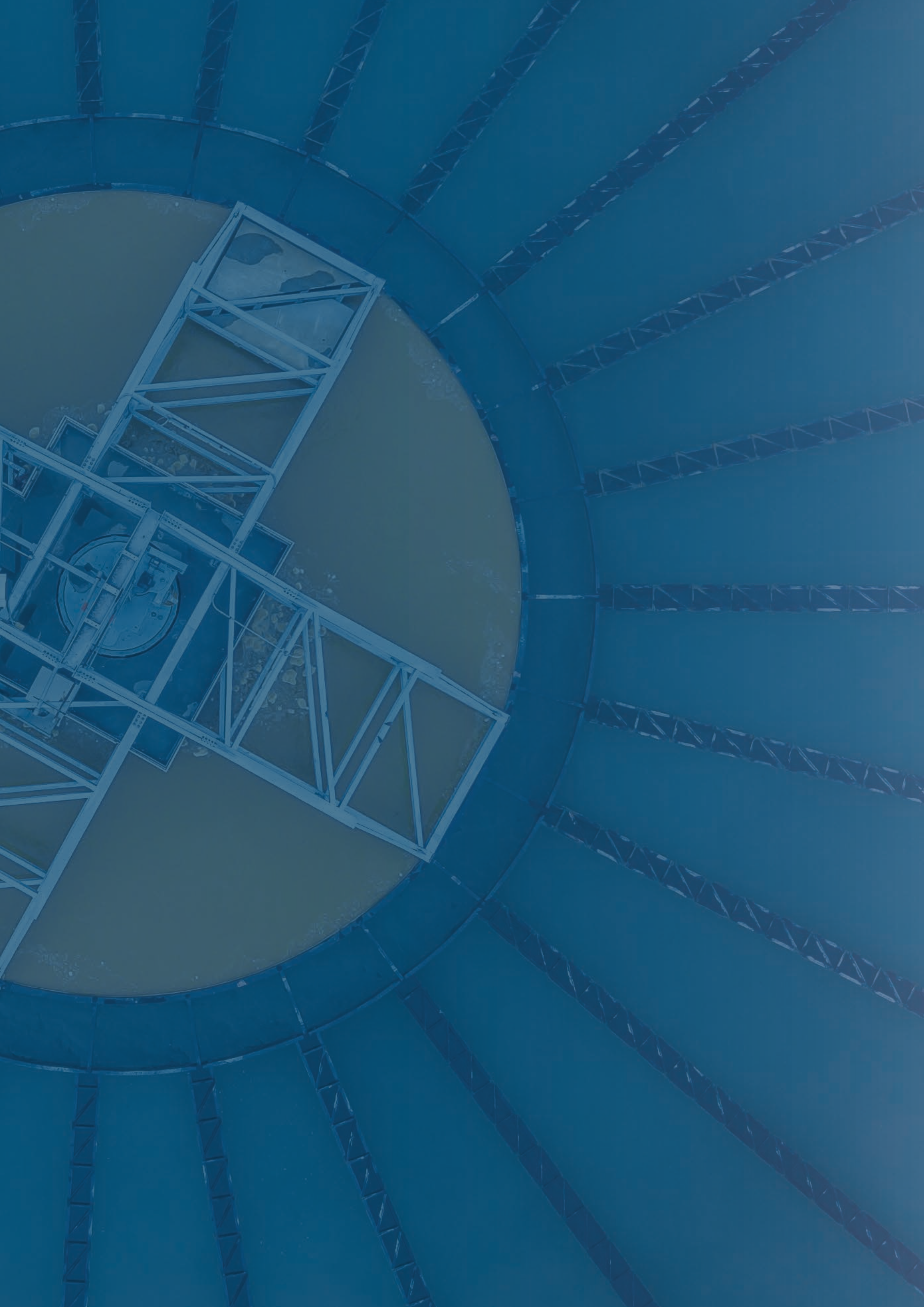

About One Ocean Foundation

This research has been carried out by the One Ocean Foundation as part of its Ocean Impact Initiative project.

At the Foundation, we believe that protecting the ocean goes beyond mitigating existing damage — it involves addressing the root causes of the issue. Our approach extends conservation efforts: we actively collaborate with businesses and policymakers to drive systemic change, ensuring a sustainable future for marine ecosystems. The One Ocean Foundation is dedicated to promoting a nature-positive economy that balances resource use with the urgent need to protect and restore marine ecosystems and their biodiversity.

The distinctive feature of the One Ocean Foundation is that every project we undertake is rooted in science and designed to create measurable, long-term impact. Our initiatives are carried out under the guidance of our international scientific committee and through continuous collaboration with cutting-edge research centers and universities. Through collaboration with companies, we help them understand and reduce their environmental footprint while fostering policies that safeguard the ocean.

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About the Ocean Impact Initiative

The Ocean Impact Initiative (formerly named Ocean Disclosure Initiative) is part of the multi-year research "Business for Ocean Sustainability" promoted by the One Ocean Foundation (OOF) in collaboration with SDA Bocconi School of Management Sustainability Lab, McKinsey & Company and CSIC (Consejo Superior de Investigaciones Científicas) and aimed at building knowledge about the relationship between business activities and the ocean.

The project commenced in 2019 with the goal of investigating the role of companies in addressing ocean challenges, focusing on the pressures on marine ecosystems, the level of awareness within the business community and the main responses (technological and organisational) implemented.

The Ocean Impact Initiative aims to provide a science-based framework and methodology with the objective of supporting businesses from all industries in taking action on ocean-related issues, promoting prevention and/or mitigation responses, and favouring disclosure and reporting.

Introduction to the utilities industry

When you lift the handle on a faucet, flip on a light switch, or set your home's thermostat, you expect water to flow, lights to illuminate your home, and the heat or air conditioning to kick on. All of those functions are provided by utilities.

The utility sector comprises establishments engaged in the provision of the following services: electric power, natural gas, steam supply, water supply, and sewage removal. Within this sector, the specific activities associated with the utility services provided vary by utility: electric power includes transmission and distribution; natural gas includes distribution; steam supply includes provision and/or distribution; water supply includes treatment and distribution; and sewage removal includes collection, treatment, and disposal of waste through sewer systems and sewage treatment facilities.[1] Because of their essential nature, utility companies typically operate in highly regulated environments with governments imposing strict rules and guidelines to ensure that these services are delivered safely, efficiently, and at a reasonable cost. Recent regulatory changes have significantly affected the utility industry in several ways:[2]

The utility sector delivers critical services — electricity, gas, water, and waste removal — supporting daily life and economic activities

Compliance costs:

Stricter compliance requirements to protect consumers and the environment have forced utilities to make substantial investments in technology, training, and equipment upgrades to meet new standards, driving up operating costs that are often passed on to consumers.

1. North American Industry Classification System (NAICS 221). https://www.bls.gov/iag/tgs/iag22.htm

2. UtilitiesLabs. (2023). "The Impact of Regulatory Changes on the Utilities Sector". https://www.utilitieslabs.com/the-impact-of-regulatory-changes-on-the-utilities-sector/

Increased competition:

As governments seek to promote competition and reduce the dominance of large utility companies, they are introducing new regulations that lower barriers for new market entrants, many of whom can offer more innovative and cost-effective services.

Renewable energy targets:

As policies seek to reduce carbon emissions and promote the use of renewable energy sources, governments are introducing targets for the proportion of energy that must be generated from renewable sources. It can increase costs for infrastructure and technology, though it can lead to a sustainable transformation in the industry.

Smart grid technologies:

These new technologies can improve energy efficiency and reduce costs. However, the implementation of smart grid technologies can be costly, though they bring long-term benefits.

In this industry review, we will focus on the water utilities, energy utilities (in terms of transmission and distribution) and waste utilities.

WATER UTILITIES:

Own and operate water supply and wastewater treatment systems or provide operational and other specialised water services to system owners (usually market-based operations). Water supply systems include the sourcing, treatment and distribution of water to residences, businesses and other entities such as governments. Wastewater systems are designed to collect and treat wastewater, including sewage, greywater, industrial waste fluids, and stormwater runoff, before discharging the resulting effluent back into the environment.[3]

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3. Taskforce on Nature-related Financial Disclosure (TNFD) (2025). "Additional sector guidance – Water utilities and services". https://tnfd.global/publication/additional-sector-guidance-water-utilities-and-services/

As the global population grows and the trend toward urbanisation continues, demand for efficient wastewater systems will also increase. These include subsegments, such as water and wastewater treatment, desalination, and irrigation, all of which require significant amounts of energy.

ENERGY UTILITIES:

Provide energy services, such as electricity and natural gas.[4] In this industry review, the focus will be on **energy transmission and distribution**, which refer to the infrastructure that facilitates the movement of energy from generation sources to end-users, ensuring its safe, efficient, and consistent delivery. The increasing need for access to energy, driven by population growth, urbanisation, and rising industrial demand, requires the installation of new transmission lines. Due to the long distances between power plants and the main consumption regions, electricity reaches consumers through an extensive network of transmission (high-voltage) and distribution (low-voltage) lines. Transmission lines differ from distribution lines by supporting higher voltages (from 69 kV to 800 kV) and usually extending for longer distances.[5]

WASTE UTILITIES:

Are responsible for collecting, managing, processing, and disposing of various types of waste, including municipal solid waste, agricultural waste and industrial waste.[6] Municipal solid waste is generated from household and commercial activities and consists of food waste, paper, plastic, metal, glass, and other materials. Sources of agricultural waste include livestock waste, agricultural crop residues, and agro-industrial by-products. Whereas industrial waste is generated during manufacturing or industrial activities in factories, mills, and mines. Waste management services encompass landfilling, incineration, recycling, and waste-to-energy processes.

4. ScienceDirect (2013). "Energy Utility". https://www.sciencedirect.com/topics/social-sciences/energy-utility#:~:text=Energy%20utilities%20are%20defined%20as,associated%20with%20fossil%20fuel%20use.

5. Biasotto, L. D., & Kindel, A. (2018b). Power lines and impacts on biodiversity: A systematic review. Environmental Impact Assessment Review, 71, 110–119. https://doi.org/10.1016/j.eiar.2018.04.010

6. Hajam, Y. A., Kumar, R., & Kumar, A. (2023). "Environmental waste management strategies and vermi transformation for sustainable development." Environmental Challenges, 13, 100747. https://doi.org/10.1016/j.envc.2023.100747

Rapid urbanisation, population growth, and rising consumption have driven waste generation to alarming levels, creating a global issue. Waste quantities and generation are expected to continue rising, with available data projecting a 73% increase in waste production by 2050 compared to 2020.[7]

Utility services are critical for society, powering homes, industries, and infrastructure. However, the environmental impact of the utility sector, particularly on the ocean, can be significant. As illustrated by the scientific review conducted within the framework of the OII project,[8] the utility sector impacts all Good Environmental Status (GES) descriptors defined by the Marine Directive of the European Union[9] to describe the state of the marine environment.

The current analysis involved a comprehensive review of relevant publications on the environmental pressures of the industry, along with sustainability reports from the main companies operating in the sector. The core objective of the analysis is to map and better understand the pressures exerted on marine ecosystems, thus creating the basis for the industry-specific edition of the OII questionnaire. To this end, the following paragraphs introduce the industry and present its main pressures on the ocean.

As the scientific review within the OII project has revealed (shown in red and orange in Figure 1 below), the core potential pressures exerted by the utilities industry on the marine environment relate to:

- **Contaminants**
  (including contaminants in seafood)
- **Eutrophication**
- **Loss of biodiversity**
  (including alteration of food webs and disruption of commercial fish and shellfish)

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7. The World Bank. (2022). "Clean and Low-Carbon Cities: the Relationship Between the Solid Waste Management Sector and Greenhouse Gases." https://www.thegpsc.org/knowledge-products/solid-waste-management/clean-and-low-carbon-cities-relationship-between-solid

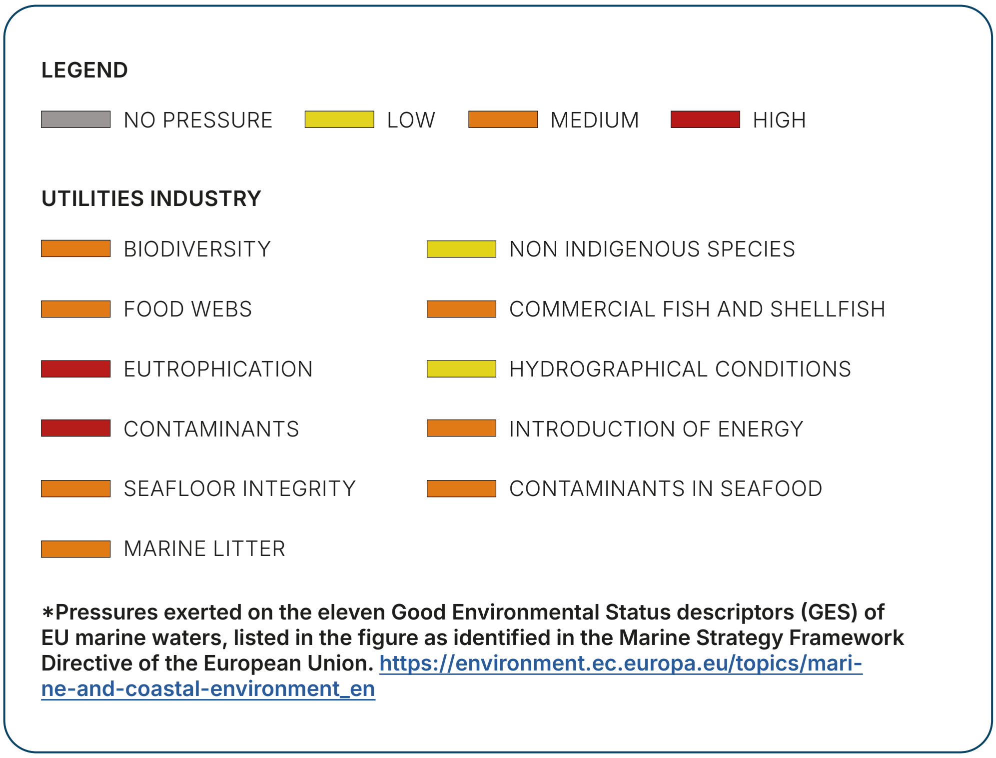
8. One Ocean Foundation (2021) "Ocean Disclosure Initiative". Available at: https://cdn.prod.website-files.com/622f5dc681e480028f7fc611/6285f9ad1722f2a75ca6c605_OOF_Ocean_Disclosure_Initiative_ODI_EN.pdf

9. EU Marine Strategy Framework Directive [online]. Available at: https://research-and-innovation.ec.europa.eu/research-area/environment/oceans-and-seas/eu-marine-strategy-framework-directive_en

- **Seafloor integrity**
- **Marine litter**
- **Introduction of energy**

Beyond these main pressures, this industry review also explores the impacts of GHG emissions produced by the industry.

FIGURE 1: Review of the negative pressures of the utilities industry[10]

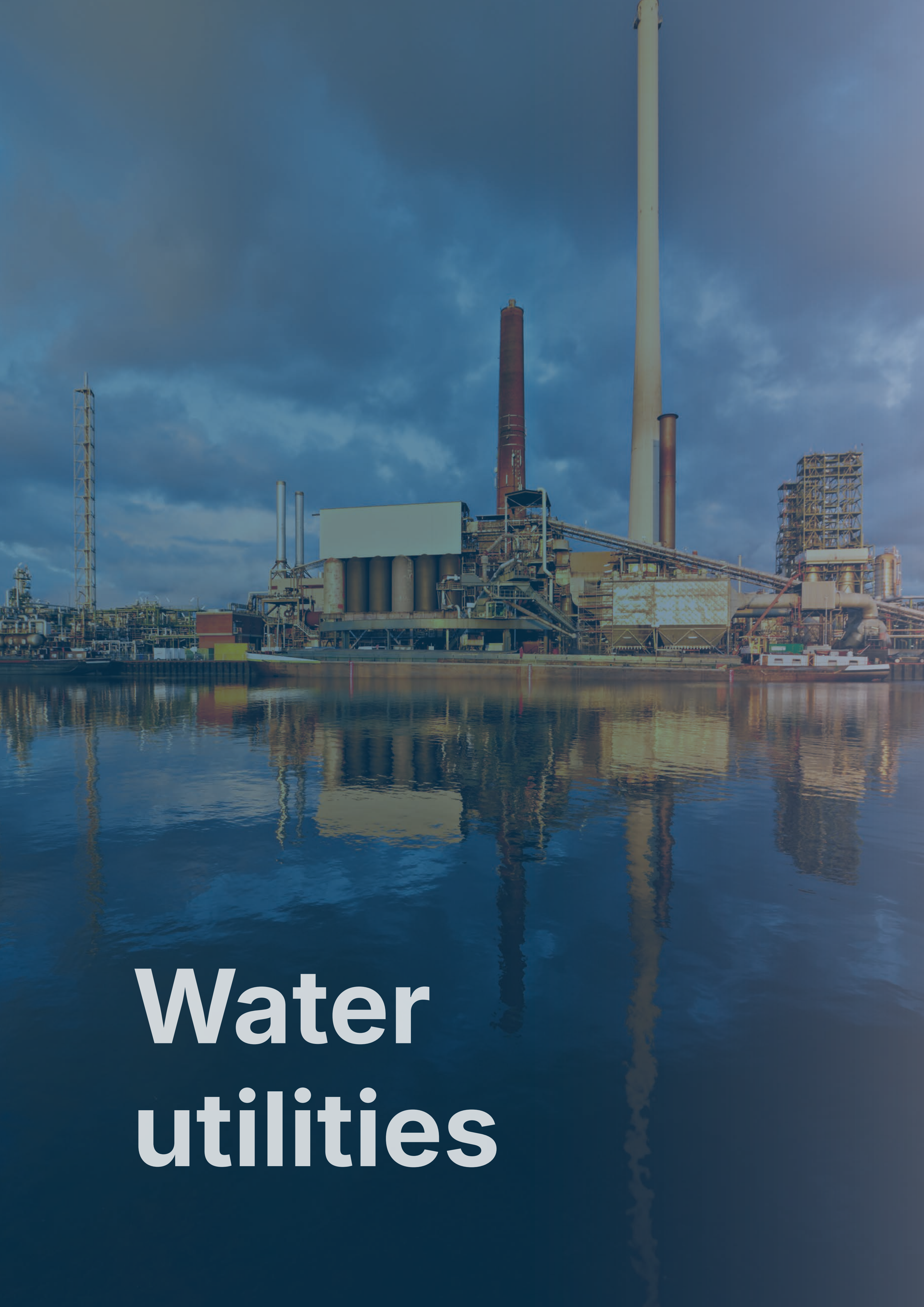


Source: Author's elaboration

10. A summary of the impacts is provided in Table 1 of the Appendix.

The main pressures exerted by the utilities industry

As mentioned above, the utility sector has the potential to impact the ocean through the introduction of nutrients and contaminants, disruption of biodiversity, physical alteration of the seafloor, contribution to marine litter, and introduction of energy. Mitigating these pressures requires a concerted effort from both industry and policymakers to adopt more sustainable practices, such as improving wastewater treatment technologies, reducing pollutant emissions, and developing offshore energy infrastructure in harmony with marine ecosystems.



Water utilities

CONTAMINANTS

Water utilities are essential for managing used water and returning it safely to the environment, but if not efficiently managed, wastewater can also become a significant source of contaminants entering aquatic and marine ecosystems.

Today, only 11 per cent of the world's treated wastewater is reused, and around half of the world's untreated wastewater still enters rivers, lakes, and seas.[11] Even during wastewater treatment, not all pollutants are fully removed; therefore, contaminants can accumulate in sediments and bioaccumulate in marine organisms, threatening biodiversity and potentially impacting human health through seafood consumption. Contamination can stem from agriculture, industrial discharges, and especially urban wastewater, which often carries organic matter, nutrients, and untreated sewage as well as emerging pollutants such as pharmaceuticals and microplastics.[12]

About half of the untreated wastewater still flows directly into rivers, lakes, and seas

Sewage is a major global problem, consisting of liquid waste or waste matter usually carried away by sewers. Urban areas are particularly vulnerable, as high population density results in high demand and equally high volumes of contaminated return flows.[13]

11. United Nations Environment Programme (UNEP). (2023). "Wastewater: Turning Problem to Solution". Available at: https://www.unep.org/news-and-stories/press-release/down-drain-lies-promising-climate-and-nature-solution-un-report

12. Rebello, T. A., Chhipi-Shrestha, G., Hewage, K., & Sadiq, R. (2022). "Environmental, economic, and social sustainability of urban water systems: a critical review using a life-cycle-based approach". Environmental Reviews, 31(1), 26–44. https://doi.org/10.1139/er-2021-0126

13. Rebello, T. A., Chhipi-Shrestha, G., Hewage, K., & Sadiq, R. (2022). "Environmental, economic, and social sustainability of urban water systems: a critical review using a life-cycle-based approach". Environmental Reviews, 31(1), 26–44. https://doi.org/10.1139/er-2021-0126

Even where treatment occurs, technical limitations mean effluent still carries residual nutrients, pathogens, and chemicals.[14]

Furthermore, industrial wastewater contains significant amounts of heavy metals that are detrimental to human health, aquatic organisms, and the ecosystem. These include mercury (Hg), lead (Pb), cadmium (Cd), arsenic (As), and others. Heavy metals are persistent, non-biodegradable trace elements highly soluble in aquatic environments that tend to accumulate over time.[15] In addition, in coastal areas, desalination plants may also introduce chemical residues, such as chlorine and antifouling agents, as well as concentrated brine, which may alter local salinity levels and stress marine life.[16] Poorly managed infrastructure, leakages, and inadequate monitoring systems can further amplify these risks.

Moreover, conventional wastewater treatment plants (WWTPs) remain important pathways for micropollutants and microplastics. Tertiary steps in wastewater treatment reduce but do not eliminate loads, and large throughputs translate into significant mass discharges.[17] Growing evidence also shows that WWTPs disseminate antibiotic-resistance genes (ARGs) and bacteria (ARBs to receiving waters.[18]

GOOD PRACTICES

Advanced wastewater treatment technologies can significantly improve water purification and contaminant removal. For example, ultrafiltration (UF), reverse osmosis (RO) and membrane bioreactor (MBR) use high-pressure membranes to filter out pollutants, producing water suitable for reuse.[19]

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14. Taskforce on Nature-related Financial Disclosure (TNFD) (2025). "Additional sector guidance – Water utilities and services". https://tnfd.global/publication/additional-sector-guidance-water-utilities-and-services/

15. Oladimeji, T. E., Oyedemi, M., Emetere, M. E., Agboola, O., Adeoye, J. B., & Odunlami, O. A. (2024). Review on the impact of heavy metals from industrial wastewater effluent and removal technologies. Heliyon, 10(23), e40370. https://doi.org/10.1016/j.heliyon.2024.e40370

16. Taskforce on Nature-related Financial Disclosure (TNFD) (2025). "Additional sector guidance – Water utilities and services". https://tnfd.global/publication/additional-sector-guidance-water-utilities-and-services/

17. European Investment Bank. (2023). "Microplastics and micropollutants in water." Available at: https://www.eib.org/attachments/lucalli/20230042_microplastics_and_micropollutants_in_water_en.pdf

18. Zhou, L., Wu, Y., Wang, X., Ma, L., & Liu, G. (2023). "Microplastics aggravate the development of cancer by disrupting cellular homeostasis: A comprehensive review". Frontiers in Oncology, 13, 11274174. https://pmc.ncbi.nlm.nih.gov/articles/PMC11274174/

Ultrasonic reactors employ high-frequency waves to generate microbubbles that decompose contaminants and microorganisms. Naturally and genetically enhanced microorganisms target stubborn organic pollutants and specific chemicals, while electrocoagulation and electrooxidation use electrical currents to remove contaminants through coagulation and oxidation, collectively enhancing wastewater treatment efficiency.[20] Recent technologies like nanotechnology, photocatalysis, and electrochemical coagulation have significant advantages over conventional methods for removing heavy metals, including higher removal rates, improved energy efficiency, and greater selectivity for specific contaminants.[21]

EUTROPHICATION

Eutrophication, driven largely by excess nitrogen and phosphorus entering aquatic systems, is a serious environmental impact associated with water utilities. These nutrients often originate from untreated or partially treated wastewater, sewer overflows, and agricultural runoff, especially during heavy rainfall events. Such nutrient-rich discharges promote harmful algal blooms (HABs) that reduce oxygen levels in water, block sunlight, and damage aquatic ecosystems, resulting in hypoxic "dead zones" where marine life cannot survive.[22] Additionally, these blooms can be toxic to marine species, further threatening biodiversity and ecosystem stability.

Excess nitrogen from untreated wastewater, sewer overflows and agricultural runoff have potential to drive eutrophication

Ineffective wastewater management and sewer overflows contribute to nutrient loading, often causing the spread of aquatic weeds and deteriorating water quality. Utilities are legally responsible for meeting nutrient pollution standards to protect water bodies;[23] however, if not properly managed, it can compromise ecosystem services such as natural water purification and may lead to

19. For further details, please refer to the in-depth paragraph "Advanced technologies and innovations in wastewater treatment" provided later in this document

20. IDRICA. (2024). "Water technology trends 2024." https://www.idrica.com/wp-content/uploads/2024/02/202401-trends-2024-EN_def.pdf

21. Oladimeji, T. E., Oyedemi, M., Emetere, M. E., Agboola, O., Adeoye, J. B., & Odunlami, O. A. (2024). Review on the impact of heavy metals from industrial wastewater effluent and removal technologies. Heliyon, 10(23), e40370. https://doi.org/10.1016/j.heliyon.2024.e40370

22. FAO. (2018) "More people, more food, less water? A global review of water pollution from agriculture". https://www.fao.org/3/ca0146en/CA0146EN.pdf

23. Taskforce on Nature-related Financial Disclosure (TNFD) (2025). "Additional sector guidance – Water utilities and services". https://tnfd.global/publication/additional-sector-guidance-water-utilities-and-services/

contaminated drinking water sources and depleted marine habitats.[24]

GOOD PRACTICES

To reduce eutrophication risks, water utility companies should prioritise upgrading wastewater treatment plants with advanced nutrient removal technologies, including biological nutrient removal (BNR), membrane bioreactors (MBR) and advanced oxidation processes such as photocatalytic oxidation. These methods significantly reduce nitrogen, phosphorus, and persistent pollutants in effluent before discharge.[25] Beyond treatment plants, green infrastructure solutions like wetlands, rain gardens, and vegetated buffer zones can intercept and filter stormwater, preventing excess nutrients from reaching rivers and marine environments.[26]

Green infrastructure, like rain gardens and vegetated buffers, captures stormwater and has the capacity to prevent nutrient pollution

Equally important are measures at the sewer network scale. These may include controlling combined sewer overflows (CSOs) through storage, separation, and retention basins or deploying real-time control systems that use smart sensors and automated gates to dynamically reroute flows during storms. Such approaches reduce the frequency and severity of untreated discharges, complementing both treatment-plant upgrades and nature-based solutions.[27]

LOSS OF BIODIVERSITY

Overall, water utilities influence marine and coastal ecosystems through infrastructure development, resource abstraction, and pollution discharge. Poor water resource management can result in the over-extraction of freshwater from ecologically sensitive areas, causing habitat degradation, water scarcity, and loss of aquatic biodiversity.

Water utilities can affect marine and coastal ecosystems through infrastructure development, resource use, and industrial discharge

24. Badamasi, H. Yaro, M. N., Ibrahim, A., Bashir, I.A. (2019) "Impacts of Phosphates on Water Quality and Aquatic Life." Chemistry Research Journal 4(3), 124–133. https://www.researchgate.net/publication/339209495_Impacts_of_Phosphates_on_Water_Quality_and_Aquatic_Life

25. Bergbusch, N. T., Wong, A. R., Russell, J. N., Swarbrick, V. J., Freeman, C., Bergsveinson, J., Yost, C. K., Courtenay, S. C., & Leavitt, P. R. (2023). Impact of wastewater treatment upgrade and nitrogen removal on bacterial communities and their interactions in eutrophic prairie streams. FEMS Microbiology Ecology, 99(12). https://doi.org/10.1093/femsec/fiad142

26. European Environmental Agency. (2017). "Green Infrastructure and Flood Management: Promoting cost-efficient flood risk reduction via green infrastructure solutions". https://www.eea.europa.eu/en/analysis/publications/green-infrastructure-and-flood-management

27. United States Environmental Protection Agency (EPA). (2025). "Combined Sewer Overflow Solutions - Management Approaches". Available at: https://www.epa.gov/npdes/combined-sewer-overflow-solutions-management-approaches#:~:text=Green/Gray%20Infrastructure%20Green%20infrastructure%20can%20complement%20gray,energy%20expenditures.%20Learn%20more%20about%20green%20infrastructure.

Desalination plants, increasingly used in water-scarce regions, can pose significant risks to marine and coastal ecosystems. Their development often leads to the conversion of critical habitats such as mangroves, coral reefs, and coastal wetlands—areas essential for the breeding and shelter of marine and bird species. In addition, desalination often involves open ocean intake, which can result in smaller marine species becoming entangled in the intake pipes.[28]

Another concern is the discharge of hypersaline brine- the highly concentrated salt by-product of desalination, often containing chemical additives such as antiscalants and coagulants. This dense brine, being heavier than seawater, sinks to the ocean floor and can creep along the seabed for several kilometres from the discharge point. Its accumulation in benthic zones can create low-oxygen conditions, impair nutrient fluxes from sediment to the water column, and reduce oxygen availability for benthic organisms, including fish, corals, seagrasses, and invertebrates.[29] Impacts observed within the discharge mixing zones range from physiological stress and morphological deformations to changes in community composition. Brine infiltration into sediment porewater may also alter redox conditions and disrupt biogeochemical processes. With global demand for freshwater increasing, brine volumes are expected to triple this century, highlighting the urgent need for environmentally friendly additives and technologies to minimise brine discharge.[30]

GOOD PRACTICES

Desalination plants can reduce their ecological footprint by using fine mesh intake screens, low-velocity water withdrawal, and diffused brine discharge systems. To minimise the entanglement of marine organisms in the intake pipes, water utilities should implement early detection at intake points using tools like eDNA and remote sensing for timely intervention.[31]

Pressures can be mitigated through fine mesh screens, diffused brine discharge systems, and early detection tools such as eDNA and remote sensing

28. Taskforce on Nature-related Financial Disclosure (TNFD) (2025). "Additional sector guidance – Water utilities and services". https://tnfd.global/publication/additional-sector-guidance-water-utilities-and-services/

29. Taskforce on Nature-related Financial Disclosure (TNFD) (2025). "Additional sector guidance – Water utilities and services". https://tnfd.global/publication/additional-sector-guidance-water-utilities-and-services/

30. Sirota R, Winters G, Levy O, Marques J, Paytan A, Silverman J, Sisma-Ventura G, Rahav E, Antler G, Bar-Zeev E. (2024). "Impacts of Desalination Brine Discharge on Benthic Ecosystems." Environ Sci Technol 58(13):5631-5645. doi: 10.1021/acs.est.3c07748

31. Taskforce on Nature-related Financial Disclosure (TNFD) (2025). "Additional sector guidance – Water utilities and services". https://tnfd.global/publication/additional-sector-guidance-water-utilities-and-services/

SEAFLOOR INTEGRITY

Water utilities affect seafloor integrity primarily through the discharge of treated or untreated wastewater into coastal and marine environments. Wastewater effluent and land-based runoff can carry sediments, nutrients, and pollutants such as microplastics, which may smother seafloor habitats such as seagrass meadows or coral areas, degrading ecosystem function and weakening biodiversity resilience. Beyond discharges, physical damage to ecosystems may occur during the construction of treatment facilities (wastewater treatment plants, pumping stations, and desalination plants) and the installation of sewage pipes, which are needed to collect and transport wastewater from residential, industrial, and commercial areas to treatment facilities.

The sector impacts seafloor integrity through wastewater discharges, construction of treatment facilities and pipeline installation

These activities can involve removal of natural plant cover and trench digging, leading to habitat fragmentation, erosion, and increased sediment runoff into the sea.[32]

GOOD PRACTICES

Improvements in wastewater treatment can potentially reduce sediment and nutrient discharge and limit the smothering of benthic ecosystems. Good practices also include scheduling construction activities outside of critical breeding seasons, using silt curtains to control sediment plumes, adopting horizontal directional drilling (HDD) for pipeline and outfall landfalls to minimise direct seabed disturbance,[33] and restoring disturbed areas through replanting seagrass or rebuilding reef structures.

Advanced wastewater treatment and the adoption of horizontal directional drilling can help to minimise seabed disturbance

32. Taskforce on Nature-related Financial Disclosure (TNFD) (2025). "Additional sector guidance – Water utilities and services". https://tnfd.global/publication/additional-sector-guidance-water-utilities-and-services/

33. NEC Corporation. (2024). "Horizontal directional drilling (HDD) method: Minimizing environmental impact in submarine cable landings." NEC Technical Journal, 24(1). https://www.nec.com/en/global/techrep/journal/g24/n01/240120.html

Ongoing monitoring and adaptive management ensure that unforeseen impacts are addressed promptly, preserving the ecological functions and biodiversity of the seafloor.

MARINE LITTER

Water utilities contribute to marine litter through stormwater and wastewater discharges. Combined sewer overflows, particularly during heavy rainfall, can result in untreated waste inside water, including plastics, sanitary products, and industrial solid waste, being released directly into rivers and the ocean.[34] Additionally, water utilities generate solid waste through construction and maintenance activities (e.g., pipe repair), which may inadvertently enter water bodies if not properly handled.[35] Wastewater treatment plants, even when functioning normally, may not fully capture microplastics and other synthetic particles, allowing these pollutants to reach the marine environment. For instance, in Sydney, Australia, the Malabar wastewater treatment plant was found to discharge an estimated 5.4 billion to 120 billion microplastic particles into the ocean each day.[36]

Marine litter can originate from sewer overflows, construction waste, and microplastics from wastewater treatment

GOOD PRACTICES

Companies in the sector can reduce marine litter by enhancing solid waste removal and resource recovery. Investing in advanced filtration technologies at wastewater treatment plants helps capture microplastics and solid waste before they reach rivers and the ocean. Implementing circular wastewater treatment processes, such as transforming sewage sludge into biosolids, biofuels, or fertilisers, turns waste into valuable resources and reduces disposal volumes.[37]

Companies can reduce their impact by improving waste removal, advanced filtration and circular treatment processes

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34. Circular Economy Lab & Observatory (2020) "Water pollution: Sewage water pollution" https://www.educazionedigitale.it/cielo-erasmus/wp-content/uploads/2023/01/Lithuania-1.2Water-pollution.pdf

35. Taskforce on Nature-related Financial Disclosure (TNFD) (2025). "Additional sector guidance – Water utilities and services". https://tnfd.global/publication/additional-sector-guidance-water-utilities-and-services/

36. The Guardian. (2025). "Sydney's archaic sewerage system a 'significant' source of microplastic pollution into the sea". Available at: https://www.theguardian.com/australia-news/2025/feb/16/sydney-sewerage-system-a-significant-source-of-microplastic-pollution-csiro-finds

37. Taskforce on Nature-related Financial Disclosure (TNFD) (2025). "Additional sector guidance – Water utilities and services". https://tnfd.global/publication/additional-sector-guidance-water-utilities-and-services/

Furthermore, infrastructure lifecycle planning should consider the reuse or recycling of components (e.g., pipes) to prevent waste accumulation. Utilities should also run public awareness campaigns to discourage improper disposal of items like fats, wet wipes, and plastics down household drains, which contribute significantly to marine pollution.[38]

INTRODUCTION OF ENERGY

Companies in the sector can reduce marine litter by enhancing solid waste removal and resource recovery. Investing in advanced filtration technologies at wastewater treatment plants helps capture microplastics and solid waste before they reach rivers and the ocean.[39]

Noise from pumps and machinery at wastewater plants can disrupt communication, feeding, and stress responses in seabirds and aquatic species

GOOD PRACTICES

Enclosing noisy machinery, installing sound barriers, and using vibration-dampening materials in pumping stations and treatment facilities can significantly reduce noise pollution.[40]

For instance, strategic vegetation buffers — designed strips or zones of trees, shrubs, and grasses planted around treatment plants, landfills, or along rivers and coastlines — offer multiple benefits. They not only mitigate noise and light pollution but also filter dust, nutrients, and contaminants from runoff while enhancing habitat quality and connectivity for wildlife.

Noise and pollution can be reduced by installing sound barriers and vegetation buffers

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38. Ibidem

39. Ibidem

40. Flexshield (2024). "Managing noise in wastewater treatment plants with barrier walls". https://flexshield.com.au/managing-noise-in-wastewater-treatment-plants-with-barrier-walls/

GHG AND NON-GHG AIR EMISSIONS

Urban water utilities are significant energy users, primarily due to the energy-intensive nature of wastewater treatment, which involves extensive pumping, treatment, and distribution processes. Electricity used to power these systems is often derived from fossil fuels, leading to GHG emissions. In wastewater treatment plants, biological processes also release greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O). Methane is produced during anaerobic digestion of organic matter and uncontrolled sludge storage, while N_2O results from nitrification-denitrification as part of nitrogen removal processes.[41] The wastewater sector contributes approximately 5-7 % of global anthropogenic CH4 emissions[42] and approximately 3-7% of anthropogenic N2O emissions.[43]

Wastewater contributes 5-7% of global anthropogenic CH4 emissions and approximately 3-7% of anthropogenic N2O emissions

In addition to GHGs, water utilities also emit non-GHG air pollutants during the treatment and sludge disposal. These include particulate matter (PM), sulphur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOCs), and heavy metals. These substances pollute the air and have an impact on nature. PM can cause respiratory stress in animals, while SO_2 and NO_x drive acid rain, affecting aquatic systems, while VOCs can be toxic to aquatic life if they enter waterways.[44]

GOOD PRACTICES

To reduce greenhouse gas and air pollutant emissions, water utilities can adopt a series of operational and technological improvements. The use of ***digital twin systems*** and advanced data analytics allows operators to monitor plant performance in real time, optimise aeration processes, and predict failures, thereby lowering

Emissions can be reduced by optimising operations with digital twin systems, energy recovery solutions, aeration optimisation, and renewable energy integration

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41. Yan, G., Kenway, S. J., Lam, K. L., & Lant, P. A. (2025). "Greenhouse gas emission dynamics and trajectories in urban water supply and wastewater systems". Water Research, 275. https://doi.org/10.1016/j.watres.2025.123153

42. Song, C., Zhu, J., Willis, J. L., Moore, D. P., Zondlo, M. A., & Ren, Z. J. (2023). "Methane Emissions from Municipal Wastewater Collection and Treatment Systems." Environmental Science & Technology, 57(6), 2248–2261. https://doi.org/10.1021/acs.est.2c04388

43. Wu, Q., Wang, H., Ran, X., Zhou, M., & Wang, Y. (2025). "Recent advances in variability analysis of N2O emissions from WWTPs and innovative mitigation/utilization approaches." Environmental Research, 285, 122448. https://doi.org/10.1016/j.envres.2025.122448

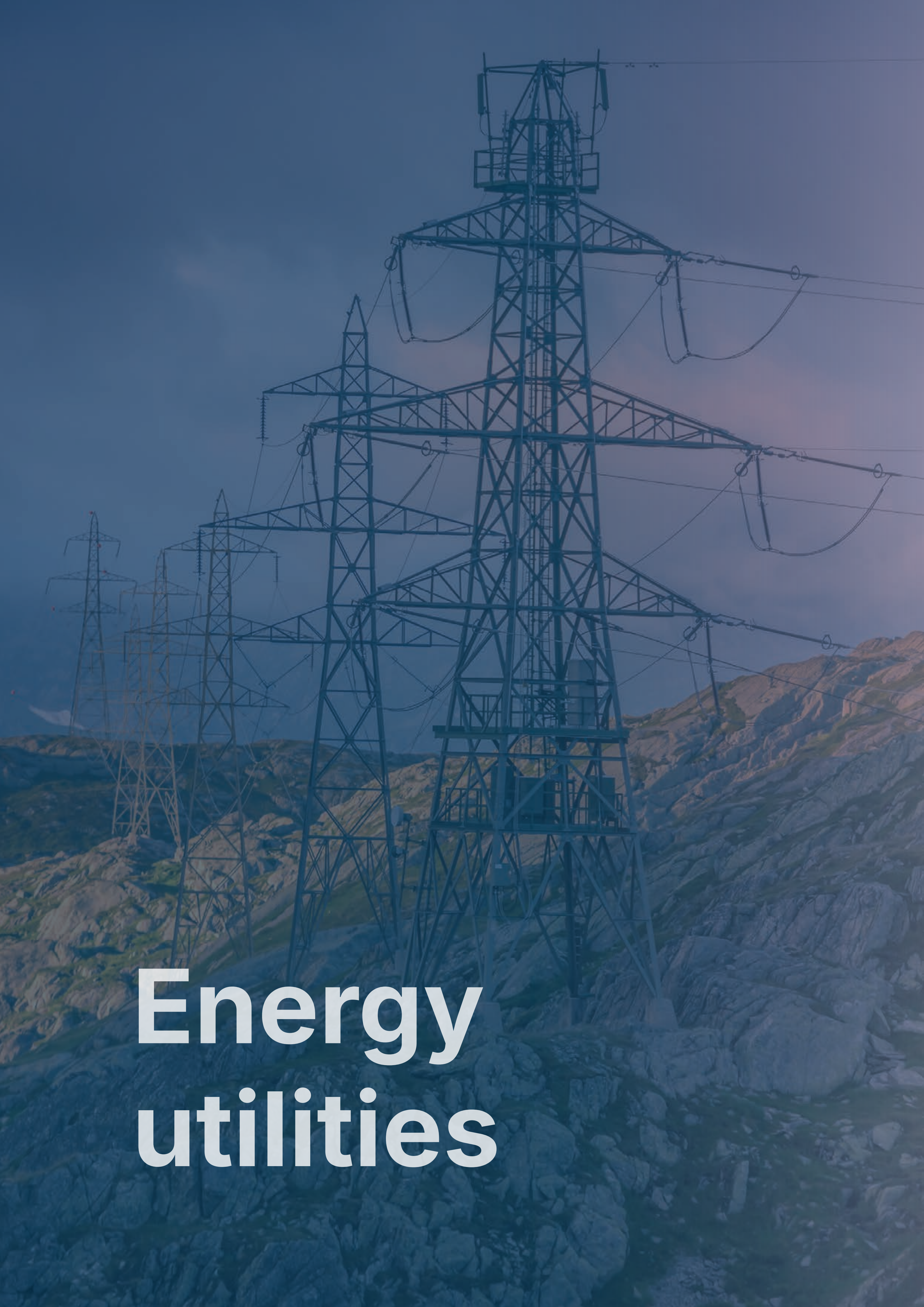
44. Taskforce on Nature-related Financial Disclosure (TNFD) (2025). "Additional sector guidance – Water utilities and services". https://tnfd.global/publication/additional-sector-guidance-water-utilities-and-services/

both energy consumption and nitrous oxide formation. Alongside this, smart asset monitoring of pumps and blowers ensures that equipment runs efficiently, avoiding unnecessary electricity use and cutting indirect CO_2 emissions. The integration of leak detection and condition assessment tools, such as acoustic and pressure sensors, can further reduce water losses and the excess pumping and energy demand associated with them.

Utilities can also make use of energy recovery solutions to close the loop in treatment processes: hydro turbines can capture energy from water flows in distribution systems, heat exchangers can recover thermal energy from effluent, and biogas from anaerobic sludge digestion can be upgraded and used as a renewable fuel.[45]

Additional savings can be achieved through **aeration optimisation**, which fine-tunes oxygen supply in biological reactors, reducing both electricity demand and nitrous oxide emissions. Finally, sourcing electricity from **renewable energy** such as solar, wind, or hydropower further reduces indirect CO_2 emissions, helping utilities lower their climate footprint and contribute to broader decarbonisation goals.

45. Xylem Water (2022) "Meet the Utilities Setting the Pace on Decarbonization". https://www.xylem.com/siteassets/campaigns/global/net-zero-campaigns/xylem_net-zero-the-race-we-all-win_final.pdf



Energy utilities

CONTAMINANTS

Energy utility facilities pose a risk of environmental contamination, particularly from subsea cables during their installation, operation and eventual removal, with potential pollutants including arsenic, cadmium, copper, lead, mercury, nickel, selenium, silver, zinc, and total polycyclic aromatic hydrocarbons (PAHs). Over time, cable coatings degrade due to temperature fluctuations, wave action, and currents, potentially exposing conductors and sheaths made of copper, lead, and other metals.

Subsea energy cables can release heavy metals and hydrocarbons through material degradation and accidental spills

These components can leach heavy metals into sediments, creating long-term environmental risks for benthic ecosystems.[46] Contamination risks are highest for legacy fluid-filled cables, where joints and sheaths can leak dielectric oil into the marine environment as well as for installation or repair activities that may release fuels, lubricants or hydraulic fluids. Modern cross-linked polyethylene (XLPE) submarine cables mitigate oil leakage risks. However, any subsea asset can still contribute to contamination through accidental spills or material degradation.[47]

46. Institute of Applied Ecology (2006) "Impacts of submarine cables on the marine environment: A literature review" https://www.researchgate.net/profile/Ahmad-Al-Khraisat-2/post/How_underwater_data_centers_affect_the_environment_in_general_and_marine_environment_in_Particular/attachment/602c2019af00c40001f72af1/AS%3A991924076949505%401613504537583/download/BfN_Literaturstudie_Effekte_marine_Kabel_2007-02_01.pdf

47. Caimi, S., Colombo, C., Ferrari, R., Storti, G., & Morbidelli, M. (2019). "Recovery of mineral oil from underground electrical cables." International journal of environmental research and public health, 16(13), 2357.

GOOD PRACTICES

Companies can reduce contamination from subsea cables by using durable, non-toxic, and corrosion-resistant materials to limit the leaching of heavy metals. Low-impact installation methods, such as precision trenching, HDD landfalls or careful burial, help minimise seabed disturbance. Regular monitoring through ROV inspections, seabed surveys, and eDNA sampling allows early detection of degradation or leaks. At end-of-life, utilities should prioritise safe retrieval and recycling of cables — or stabilisation in place where removal is infeasible — to prevent future risks. Close collaboration with regulators and scientists ensures compliance with environmental standards and continuous improvement in cable design and management.

Contamination from cables can be reduced through the use of durable materials, low-impact installation and regular monitoring

LOSS OF BIODIVERSITY

Energy transmission systems — especially overhead power lines, substations, and subsea cables — can significantly impact biodiversity and natural habitats. Habitat fragmentation occurs both on land and at sea, as the installation and operation of transmission infrastructure damages ecological connectivity. Overhead lines fragment coastal and marine ecosystems, creating barrier and edge effects that alter species movement, microclimates, and population dynamics.[48] While some seabirds may use pylons for nesting or perching, this behaviour increases the risk of collisions and electrocution — fatal current flow that occurs when birds touch live wires or grounded structures — particularly for large or migratory species. Vegetation clearance during construction — especially beneath transmission corridors — can lead to habitat conversion, creating conditions that favour invasive plant species,

Energy transmission infrastructure can fragment habitats, disrupt species movement, and increase risks of collision and electrocution

48. Taskforce on Nature-related Financial Disclosures (TNFD) (2025). "Additional sector guidance – Electric utilities and power generators". https://tnfd.global/publication/additional-sector-guidance-electric-utilities-and-power-generators/

which may outcompete native flora and disrupt local ecosystems.[49]

These combined pressures contribute to habitat degradation, alter food webs of wildlife, and result in broader biodiversity loss and ecosystem disruption.

GOOD PRACTICES

During the design phase, safe distribution lines with insulated conductors and appropriate spacing can help prevent electrocution of birds.[50] To address habitat disruption, planners should minimise vegetation clearance and avoid habitat conversion wherever possible. Furthermore, the end of life of energy infrastructure and transmission and distribution lines should be considered, with emphasis on recyclability to minimise new resource exploitation.[51]

Designing insulated lines and minimising vegetation clearance can reduce impact on marine wildlife

SEAFLOOR INTEGRITY

Activities associated with the energy utility sector, such as constructing subsea power cables and oil and gas pipelines, can significantly disturb the seafloor. During installation, dredging, drilling, or laying heavy structures damages sediments and affects benthic organisms, including sensitive habitats like coral reefs, seagrass beds, and sponge gardens.[52] This physical alteration may reduce biodiversity, displace benthic fauna, and alter sediment dynamics, potentially causing erosion or habitat loss.

Installation, dredging and drilling subsea cable construction have the potential to disrupt sediments and benthic habitats

GOOD PRACTICES

Minimising seafloor impacts can be achieved through careful site selection using marine spatial planning and environmental

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49. Biasotto, L. D., & Kindel, A. (2018b). Power lines and impacts on biodiversity: A systematic review. Environmental Impact Assessment Review, 71, 110–119. https://doi.org/10.1016/j.eiar.2018.04.010

50. Taskforce on Nature-related Financial Disclosures (TNFD) (2025). "Additional sector guidance – Electric utilities and power generators". https://tnfd.global/publication/additional-sector-guidance-electric-utilities-and-power-generators/

51. Ibidem

52. Institute of Applied Ecology (2006) "Impacts of submarine cables on the marine environment: A literature review" https://www.researchgate.net/profile/Ahmad-Al-Khraisat-2/post/How_underwater_data_centers_affect_the_environment_in_general_and_marine_environment_in_Particular/attachment/602c2019af00c40001f72af1/AS%3A991924076949505%401613504537583/download/BfN_Literaturstudie_Effekte_marine_Kabel_2007-02_01.pdf assessments, along with detailed pre-installation surveys. This information helps in designing installation methods that minimise disturbance to sensitive areas.[53] The use of less invasive installation techniques—such as horizontal directional drilling (HDD) for subsea cables or floating platforms for offshore energy — can reduce direct disturbance to the seabed. Moreover, routeing offshore can steer infrastructure clear of coral, seagrass beds, and other ecologically sensitive areas.

Pressures on the seafloor can be reduced through careful site selection, pre-installation surveys, and routing infrastructure away from sensitive habitats

MARINE LITTER

Energy utilities, particularly offshore transmission and distribution infrastructure such as oil rigs, subsea cables, and associated platforms, can contribute to the issue of marine litter. Materials such as plastic sheathing, insulation fragments, cable coatings, packaging waste, and construction debris may be lost during installation, maintenance, or decommissioning related to distribution and transmission grids and enter the marine environment. Over time, mechanical abrasion, UV exposure, and saltwater corrosion can cause protective cable coverings and polymer-based components to degrade, shedding microplastics and synthetic fibres into the water column and sediments. Lost or discarded materials from repair works — such as cable ties, protective mats, and plastic wrapping — further add to persistent marine litter. Unlike natural debris, these materials do not biodegrade, posing long-term risks by entangling marine life, smothering benthic habitats, and introducing microplastics into food webs. In addition, abandoned or improperly removed subsea cables and infrastructure left on the seafloor may continue to fragment and release pollutants for decades, intensifying the challenge of marine litter management.

Energy utilities have the potential to impact the marine environment due to the introduction of degraded materials, construction debris, and abandoned equipment

53. One Ocean Foundation (2024) "Ocean Impact Initiative: Offshore wind energy industry review" https://www.1ocean.org/news/offshore-wind-energy-industry-and-its-impact-on-the-ocean-analysis-and-solutions

GOOD PRACTICES

Companies can adopt strict waste management protocols during construction, operation, and decommissioning phases. This includes responsible handling of packaging, insulation, and protective materials, as well as tracking and retrieval systems for tools and materials that could be lost at sea. Rigorous materials accounting and retrieval plans during construction and maintenance further help ensure that items such as ties, mats, and packaging do not persist as marine litter. Designing infrastructure with recyclable components and planning for end-of-life recovery reduces the long-term risk of marine litter.

Adoption of strict waste management protocols and tracking and retrieval systems for lost tools and materials can minimise the impact

INTRODUCTION OF ENERGY

Utility infrastructure can generate significant noise disturbances. Transmission lines and submarine power cables emit electromagnetic fields (EMFs) due to electrical currents, which may disturb wildlife [54], particularly magneto-sensitive species such as sharks, rays and eels. Evidence from field and laboratory studies shows species- and life-stage-specific responses, but population-level effects remain uncertain.[55] Continuous exposure to an electromagnetic field (EMF) might generate behavioural changes and impact the reproductive success and the individual survival, in addition to other "silent" disturbances in the biochemical processes.

While operational noise from subsea cables is comparatively minor, noise pollution arises from onshore energy infrastructure, such as cable vibrations and corona discharges (the release of sound and electromagnetic energy caused by ionisation of air around high-voltage equipment), which can disturb wildlife.[56]

Disturbance to wildlife can be caused by electromagnetic fields from transmission lines, operational noise from cable vibrations, and construction activities

54. Biasotto, L. D., & Kindel, A. (2018b). "Power lines and impacts on biodiversity: A systematic review". Environmental Impact Assessment Review, 71, 110–119. https://doi.org/10.1016/j.eiar.2018.04.010

55. Gill, A. B., Huang, Y., Gloyne-Philips, I., Metcalfe, J., Quayle, V., Spencer, J. & Wearmouth, V. (2009). "COWRIE 2.0 Electromagnetic Fields (EMF) Phase 2: EMF-sensitive fish response to EM emissions from sub-sea electricity cables of the type used by the offshore renewable energy industry. Report to Collaborative Offshore Wind Research into the Environment" (COWRIE) COWRIE.

56. Biasotto, L. D., & Kindel, A. (2018b). "Power lines and impacts on biodiversity: A systematic review". Environmental Impact Assessment Review, 71, 110–119. https://doi.org/10.1016/j.eiar.2018.04.010

Noise impacts are most significant during construction activities such as trenching, dredging, rock placement, and vessel operations, which can disturb benthic organisms and marine mammals that rely on sound for orientation and echolocation.

GOOD PRACTICES

The use of low-noise design in transformers, substations, and overhead lines, along with the careful siting of infrastructure away from sensitive ecosystems and residential areas, can reduce acoustic disturbance.[57] Cable burial, shielding, insulating and routing away from ecologically sensitive areas can limit EMF exposure. Regular maintenance reduces unnecessary vibration and hum, while careful siting of infrastructure ensures distance from sensitive ecosystems.

The pressures can be mitigated through low-noise equipment, careful siting and regular maintenance to limit vibrations and hum

GHG EMISSIONS AND AIR POLLUTION

Although most GHG emissions in the energy sector originate from power generation, the transmission and distribution (T&D) segment also contributes to climate and air pollution. GHG emissions from transmission and distribution systems arise primarily from energy losses in the grid, known as line losses, and from the leakage of sulphur hexafluoride (SF_6)[58] — a synthetic gas used as an electrical insulator in high-voltage equipment such as circuit breakers and transformers. In addition to GHGs, non-GHG emissions are linked to the construction phase of transmission and distribution infrastructure. Activities such as land clearing, road building, and equipment transport can generate airborne particulate matter and dust, while mobile sources (e.g., construction vehicles and generators) emit NO_x, CO, and other pollutants, contributing to localised air quality impacts.[59]

The sector generates airborne particulate matter and emits NO_x, CO, and other pollutants, impacting local air quality

57. Sound Fighter Systems. "Addressing Noise Pollution in the Utilities Sector: Transformer Noise Reduction Solutions". https://www.soundfighter.com/applications/transformer-noise-reduction/

58. Taskforce on Nature-related Financial Disclosures (TNFD) (2025). "Additional sector guidance – Electric utilities and power generators". https://tnfd.global/publication/additional-sector-guidance-electric-utilities-and-power-generators/

59. Biasotto, L. D., & Kindel, A. (2018). Power lines and impacts on biodiversity: A systematic review. Environmental Impact Assessment Review, 71, 110–119. https://doi.org/10.1016/j.eiar.2018.04.010

GOOD PRACTICES

To reduce GHG emissions, energy utilities must focus on minimising power losses and improving efficiency across transmission and distribution systems.[60] Traditional infrastructure often results in significant electricity losses, especially over long distances.

Upgrading to advanced technologies, such as high-voltage direct current (HVDC) lines, can significantly reduce these losses and enable the efficient transfer of renewable energy from remote generation sites to urban centres.[61]

Emissions could be reduced by using advanced technologies and optimising power flow through smart grids and real-time monitoring

Additionally, smart grid systems and real-time monitoring technologies are transforming energy distribution.[62] These tools enhance grid visibility, enable proactive maintenance, and optimise power flow, all of which help reduce unnecessary energy generation and associated emissions.

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60. Janicke, L., Nock, D., Surana, K., & Jordaan, S. M. (2023). Air pollution co-benefits from strengthening electric transmission and distribution systems. Energy, 269, 126735. https://doi.org/10.1016/j.energy.2023.126735

61. Ibidem

62. Mahmood, M., Chowdhury, P., Yeassin, R., Hasan, M., Ahmad, T., & Chowdhury, N. (2024). Impacts of digitalization on smart grids, renewable energy, and demand response: An updated review of current applications. Energy Conversion and Management X, 24, 100790. https://doi.org/10.1016/j.ecmx.2024.100790

Waste utilities

CONTAMINANTS

Contamination from waste utilities mainly comes from leachate from landfills, especially those lacking proper liners that release heavy metals such as lead, chromium, and cadmium into groundwater and surface waters, which may ultimately reach marine environments.[63] For example, elevated concentrations of copper, zinc, and arsenic have been observed in coastal sediments downstream from landfill sites, indicating hydrological spread of toxins. More recently, landfill leachate has been recognised as a reservoir of microplastics and persistent chemicals such as per- and polyfluoroalkyl substances (PFAS), which may be tankered to WWTPs, where partial removal occurs at best, creating downstream loads to rivers, coasts, and agricultural soils via biosolids.[64] In addition, improper disposal and open burning practices of waste generate persistent organic pollutants (POPs), dioxins, and heavy metals that enter the atmosphere and eventually deposit in marine environments through rainfall.

Contamination can arise from landfill leachate, releasing heavy metals, microplastics, and PFAS into water systems

GOOD PRACTICES

Companies can reduce contamination by upgrading landfills with liners, leachate collection, and treatment systems to prevent

63. Alharbi, T., El-Sorogy, A. S., Rikan, N., & Algarni, H. M. (2025). Impact of Landfill Sites on Coastal Contamination Using GIS and Multivariate Analysis: A Case from Al-Qunfudhah in Western Saudi Arabia. Minerals, 15(8), 802. https://doi.org/10.3390/min15080802

64. Kabir, M. S., Wang, H., Luster-Teasley, S., Zhang, L., & Zhao, R. (2023). "Microplastics in landfill leachate: Sources, detection, occurrence, and removal". Environmental Science and Ecotechnology, 16, 100256 heavy metal pollution in groundwater and coastal waters.[65] Proper segregation and treatment of hazardous and electronic waste can further prevent toxic leachates, while circular economy measures like recycling and composting lower landfill dependence and pollutant emissions.[66] Moreover, advanced leachate treatment technologies (e.g. activated carbon adsorption, nanofiltration, and advanced oxidation) can also help capture PFAS and microplastics before discharge, closing one of the critical leakage pathways.

Upgrading landfills with liners and leachate treatment, managing hazardous waste, and applying advanced treatment technologies can reduce pollution

EUTROPHICATION

Eutrophication arises mainly from nutrient-rich leachate and runoff originating from landfills, dumpsites, and poorly managed waste treatment facilities. Leachate often contains high levels of nitrogen and phosphorus, which, if inadequately collected or treated, can infiltrate soils, groundwater, and surface waters, eventually reaching rivers and coastal ecosystems. Once in aquatic environments, these nutrients stimulate harmful algal blooms, deplete oxygen levels, and create hypoxic "dead zones". In addition, waste incineration and open burning release nutrient-bearing particulates and reactive nitrogen compounds into the atmosphere, which later deposit into marine and freshwater systems via rainfall, compounding nutrient loading. Collectively, these waste-related nutrient inputs disrupt ecological balance, degrade water quality, and pose risks to biodiversity and human health through contaminated fisheries and drinking water sources.

Eutrophication can arise mainly from nutrient-rich leachate and runoff originating from landfills, dumpsites, and poorly managed waste treatment facilities

GOOD PRACTICES

Companies can focus on preventing nutrient-rich leachate and runoff from reaching water bodies. Modern landfills should be equipped with impermeable liners, leachate collection systems,

65. Renou, S., Givaudan, J., Poulain, S., Dirassouyan, F., & Moulin, P. (2007). Landfill leachate treatment: Review and opportunity. Journal of Hazardous Materials, 150(3), 468–493. https://doi.org/10.1016/j.jhazmat.2007.09.077

66. Song, Q., Li, J., & Zeng, X. (2014b). Minimizing the increasing solid waste through zero waste strategy. Journal of Cleaner Production, 104, 199–210. https://doi.org/10.1016/j.jclepro.2014.08.027

and on-site treatment plants to remove nitrogen and phosphorus before discharge. Green infrastructure that works as nature-based "polishing" mechanisms, such as constructed wetlands, biochar filters, and vegetated buffer strips, can further capture and filter nutrients from runoff, enhancing nutrient removal and reducing transport into rivers and coastal areas.[67] Incineration facilities must be fitted with advanced air pollution control systems (e.g., selective catalytic reduction and electrostatic precipitators) to limit nitrogen oxide emissions and nutrient-bearing particulates.

LOSS OF BIODIVERSITY

Waste utilities contribute to biodiversity loss mainly through pollution and habitat disturbance. Improperly managed landfills and waste transfer stations near coastal zones increase the likelihood of plastics, hazardous chemicals, and other solid waste entering the ocean. These substances degrade water quality, alter food webs, and can be toxic to marine organisms. Waste utilities activities have the potential to reduce species diversity, damage sensitive habitats such as coral reefs and seagrass beds, and threaten ecosystem services — such as fisheries and natural water purification — that both marine life and human communities depend on.

The sector has the potential to reduce species diversity and damage sensitive habitats through pollution and habitat disturbance

Additionally, odours from waste handling can further damage local ecosystems, affecting both humans and wildlife by causing disturbances, altering habitat function and leading to long-term ecological and social consequences.

GOOD PRACTICES

To mitigate the impact on biodiversity, companies can enhance landfill design by incorporating impermeable liners,

67. Yang, R., & Yang, Q. (2024). "A review of emerged constructed wetlands based on biochar filler: Wastewater purification and carbon sequestration/greenhouse gas reduction." Environmental Engineering Research, 29(2).

leachate collection systems, and implementing regular monitoring to prevent contaminants from entering coastal waters. Expanding recycling and composting programs reduces the volume of waste sent to landfills, while safe handling and treatment of hazardous and electronic waste prevent the release of toxic chemicals. Coastal waste facilities could establish buffer zones with vegetation to trap runoff and reduce debris entering marine systems.

Impacts on biodiversity can be mitigated through improved landfill design, waste management, and vegetated coastal buffer zones

MARINE LITTER

Waste utilities are among the largest contributors to marine litter. Poorly managed land-based waste, especially from landfills or transfer stations near waterways, can be blown or washed into the sea. Insufficiently contained coastal landfills and transfer stations are particularly high-leakage nodes during storms, when floodwaters mobilise large amounts of plastics and debris into marine environments. Lightweight plastics, packaging materials, and chemical containers are particularly vulnerable to becoming marine debris. Illegal dumping and inadequate solid waste infrastructure in some regions exacerbate the issue. Additionally, when solid waste such as sewage sludge or animal manure is not properly treated, it can reduce oxygen levels in water, harming aquatic ecosystems and affecting essential ecosystem services like natural water purification.[68] Microplastics represent another growing threat. Landfill leachate increasingly serves as a reservoir for microplastics — especially from polyethylene, polypropylene, and polystyrene — which persist in environments and pose risks to aquatic and marine organisms.[69]

Waste utilities are among the largest contributors to marine litter from poorly managed land-based waste

GOOD PRACTICES

Companies can mitigate the issues of accumulation of marine

68. Taskforce on Nature-related Financial Disclosure (TNFD) (2025). "Additional sector guidance – Water utilities and services". https://tnfd.global/publication/additional-sector-guidance-water-utilities-and-services/

69. Kabir, M. S., Wang, H., Luster-Teasley, S., Zhang, L., & Zhao, R. (2023). Microplastics in landfill leachate: Sources, detection, occurrence, and removal. Environmental Science and Ecotechnology, 16, 100256. https://doi.org/10.1016/j.ese.2023.100256 litter through improved collection, sorting, and recycling systems, especially in coastal and urban areas. Expanding waste collection, promoting a circular economy, where products are designed for reuse and recyclability, and implementing Extended Producer Responsibility (EPR) policies can reduce plastic production and improve end-of-life product management. Investing in advanced plastic treatment technologies — such as chemical recycling or pyrolysis — converts non-recyclable waste into usable resources. Solid waste biorefinery approaches can also recover energy and create value-added products like compost, biofuels, and chemical feedstocks.[70]

Advanced plastic treatment and biorefinery technologies convert waste into usable resources and value-added products like energy, compost, and biofuels

GHG EMISSIONS AND AIR POLLUTION

Waste utility operations are one of the main sources of methane emissions, primarily generated during the anaerobic decomposition of organic waste in landfills. Globally, solid waste in landfills has become the third-largest anthropogenic source of methane.[71] In addition, the uncontrolled burning of waste releases carbon dioxide (CO_2) and black carbon, further intensifying climate change and contributing to air pollution.[72]

Waste utilities contribute ~4% of global GHG emissions, driven by methane released from landfill decomposition and CO_2 from waste burning

GOOD PRACTICES

Reducing methane emissions from the waste utilities begins with landfill diversion, ensuring that each type of waste is directed to the most suitable treatment option based on the waste hierarchy. For non-recyclable waste, two main alternatives exist: landfilling or energy recovery.[73] Prioritising waste-to-energy (WTE) solutions offers multiple benefits, including the prevention of methane emissions from anaerobic decomposition in landfills, recovery of both energy and materials, significant reduction in waste volume, land conservation, and improved sanitation.

Emissions can be reduced by prioritising waste-to-energy solutions

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70. International Water Association (2016). "Water Utility Pathways in a Circular Economy". https://iwa-network.org/wp-content/uploads/2016/07/IWA_Circular_Economy_screen.pdf

71. Tong, H., Cheng, T., Li, X., Zhu, H., Ye, X., Fan, D., & Tang, T. (2025). Reduction of methane emissions through improved landfill management. Nature Climate Change. https://doi.org/10.1038/s41558-025-02391-1

72. De La Barrera, B., & Hooda, P. S. (2016). Greenhouse gas emissions of waste management processes and options: A case study. Waste Management & Research the Journal for a Sustainable Circular Economy, 34(7), 658–665. https://doi.org/10.1177/0734242×16649680

73. European Suppliers of Waste to Energy Technology (ESWET). https://commission.europa.eu/document/download/0cea0671-32ef-4e9e-b8f1-0a8e50c027b0_en?filename=speaker_intervention_-_eswet.pdf

In-depth: advanced technologies and innovations in wastewater treatment

Wastewater, originating from domestic, industrial, agricultural, and runoff sources, consists primarily of water (≈99.9%) with small amounts of solids and pollutants.[74] If not properly treated, it poses serious risks to ecosystems, biodiversity, and public health. Conventional wastewater treatment follows four main stages:

- *preliminary treatment*, where large debris and grit are screened out to protect downstream equipment;

- *primary treatment*, which uses sedimentation and flotation to remove suspended solids and organic matter and reduce turbidity;

- *secondary treatment*, where biological processes such as activated sludge, trickling filters, or sequencing batch reactors employ microbes to break down organic matter;

- *tertiary treatment*, which applies advanced disinfection and filtration techniques, including chlorination, ozonation, and UV irradiation, to eliminate pathogens and further improve water quality.

While traditional wastewater treatment methods are effective at removing certain contaminants, they often face challenges related to energy consumption, sludge production, and the treatment of new pollutants.[75]

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74. S. Sharma, R. Bangotra, B. Habib, M. Chib, A. Thakur, R. Mahajan, et al., (2024). "Wastewater-Derived Biomass for Energy."Sewage and Biomass from Wastewater to Energy, pp. 195–224. https://doi.org/10.1002/9781394204502.ch8

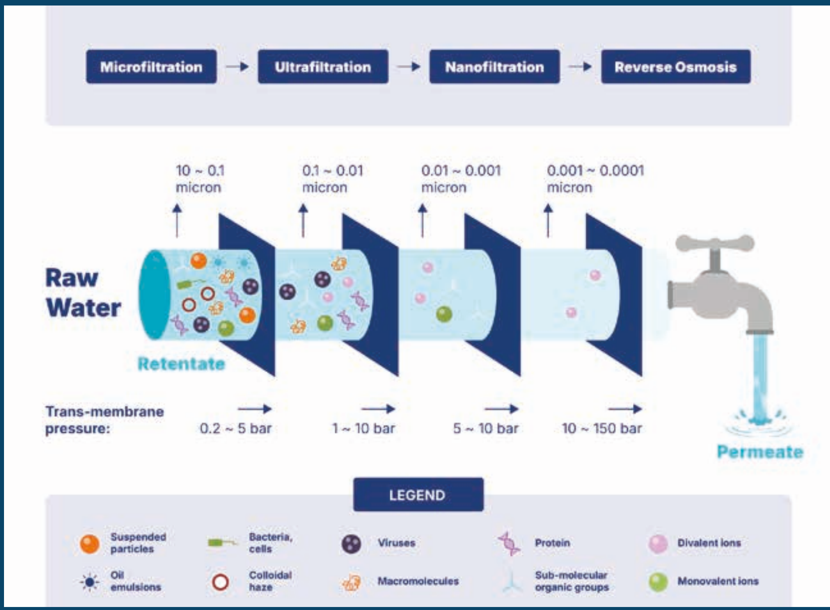
75. Saravanan, A., Kumar, P. S., Jeevanantham, S., Karishma, S., Tajsabreen, B., Yaashikaa, P., & Reshma, B. (2021). "Effective water/wastewater treatment methodologies for toxic pollutants removal: Processes and applications towards sustainable development." Chemosphere, 280, 130595. https://doi.org/10.1016/j.chemosphere.2021.130595

To overcome these limitations, water utilities start to adopt advanced technologies:

Membrane-based systems such as microfiltration(MF) (removal of larger particles such as suspended solids and bacteria), ultrafiltration (UF) (smaller particles including proteins and colloids) (see Figure 2), nanofiltration (NF) (removal of divalent ions and small organic molecules), reverse osmosis (RO) (can eliminate nearly all contaminants, including monovalent ions and small molecules), and membrane bioreactors (MBRs) (combine biological treatment with membrane filtration to produce high-quality effluent). These technologies provide superior pollutant removal efficiency, capturing pathogens, fine particulates, and even dissolved contaminants. Their ability to deliver high-quality effluent makes them particularly valuable for water reuse and recycling, supporting irrigation and industrial processes.

Biological treatment methods that use microorganisms to remove pollutants are another solution for the transformation of wastewater management. Enhanced microorganisms, including genetically engineered or naturally optimised strains, can degrade refractory pollutants such as pharmaceuticals, dyes, or endocrine-disrupting chemicals. Constructed wetlands mimic natural purification processes by using plants, microbes, and sediments to remove nutrients, while algal-bacterial systems simultaneously clean wastewater and produce biomass that can be used for biofuels or fertilisers. Anaerobic treatment technologies, such as up-flow anaerobic sludge blanket (UASB) reactors, not only reduce organic loads but also generate biogas as a renewable energy source. This aligns wastewater treatment with the principles of the circular economy by converting waste into a resource.

Figure 2: Membrane filtration process



Source: Aziz, S., Mazhar, A. R., Ubaid, A., Shah, S. M. H., Riaz, Y., Talha, T., & Jung, D. (2024). A comprehensive review of membrane-based water filtration techniques. Applied Water Science, 14(8). https://doi.org/10.1007/s13201-024-02226-y

Beyond biological processes, **advanced oxidation processes (AOPs)** — including ozonation, photocatalysis, UV disinfection and electrochemical oxidation — offer powerful solutions for breaking down persistent organic pollutants, pharmaceuticals, and industrial chemicals that cannot be removed by conventional means.

At the systems level, **smart monitoring technologies** are revolutionising wastewater management. Tools like real-time sensors, environmental DNA (eDNA), and remote sensing allow utilities to detect pollutants, track microbial populations, and identify early contamination events. This facilitates faster responses, predictive maintenance, and optimised treatment operations. In summary, wastewater utilities are transitioning from linear "treatment and disposal" models to circular systems that recover water, energy, and resources. By adopting membrane filtration, biological innovations, advanced oxidation, and digital monitoring, utilities can better safeguard ecosystems, support water reuse, and contribute to climate adaptation strategies.

The importance of disclosing business pressures on the ocean

This industry-specific edition of the Ocean Impact Initiative tool, dedicated to the utilities industry, developed by One Ocean Foundation in collaboration with its partners, reflects the main pressures exerted by the sector. The objective is to support companies in becoming aware of their potential impacts on marine ecosystems, assessing the related risks, and disclosing key information and strategic responses to the significant issues related to offshore wind energy production.

As identified in our research and reflected in the industry-specific tool, these pressures include i) contaminants (including contaminants in seafood); ii) eutrophication; iii) biodiversity loss (including alteration of food webs and disruption of commercial fish and shellfish); iv) damage to seafloor integrity; v) introduction of marine litter; vi) introduction of energy.

The importance of the Ocean Impact Initiative lies in the fact that, for the first time, companies, scientific and financial communities, and civil society can rely on a common language to measure, address, and mitigate the most significant pressures that humanity exerts on the marine environment, industry by industry, with considerable benefits for the health of the ocean.

Appendix

Table 1: Overview of environmental pressures exerted by the utilities sector on the marine environment, grouped by type of utility, value chain stage and relevant GES descriptors

C: Construction | **O:** Operation | **D:** Decommissioning

PRESSURE	Water Utilities *(supply, wastewater, desalination)*	Energy Utilities *(electric T&D, gas, steam)*	Waste Utilities *(landfills, solid waste, sewage treatment)*
Contaminants (chemicals, metals, micro-pollutants) *D8 (Contaminants)* *D9 (Contaminants in seafood)* *D1 (Biodiversity)*	**C:** Pipe/outfall installation spills. **O:** WWTP effluent carries residual nutrients, pathogens, metals (Hg, Pb, Cd, As), pharmaceuticals, PFAS, and microplastics; AMR bacteria/genes are increasingly observed. Desalination adds chlorine, antifouling agents, and brine salinity. **D:** Risk of leaks from old pipes/infrastructure.	**C:** Installation/repair spills (fuels, lubricants, hydraulics). **O:** Legacy fluid-filled cables may leak dielectric oil; modern XLPE cables mitigate oil risks. Localised inputs from anodes/ cathodic protection; minor material degradation possible. **D:** Improperly removed cables/pipelines leave residues.	**C:** Poorly lined landfills leach heavy metals (Pb, Cr, Cd) and POPs into water. **O:** Leachate now recognised as reservoir for PFAS & microplastics; leachate sometimes trucked to WWTPs, partially removed, then passed to rivers/sea. **D:** Legacy dumpsites continue to leach.
Eutrophication (nutrient & organic enrichment) *D5 (Eutrophication)* *D1 (Biodiversity)* *D4 (Food webs)*	**C:** Sewer bypasses/ overflows during construction works. **O:** Residual N/ P from WWTP effluent; CSOs during storms; agricultural runoff routed via sewers; algal blooms create hypoxia (oxygen depletion). **D:** Sludge disposal mishandling.	Low pressure.	**C:** Landfill construction runoff with high N/P. **O:** Nutrient-rich leachate drives HABs, hypoxia. Atmospheric deposition from incineration NO_x adds reactive N. **D:** Legacy landfill seepage.

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PRESSURE	**Water Utilities** *(supply, wastewater, desalination)*	**Energy Utilities** *(electric T&D, gas, steam)*	**Waste Utilities** *(landfills, solid waste, sewage treatment)*
Loss of biodiversity/ habitat degradation *D1 (Biodiversity)* *D2 (Non-indigenous species)* *D4 (Food webs)* *D5 (Eutrophication)* *D6 (Seafloor integrity)* *D7 (Hydrographical conditions)* *D8 (Contaminants)* *D9 (Contaminants in seafood)* *D10 (Marine litter)* *D11 (Introduction of energy)*	**C:** Construction of WWTPs/desalination plants fragments; coastal habitats loss **O:** Entrainment/ impingement from desalination intake; dense brine plumes alter salinity/ stratification, affecting seagrasses/corals.	**C:** Land clearing for substations/T&D corridors fragments terrestrial – coastal habitats. **O:** Subsea cable pipeline landfalls disrupt benthos. Bird collisions/ electrocution by overhead lines. **D:** Poor decommissioning leaves the habitat altered.	**C/O:** Leachate and debris reduce water quality; habitat loss from near-coast dumps/ transfer stations. **O:** Odours and debris affect local wildlife; invasive species may colonise disturbed zones.
Seafloor integrity *D6 (Seafloor integrity)* *D1 (Biodiversity)*	**C:** Trenching/HDD for intakes, outfalls, desalination brine pipes disturb the seabed, smothers habitats. **O:** Sediment plumes from outfalls affect seagrasses/corals. **D:** Pipe removal re-suspends sediments.	**C:** Subsea cable/pipeline trenching, rock placement, anchors disrupt seafloor, affecting benthos. **O:** Maintenance dredging/ rock replacement. **D:** Recovery/removal causes further disturbance.	**C:** Outfall/ diffuser construction from treatment sites. **O:** Sediment/nutrient smothering from discharges near outfalls. **D:** Removal of old outfalls.
Marine litter & microplastics *D10 (Marine litter)* *D1 (Biodiversity)*	**C:** Construction debris (pipes, packaging). **O:** WWTPs release microplastics/ microfibres; CSOs discharge sanitary items.	**C/O:** Insulation fragments, packaging waste, protective mats/ markers lost during installation or O&M; polymer sheaths degrade into microplastics.	**C:** Windblown waste from landfills/ transfer stations. Storm-driven leakage from dumpsites.

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PRESSURE	**Water Utilities** *(supply, wastewater, desalination)*	**Energy Utilities** *(electric T&D, gas, steam)*	**Waste Utilities** *(landfills, solid waste, sewage treatment)*
Marine litter & microplastics *D10 (Marine litter)* *D1 (Biodiversity)*	**D:** Pipe replacement waste.	**D:** Abandoned subsea cables fragment.	**O:** Microplastics in leachate; illegal dumping; poor containment in coastal transfer stations. **D:** Legacy plastics persist for decades.
Introduction of energy *D11 (Introduction of energy)* *D1 (Biodiversity)*			
Underwater noise & vibration	**C:** HDD, trenching, dredging, vessel activity. **O:** WWTP pumps/ blowers produce mostly airborne noise; negligible underwater. **D:** Noisy decommissioning works.	**C:** Cable laying, dredging, rock placement, and construction vessels are the main underwater sources. **O:** Minor operational hum/ vibration; on-shore corona discharge/ vibration can disturb terrestrial receptors. **D:** Decommissioning noisy.	**C:** Outfall construction dredging/ HDD. **O:** O&M vessels. **D:** Removal of infrastructure.
Electromagnetic fields (EMF)	Low pressure.	**O:** Submarine power cables (AC/HVDC) generate EMFs affecting magneto-sensitive species (sharks, eels).	Low pressure

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PRESSURE	Water Utilities *(supply, wastewater, desalination)*	Energy Utilities *(electric T&D, gas, steam)*	Waste Utilities *(landfills, solid waste, sewage treatment)*
		HVDC fields steady; mitigable by burial/ shielding. Cathodic protection adds localised EMFs.	
Light pollution	**C/O/D:** Night light at pumping stations, WWTP/ desalination plants.	**C/O/D:** Coastal substations, compressor stations, offshore construction lighting.	**C/O/D:** Landfill and waste stations near coasts contribute light disturbance.
GHG & non-GHG emissions *Cross-cutting*	**O:** Water/wastewater utilities are energy-intensive, accounting for ~50% untreated wastewater globally. CH_4 from anaerobic digestion; N_2O from nutrient removal. Wastewater contributes ~3–7% of global anthropogenic N_2O and ~5–7% of CH_4. Non-GHG air pollutants (PM, SO_2, NO_x, VOCs, metals) affect air quality and deposition.	**O:** T&D losses create indirect CO_2 **D:** Construction dust, NO_x, SO_2, PM from works.	**O:** Waste sector ~4% global GHG. Open burning waste emits CO_2, black carbon, and VOCs.
Hydrographical changes *D7 (Hydrographical conditions) D1 (Biodiversity) D6 (Seafloor integrity)*	**O:** Desalination brine plumes increase local salinity/density; intake/ outfall hydraulics change currents.	**O:** Thermal discharges from steam networks alter temperature. Landfalls modify shoreline hydrodynamics. Large foundations/ cable protection can alter local sediment transport.	**O:** Large WWTP outfalls alter small-scale circulation and mixing.

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