

## **Navigating Growth: Unveiling the Economic Prospects of Maritime Sectors and Port Operations on Marine Environmental Dynamics**

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### **Abstract**

Innovation within the maritime sectors is positioned as a catalyst for driving economic growth throughout the European Union. By fostering innovation, the maritime economy can not only fuel economic development but also create a multitude of employment prospects across EU nations. The thrust of innovation-led development is to ensure not just economic growth but also the sustainable management of commercial marine resources. Simultaneously, it aims to shield the marine environment from potential adverse effects through prudent and innovative practices. Eco-innovation takes center stage as a critical approach to devising cost-effective measures to safeguard and preserve the marine environment. These measures align with the objectives outlined in the Marine Strategy Framework Directive, with the overarching goal of unlocking the economic potential of Europe's maritime sectors. The communication underscores the imperative of dedicating increased attention to research concerning ports as significant economic actors. This involves delving into the economic impact of ports on overall economic development and optimizing their operations for heightened efficiency. The communication strongly advocates for fortifying the relationship between port operations and the paradigm of blue growth. The communication proposes a thorough evaluation of existing mechanisms aimed at managing the marine environment. This evaluation seeks to gauge the implementation and efficacy of these mechanisms while comprehending their interconnectedness with port activities. Encouraging the development of transport solutions that are ecologically responsible is highlighted as a crucial contribution to the marine economy. These solutions are perceived as invaluable in preserving marine habitats, fostering biodiversity, and supporting sustainable growth within the maritime sector. The aim of this article is to shed light on the significant environmental impact posed by port operations, focusing on emissions, noise, water and ground pollution, and habitat fragmentation. The article emphasizes the challenges faced by ports situated in close proximity to densely populated urban areas, where the need to balance port activities with the protection of both the natural ecosystem and the urban environment is paramount. In summary, the communication from the European Commission underscores the immense potential of innovation in driving economic growth and sustainability within the maritime sectors. It underscores responsible development that conserves marine resources, safeguards the marine environment, and advances the concept of blue growth.

**KEY WORDS:** *blue growth, marine environment, green ports, blue economy*

### **1. Introduction**

Environmentally friendly transport systems with a low carbon footprint (also with low noise level) should be developed and advanced globally, including inland waterways and sea transport, port and multimodal connections to promote sustainable international and regional mobility, and also cross-border mobility. Better infrastructure and improved services are important for boosting the local economy and raising the quality of life, turning the sea into a unified space with good conditions not only for sailing and cargo shipment but also yacht tourism and travelling options by sea. European countries have ratified the United Nations General Convention on Climate Change [21]. This requires them to implement activities (use of renewable resources, reduction of consumption, use of energy efficient technologies, reduction of emissions and others) to reduce the concentration of greenhouse gases in the atmosphere. The majority of emissions in the greenhouse gas emission balance is generated by the transport sector and thermal energy production but the remaining part - fuel consumption in various sectors of the national economy and power consumption. Regarding power production, changes in climate mostly impact power production from fossil fuels (natural gases, oil products and others). In the energy production process greenhouse gases causing climate change are released.

The transport sector is the most important source of NO<sub>x</sub> and SO<sub>x</sub> emissions in the EU, one of the largest sources of greenhouse gas emissions; a large amount of emissions in the entire transport industry are also generated by shipping and port management [9]. The transport sector is one of the main sources of soil pollution (oil, oil products, heavy metals). Elimination of SEG emissions in the transport sector can be achieved implementing the latest technologies.

Global scale problems are at the higher level of regional and European Union level environmental problems. Most focus is directed towards the reduction of CO<sub>2</sub> emissions and climate change that is a common goal on a global scale. Still there are other areas that do not attract so much attention and financing, for example, biodiversity issues, as well as the protection of unique arctic, northern and other eco systems, habitat etc.

The updated EU Sustainable Development Strategy [10, 11] that is based on the declaration approved on June 2005 by the European Council, stipulates a general aim to determine and develop activities that are helping the EU to achieve constant improvement of quality of life both for the current and future generations, creating sustainable

communities able to manage and use resources efficiency and completely utilise the potential of ecological and social novelties in the national economy, securing wellbeing, environmental protection and social cohesion. One of the main strategy goals are related to environmental protection: “Maintain the ability of the Earth to provide life in all its variety, considering that the Earth’s resources are limited and provide high level environmental protection, as well as improve environmental quality. Reduce and prevent environmental pollution promoting sustainable consumption and manufacturing to eliminate a link between economic growth and environmental degradation.”

## 2. Materials and Methods

Theoretical and methodological basis of the study. Research on the economic development potential of the maritime sectors reveals that the literature has taken two main approaches: 1) scenario analysis to assess the policy options for climate change control [3, 13, 20], and 2) comparison study on different technologies based on (e.g., Palmer et al., 2018, Ruffini and Wei, 2018, Santos and Rembalski, 2021, Thiel et al., 2010). Author were used in the study, as well as information available on the Internet and in the international scientific databases.

## 3. Results and Discussion

Port operations have a significant impact due to emissions, noise, water and ground pollution and fragmentation of habitats. Ports located close to densely populated city territories frequently need to balance port operations with protection of the natural ecosystem, habitats and quality of the city environment. All activities with cargo and ships taking place in the ports are potential sources of pollution significantly impacting not only ports but also adjacent city territories. They influence various environment risks, for example, air quality (odours), noise level, water quality and habitats. These environmental components are mostly affected by port operations generating pollution, and they demand assessment and reduction to provide the sustainable development of ports, especially their harmful impact on the environment should be reduced when developing new services of ports.

While the Kyoto Protocol (adopted in 1997 and entering into force in 2005) introduced legally binding emissions targets, aviation and shipping were not included [8]. Researchers have in recent years analyzed and quantified the emissions from the maritime sector, which may form a potential baseline for future targets. While the primary focus of this article is on the port perspective, attention to emissions in the maritime sector has focused for the most part on the output of vessels while at sea. The provided delves into the critical issue of emissions from the maritime sector, highlighting their categorization into greenhouse gas (GHG) emissions impacting climate change and local air pollution, primarily sulfur oxides (SO<sub>x</sub>), nitrogen oxides (NO<sub>x</sub>), and particulate matter (PM). The data underscores the significant contribution of shipping to global GHG emissions, surpassing the levels produced by air travel during the period of 2007-2012. Furthermore, it emphasizes the disproportionate impact of local pollutants in coastal areas, underlining their adverse effects on human health. The World Health Organization's assessment of air pollution as a substantial environmental risk to health, resulting in a staggering three million deaths annually, adds weight to the urgency of addressing this issue. Shipping is recognized as a major contributor to this risk, particularly in coastal regions, where it accounts for a significant portion of harmful NO<sub>x</sub> and SO<sub>x</sub> emissions, perpetuating damage to human health and the environment [22]. These emissions can be divided broadly into greenhouse gas (GHG) emissions affecting climate change and local air pollution, primarily sulfur oxides (SO<sub>x</sub>), nitrogen oxides (NO<sub>x</sub>), and particulate matter (PM) [23]. Local pollutants are a more pressing issue in coastal areas because of their impact on human health. As discussed, Brandt et al. [6] found that emissions from shipping caused about 50,000 premature deaths in Europe alone in 2000 [2].

The excerpt [12] discusses advancements in comprehending the sustainability transition and its potential pathways, with a specific focus on the road transport sector due to its significant contribution to environmental pollution and the challenges in mitigation. It highlights the attention given by scholars to studying how system costs respond to external factors and policy changes in the context of the road transport sector. A notable gap identified is the lack of emphasis on the financing aspect of the transition within empirical studies that utilize Integrated Assessment Models (IAMs) [4, 5, 13]. Given the substantial financing needs projected for this transition, the absence of financial considerations in IAM-based studies is deemed a deficiency. Various research studies are referenced to underscore the importance of integrating financing aspects into the analysis of transition pathways [3, 15, 20]. Additionally, the limitations of low-carbon powertrains, such as lower loading capacity and longer charging time, are mentioned [14, 16]. The text notes the need to understand how these technical limitations influence the system cost during the sustainability transition, emphasizing the importance of considering such factors in the broader analysis [1, 18].

Main idea of the environmental protection activities are:

- Reduce the possible negative impact on the environment;
- Increase the possible positive impact on the environment.

Environmental aspects are to be considered as much as economic and social assumptions in performing port operations. Environmental assumptions should influence decision-making. Port development should be balanced amongst the target areas: economy, social area and environment.

Different impacts on the environment [author's construction]

Direct	Short-term	Positive	Secondary
Indirect	Long-term	Negative	Cumulative

This study perceives direct impact as the impact influencing the external environment directly and immediately, indirect – impact that interacts with the environment indirectly causing changes in the environment, positive – impacts directed towards environmental quality improvement, reduction and limitation of the burden on the environment, improvement or advancement of nature territories and culturally historical heritage objects, negative – impacts that could cause the reduction of environmental quality, increase the burden on the environment, decrease the condition of natural territories and culturally historical heritage, short-term impact is expressed as (construction, landscaping and other works) during the operation period or shortly afterwards, long-term – impact that will be expressed during the long-term development of the port and sustained until the next port development planning period (Table).



Fig. 1 Environmental risk management in the port [author's construction]

Author's port environmental risks has grouped in 3 major categories (Fig. 1): environmental quality risks, environmental pollution risks and specially protected nature territories.

#### Air quality control in the port

Main air pollution sources in ports occur during the bulk or liquid cargo transshipment procedures, as well as when storing bulk cargo in open spaces. In the course of these activities various chemical compounds creating different odours are emitted, as well as solid particles (dust) influencing ports and adjacent territories, people living nearby ports. Goal - limit the emissions creating odour disturbances due to polluting activities performed by the port operator. Goal is achieved, strengthening the responsibility of operators for the performed polluting activities. Port operator shall cover expenses related to these activities, performing the evaluation, prevention, limitation of pollution and elimination of consequences. Within the framework of air quality management and limiting the entry of polluting emissions into the atmosphere, it is important to obtain high quality and quantitative information regarding emissions from various sources. Environmental monitoring applies procedures and methods that can be tested, renewable information and technological, economic and territorial data allowing one to identify pollution, its location with the division of provinces and municipalities, as well as the type and form of polluting components. Methodology applied for performing the recording of emissions allows one to detect direct quantitative measurements of various types of emissions securing the ongoing monitoring process.

#### Noise generated in ports

It is difficult to perform tests on noise pollution as the presence of noise can be evaluated differently regarding the location and various types of sound source with different characteristics. For example, ferries, ships and trading operations, industrial and shipyard operations can cause sounds of various types and frequencies. Noise pollution can negatively impact both the natural eco-system and city population, causing a negative impact on human health. As ports have several typologies of noise sources, characteristics of noise in this area should be optimised applying environment acoustic monitoring plans. Supervision plans should be developed allowing one to identify the most critical noise areas with phonometer measurements and detect causes of the noise to acoustically characterise the noise sources (noise capacity, spectral traits, length) and evaluate what type of methodology to apply to characterise and evaluate the number of people affected by the noise of ports. The port should perform specific operative actions to improve the acoustic comfort of inhabitants of critical areas. For example, enclosing several port territories with the help of a noise wall.

#### Port marine areas and ground water monitoring

The purpose of ground water monitoring is the timely identification of potential pollution sources, as well as evaluation of the degree of change of pollution dynamics in historically polluted territories. Main causes of historic pollution are related to industrial works of earlier periods, inappropriate storage of dangerous and oil products.

Special attention should be focused on water quality in the ports as it can significantly impact the entire sea

environment, causing long-standing and significant harm and severely affecting the health of wild animals and humans. Ballast and industrial waste waters, ship waste, oil leakage and leakage of other toxic substances from ships or port operations can impact the quality of sea water. The port requires the development of a set of actions if water quality is endangered in the port territory; a plan must also be developed for how to act in emergency situations.

#### Monitoring of the bottom of the sea

Safe shipping is an essential task of the port. This purpose demands maintenance and deepening of the bottom of the ports on a regular basis. Due to these works the soil is taken out and placed in the sites on the sea or mainland, sometimes creating new port territories. Before placing of the soil bottom, sediment quality control is performed, i.e., regular soil placement monitoring. The purpose of monitoring is to gain information regarding changes of the sea environment's hydrological and hydrobiological condition caused by storage of the removed soil during the works and placing of the soil on the site in the sea. Microorganisms should also be evaluated that are destroyed when taking the soil out and putting it on the mainland, but can continue to live when the soil is placed on the site in the sea.

#### Ship waste management in ports

Ports that are members of the IMO - International Maritime Organisation - are subjected to IMO Conventions and provisions stipulating territorial waters as an international shipping space [17, 19]. 1973 Convention on the prevention of pollution from ships with 1978 Protocol corrections (MARPOL 73/78) is the determining international convention operating to prevent pollution in the sea environment due to disturbances of ship operations or ship accidents, including provisions to prevent and reduce waste pollution generated by ships. Ship-generated waste management procedures in ports are regulated by ship-generated waste and polluted waters procedures, and ship-generated waste management plans issued by every port. Provisions should stipulate that the port administration organises ship-generated waste management and is responsible for the development of ship-generated waste management plan.

#### Industrial accident risk objects

Probability of the occurrence of industrial accident risks depends on the work specifics of the industrial companies operating in the port. These industrial companies operating in the port should develop an industrial accident risk assessment procedure and risk occurrence elimination activities.

#### Port management in the case of unforeseen pollution

A case of unforeseen pollution can occur in every port, quay, group of quays, oil or chemical terminals. The probability of risk occurrence should be evaluated, as well as water area pollution threats from the quays operating with chemicals, oil products and mixtures (liquid cargo). Each port should determine a notification system in the case of pollution, as well as pollution evaluation, situation control, operational management procedure, and also measures for the elimination of water area pollution in the case of unforeseen pollution leakage, on the basis of situation analysis, bringing forward priorities and determining the procedure for the implementation of pollution elimination measures.

#### Waste management generated in ports

Waste is produced during daily operations of the port, thus in the waste management of ports the introduction of a sorted waste collecting system is of great value and it should also be more emphasised on the national level. The aim of the waste management national plan is to prevent generating waste in the course of economic growth and secure a significant reduction in the total amount of waste, maximally applying all the best available waste generation prevention options and best available technical solutions, increasing resource use efficiency and promoting the development of a sustainable consumer behaviour model, using waste as a resource for rational recycling options and making sure that generated waste is not dangerous or is causing little harm to the environment and human health, waste should be returned back to the economic life cycle as much as possible, especially using recycling, or returned to the environment in usable form (for example, compost) and waste should be recycled as close as possible to the places it was generated and if possible reducing the amount of waste in landfills and creating landfills in a form safe for human health and the environment, as well as providing household waste sorting options.

#### Circulation management of dangerous and polluting cargo

Circulation management of dangerous and polluting cargo is an important risk factor for ports. Supervision of dangerous and polluting cargo in ports is performed on several levels: radio activity level control should be performed, air pollution monitoring and potential environmental risks examined.

#### Specially protected nature territories

There are probably specially protected nature territories located in ports having a restricted area status with the purpose to secure the preservation and sustainable development of natural species and habitat. Specially protected nature territories are geographically determined areas under special state protection to protect and maintain natural diversity - rare and typical eco systems of nature, natural habitat of protected species, unique, beautiful scenery characteristic to the region, geological and geomorphological formations, dendrology plantations and venerable trees, as well as territories significant for public recreation, education and upbringing. Port operations and development are not possible in these specially protected territories.

#### Monitoring of animals, water birds in ports

Development of the port's economic activities significantly impacts the population of animals, birds and fish on port territories. Monitoring of nesting water birds in the port territories should be performed. Frequently the port territory requires separate biotechnical activities (for example, cutting of reed) to observe the population of nesting birds. Port operations and the development of new terminals also significantly impact the fish population, especially in spawning areas. Several potentially important fishery loss risk factors are related to port development plans, meaning, disturbed migration of fish, loss of fish, loss of organisms for fish nutrition, as well as alterations of the habitat of fish and other

water organisms in the affected port marine area. To reduce this negative impact on fish migration and fish natural breeding it is required to perform the above-mentioned works, and also works related to significant noise emissions (placing of piling etc.), significant formation of turbidity or high water pollution risk in as short time as possible, and assessing fish migration periods. It is also necessary to reduce water pollution to the maximum extent, including according to plans in excavation works, to use machinery that generates as little amount of sludge as possible and prevents water pollution with construction chemicals, oil products or other substances from the machinery applied.

#### *Culturally historical heritage*

Culturally historical heritage objects that should be preserved can also be located within the port territory. Culturally historical heritage consists of the totality of accumulated resources inherited from the past, and irrespective of belonging, are perceived as ex-pressor and portrayer of values, convictions, knowledge and traditions on individual and public opinion. It also includes the environment created in the course of time in the interaction between people and place. Council of Europe Framework Convention on the Value of Cultural Heritage for Society [7] within the territory of this subject or status, development of the port is made more difficult, but society requires this culturally historical heritage to be preserved.

Every port should provide an environmental quality or environmental risk assessment including the interaction of several important aspects: environmental preservation and protection, promotion of efficient use of resources, preserving, protecting, promoting and developing natural and cultural heritage, promoting the use of innovative technologies for environmental protection and the effective use of resources to advance the waste management industry, water supply industry regarding the reduction of ground or air pollution.

Environmental risk management should be implemented, developing environmental policy in ports and setting long-term strategic goals. More specific goals for a shorter time period are subject to them. Tasks are developed to attain these respective goals. Programmes are created to organise and fulfil them. Goals and tasks should be measurable when applicable and comply with port sustainability goals in considering all port obligations. Still it is difficult to validate the degree of implementation and quality of various environmental tasks, especially in cases related to activities that are not precisely defined.

## 4. Conclusions

Due to the general environmental effects of the port operations (air pollution, creation of shipping roads and impact on habitat, increased intensity of the shipping traffic and accident risk) that amongst other issues also emphasises that the moving of port operations (development of new territories of economic activities) to more distant territories from territories that are located close to densely populated areas are positively favoured, thus reducing the number of people impacted by port operations. The author remarks that within the port development context special attention should be focused on the development of transport infrastructure and the selection of optimum solutions for the movement of dangerous cargo through densely populated territories should be considered, as well as the amount of heavy vehicles in the city centres, increased environmental noise level in the proximity of port terminals and the railway, as well as the occurrence of new significant environmental problems should be prevented in the close proximity of a newly constructed and reconstructed transport corridor. Activities with the purpose of maintaining good environmental condition or altering negative tendencies have a positive impact on the environment. It is especially attributed to green technologies or technologies that reduce emissions.

To promote excellence achieved in areas of environmental management and ecological characteristics, ports should develop environmental risk management plans anticipating the probability of occurrence of potential environmental risks and possible harm to the environment.

Several European ports have already established environmental management plans to better manage the impact on the environment and these initiatives should be promoted as an example in considering the potential environmental management risks in ports indicated in the publication.

Use of innovative technologies in environmental protection and resource efficiency should be promoted to improve the waste management sector, water supply sector and regarding the reduction of ground or air pollution. Successful coordination of environmental activities will positively impact economic environment and provide an indirect positive long-term impact on social environment. Increased understanding of the efficiency of resources will influence the living environment of people in a positive way. Waste sorting and the efficient use of resources like water and energy will help to keep the household expenses at a low level. Efficient use and protection of common water resources, reduction of waste generation, waste sorting and recycling will contribute to maintaining a living environment of premium quality.

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## References

1. **Ahmadi, P.** 2019. Environmental impacts and behavioral drivers of deep decarbonization for transportation through electric vehicles, *J. Clean. Prod.* 225: 1209-1219. <https://doi.org/10.1016/j.jclepro.2019.03.334>

2. **Bergqvist, R.; Monios, J.** 2019. Green Ports. Inland and Seaside Sustainable Transportation Strategies, 1-17 <https://doi.org/10.1016/B978-0-12-814054-3.00001-3>
3. **Blanco, H.; Vilchez, J.J.G.; Nijs, W.; Thiel, C.; Faaij, A.** 2019. Soft-linking of a behavioral model for transport with energy system cost optimization applied to hydrogen in EU Renew, *Sustain. Energy Rev.* 115: 109349. <https://doi.org/10.1016/j.rser.2019.109349>
4. **Böttger, D.; Jentsch, M.; Trost, T.; Gerhardt, N.; Von Bonin, M.; Eschmann, J.** 2018. June. Cost-optimal market share of electric mobility within the energy system in a decarbonisation scenario, 15th International Conference on the European Energy Market (EEM). Lodz: IEEE, pp. 1–5. <https://doi.org/10.1109/EEM.2018.8469846>
5. **Bramstoft, R.; Skytte, K.** 2017. Decarbonizing Sweden's energy and transportation system by 2050(Article), *International Journal of Sustainable Energy Planning and Management* 14: 3-20. DOI: <https://doi.org/10.5278/ijsepm.2017.14.2>
6. **Brandt, J.; Silver, J.D.; Christensen, J.H.; Andersen, M.S.; Bønløkke, J.H.; Sigsgaard, T.; Geels, C.; Gross, A.; Ayoe, B.; Hansen, A.B.; Hansen, K.M.; Hedegaard, G.B.; Kaas, E.; Frohn, L.M.** 2011. CEEH Scientific Report No 3: Assessment of Health Cost Externalities of Air Pollution at the National Level Using the EVA Model System. *Cent. Energy, Environ. Health Rep. Ser, Aarhus Univ., Nat. Environ. Res. Inst, Roskilde* (2011), p. 98 <https://meetingorganizer.copernicus.org/EGU2009/EGU2009-4196.pdf>
7. Council of Europe Framework Convention on the Value of Cultural Heritage for Society, (2005), [onlain], [04.03.2023]. Available at: <https://rm.coe.int/1680083746>
8. **Cullinane, K.; Cullinane, S.** 2013. Atmospheric Emissions from Shipping: The Need for Regulation and Approaches to Compliance (Review), *Transport Reviews* 33(4): 377-401. <https://doi.org/10.1080/01441647.2013.806604>
9. European Commission - Environment, [onlain], [12.01.2023]. Available at: [http://ec.europa.eu/environment/air/index\\_en.htm](http://ec.europa.eu/environment/air/index_en.htm)
10. European Union Sustainable Development Strategy, (2001), [onlain], [17.03.2023]. Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52001DC0264>
11. **Fridell, E.** 2019. Chapter 2 - Emissions and Fuel Use in the Shipping Sector., *Green Ports Inland and Seaside Sustainable Transportation Strategies*, 19-33, <https://doi.org/10.1016/B978-0-12-814054-3.00002-5>
12. Global Commission on the Economy and Climate, *The Sustainable Infrastructure Imperative, New Climate Economy*, London (2016) <https://newclimateeconomy.report/>
13. **Hagos, D.A.; Ahlgren, E.O.** 2020. Exploring cost-effective transitions to fossil independent transportation in the future energy system of Denmark., *Appl. Energy* 261: 114389. <https://doi.org/10.1016/j.apenergy.2019.114389>
14. **Karlström, M.; Pohl, H.; Grauers, A.; Holmberg, E.** 2019. Can fuel cells become a mass-produced option globally for heavy-duty trucks 2030+?, *Energiforsk Report*, 604. Retrieved on 1 November 2021 from <http://emobilitycentre.se/wp-content/uploads/2019/09/fuel-cells-for-heavy-duty-trucks-2030-energiforskrapport-2019-604-1.pdf>
15. **Liu, J.; Yin, M.; Xia-Hou, Q.; Wang, K.; Zou, J.** 2021. Comparison of sectoral low-carbon transition pathways in China under the nationally determined contribution and 2° C targets., *Renew. Sustain. Energy Rev.* 149: 111336. <https://doi.org/10.1016/j.rser.2021.111336>
16. **Magnusson, T.; Berggren, C.** 2018. Competing innovation systems and the need for redeployment in sustainability transitions., *Technol. Forecast. Soc. Chang.* 126: 217-230. <https://doi.org/10.1016/j.techfore.2017.08.014>
17. MARPOL (1973) International Convention for the Prevention of Pollution from Ships (MARPOL), 1973, [onlain], [24.01.2023]. Available at: [http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-\(MARPOL\).aspx](http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx)
18. **Parviziomran, E.; Bergqvist, R.** 2023. A cost analysis of decarbonizing the heavy-duty road transport sector, *Transportation Research Part D: Transport and Environment* 120: 103751. <https://doi.org/10.1016/j.trd.2023.103751>
19. **Smith, T.W.P.; Jalkanen, J.P.; Anderson, B.A.; Corbett, J.J.; Faber, J.; Hanayama, S.; O'Keeffe, E.; Parker, L.; Johansson, S. Aldous, L.** 2014. Third IMO GHG Study 2014, International Maritime Organization (IMO), London, UK <https://www.imo.org/en/ourwork/environment/pages/greenhouse-gas-studies-2014.aspx>
20. **Statharas, S.; Moysoglou, Y.; Siskos, P.; Zazias, G.; Capros, P.** 2019. Factors influencing electric vehicle penetration in the EU by 2030: A model-based policy assessment, *Energies* 12(14): 2739. <https://doi.org/10.3390/en12142739>
21. United Nations Framework Convention on Climate Change 1992. [onlain], [26.02.2023]. Available at: <https://unfccc.int/resource/docs/convkp/conveng.pdf>
22. World Health Organisation (2016). [Online] Available at: <http://www.who.int/mediacentre/factsheets/fs313/en/>
23. **Zis, T.; Angeloudis, P.; Bell, M.G.H.; Psaraftis, H.N.** 2016. Payback Period for Emissions Abatement Alternatives: Role of Regulation and Fuel Prices. *Transportation Research Record* 2549(1): 37-44. <https://doi.org/10.3141/2549-05>