A bibliometric analysis of energy efficiency assessment and management practices in ports

Federico Briatore, Simone Arena*, Marco Mosca**, Donato Morea*, Maria Teresa Pilloni*, Pier Francesco Orrù***

** Department of Mechanical, Chemical and Materials Engineering, University of Cagliari, Cagliari, Ca 09123, Italy (simone.arena@unica.it, donato.morea@unica.it, pierf.orru@unica.it, mariat.pilloni@unica.it)*

*** Mechanical, Industrial and Transport Engineer Department (D.I.M.E.), University of Genoa, Genoa, Ge 16126, Italy (federico.briatore@edu.unige.it, marco.tullio.mosca@unige.it)*

Abstract: Energy management and efficiency in port terminals play a fundamental role in facing the environmental challenges of the maritime industry. The search for novel and efficient solutions to change energy consumption patterns is increasingly becoming one of the main concerns of researchers and practitioners to ensure sustainable operation and reduce CO_2 emissions. This paper presents a bibliometric analysis of the extant literature aiming at providing a comprehensive overview of the current state of knowledge on energy efficiency assessment and management practices in ports and harbors. The main objective is to determine the most influential research streams that have been conducted in this field and identify the emerging trends and areas of interest. The findings show that energy optimization techniques and sustainable practices are receiving more and more attention in the port and maritime sectors, highlighting a consistent body of research focused on energy efficiency measures, renewable energy integration, and advanced technologies adoption. The study's achieved findings can be used to clarify the potential and challenges related to energy efficiency assessment and management practices in port terminals by providing both research and practice perspectives.

Keywords: Energy management, Energy efficiency assessment, Ports, Bibliometric analysis, Maritime sector.

1.Introduction

Maritime transport plays an important role in the expansion and development of the global economy representing 80–90% of international trade (United Nations Conference on Trade and Development, 2022). Although international seaborne trade volume suffered a decline due to the COVID-19 pandemic reaching the value of 12027 million tons in 2022, the United Nations Conference on Trade and Development expects a steady increase by about 2.1% per year in the medium term (2024-2028) (United Nations Conference on Trade and Development, 2023). At the same time, maritime industry is an important headstream of energy consumption and environmental pollution. According to the International Maritime Organization (International Maritime Organization, 2020), worldwide shipping energy demand in 2018 accounted for nearly 11 exajoules (EJ), which translated into approximately 1 billion tonnes of CO_2 (by considering both international shipping and domestic navigation) and 3% of world's yearly emissions of greenhouse gas (GHG) on a CO_2-equivalent basis. With the climate change and the rising cost of energy, this impact emphasizes the urgent need for the maritime industry to prioritize energy efficiency and environmental sustainability. Ports have a pivotal role in the paradigm shift towards sustainability as the primary node within the multidimensional structure of the maritime transport chain. The different operations and logistics activities in ports have different energy needs which may include fuels, electricity, natural gas, and thermal/cooling energy. Activities, such as passengers and cargo handling, connectivity to maritime and land transport networks, the supply of power to docked ships, and the management of various port facilities and infrastructures as services for commercial operators and passengers, all lead to a high energy demand and, consequently, significant emissions from diverse sources (Alamoush et al., 2021). Globally, the International Maritime Organization has defined a strategy to achieve zero emissions goals from ships and ports by 2050 (International Maritime Organization, 2023). This plan calls for ports to implement energy transition-related actions by making them essential nodes in the supply chain for future alternative fuels (hydrogen, ammonia, or biofuels) and energy hubs for terminals, warehouses, and ships through the use of renewable energy and smart technologies (Buonomano et al., 2023). The advent of Industry 4.0 has paved the way for the concept of smart ports considered a strategic path towards sustainable development of modern seaports (Li et al., 2023; Pham, 2023). The body of literature on effective energy management at ports including its design, optimization, and operation has increased over the past few decades. In this regard, some valuable review articles have been

published to provide comprehensive overviews (Alamoush et al., 2020; Bjerkan and Seter, 2019; Davarzani et al., 2016; Diniz et al., 2024; Iris and Lam, 2019; Lim et al., 2019; Wang et al., 2023; Wang and Li, 2023) and recent advances (Balcombe et al., 2019; Buonomano et al., 2023; Herazo et al., 2024; Schipper et al., 2017) on the topic. However, given the recent development in ports, existing literature requires a comprehensive analysis of the background of knowledge with the purpose of mapping the state-of-the-art of energy management at ports enabling an understanding of how the topic has evolved and which trends have the best potential to make new contributions.

This work aims at providing a bibliometric analysis of energy assessment models and best practices for energy management. To explore the directions and technologies for improving energy efficiency and reducing emissions in ports, it is necessary to provide a clear picture of these topics that integrates the main research streams investigated and findings achieved into a coherent research narrative. Hence, the aims of this work are (i) to depict the current status of knowledge by analysing the main statistics of the key journals and publication trends, (ii) to identify the most relevant research streams that have defined the activity of researchers and practitioners over the years, (iii) discuss the potential gaps and forecast future directions. The remainder of the paper is organized as follows. Section 2 describes the searching methodology adopted for identifying the papers collection. Sections 3 and 4 present and discuss the results of the bibliometric analysis and the cluster analysis by using co-occurrence keywords. Finally, Section 5 depicts the conclusions and future research perspectives.

2.Methodology

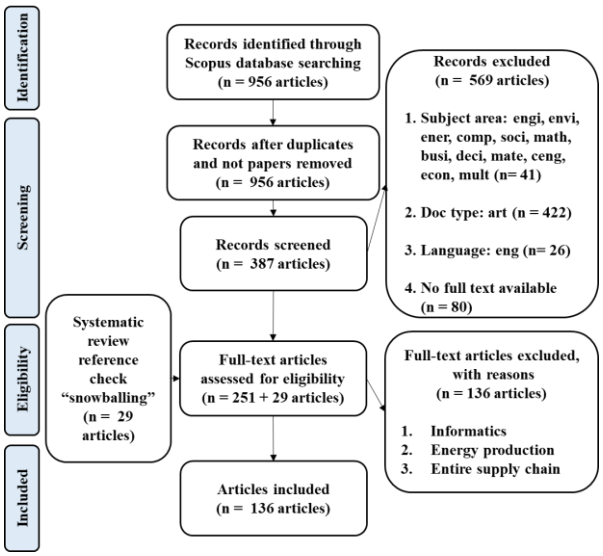


Figure 1: Prisma protocol

The first step was a deep literature research on Scopus adopting the PRISMA protocol (Moher et al., 2010) as shown in Fig. 1, aiming to a clear picture of the current areas of interest in the field of sustainability applied to ports. Then, two groups of keywords have been defined as reported in Tab 1. The search query has been generated by using the logical operators "AND" and "OR" to determine Boolean keyword combinations as "(keyword of group A) AND (keyword of group B) OR (another keyword of group B)".

Table 1. Search keywords used in the literature review

Group A	Group B
"port", "harbor", "seaport"	transport*", "freight mobility", "ship*", "hub", "node", "terminal", "maritime", "management", "energy manag*", "energy consum*", "energy assessment", "energy efficiency", "energy waste", "sustain*" By including proximity operator W/2 (i.e. within 2 words): "model", "algorithm", "analysis", "assessment", "representation", "evaluation"

The first search carried out by considering TITLE+ABS+KEY fields resulted in 956 documents. To reduce the result, only the following subject areas have been considered: Environmental Science, Engineering, Energy, Social Sciences, Computer Science, Business, Management and Accounting, Mathematics, Decision Sciences, Materials Science, Chemical Engineering, Economics, Econometrics and Finance, Multidisciplinary. The new number of records was 915. Additionally, the screening phase of the Prisma protocol involved the introduction of further eligibility criteria: (i) only papers published in journals, (ii) English language, (iii) full-text availability. Then, they were manually screened by reading their title and abstract to remove those that were unrelated to the topic under investigation. At the end, the article set has been reduced to 251. In the eligibility phase, the full texts of these papers have been examined by all the authors to ensure their fit for the topic. Finally, in the inclusion phase, an in-depth review of the contents has been carried out to identify the papers deemed to have made a significant contribution to this work (136). Due to space constraints, the full list of the collected papers can be acquired by contacting the authors.

3.Bibliometric analysis and findings

This section presents the results of the bibliometric analysis performed reviewing the literature on energy efficiency assessment and management practices in ports. The evolution of published studies in Fig. 2. shows that the interest in the topic has increased over the years, mainly due to a greater concern about sustainability. Governments are opening projects to reduce carbon emissions, augmenting the interest in this kind of research, especially after 2015, when a large boost to research was determined by the signing of the Paris Agreement (UN Climate Change Conference (COP21), 2015), which intends to significantly reduce global greenhouse gas emissions to prevent climate change.

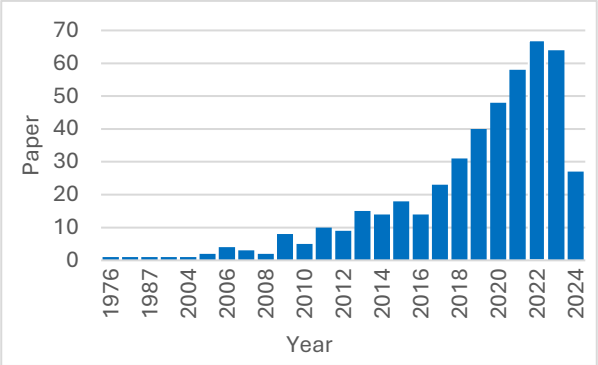


Figure 2: Distribution of papers over time

Moreover, the observed trend may be related to the growing impact of Industry 4.0 which is characterized by the adoption of various digital technological advancements, such as cloud computing, internet of things (IoT), data analysis, and artificial intelligence. These advancements have certainly prompted the integration of port operations, environment, energy, and security, fostering the growth of research areas aimed at enhancing energy efficiency management (Li et al., 2023).

Fig. 3 shows the research areas of energy efficiency assessment at ports. "Environmental science", "engineering" and "energy" are the three main research areas that collect the largest amount of published papers with approximately 62,49% of the total.

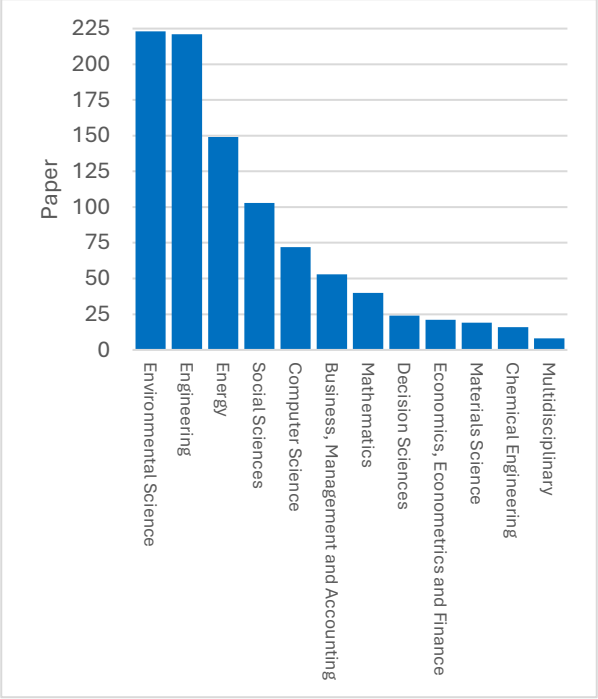


Figure 3: Research areas of energy efficiency assessment at ports

It is worth mentioning that the research areas "social sciences" and "computer science" also involve a significant number of papers with around 10,85% and 7,59%, respectively. The former suggests that interest in sustainability is growing due to its social implications and environmental effects, while the latter stems from the potential of emerging Industry 4.0 technologies in process optimization and integrated strategies-oriented energy efficiency.

Concerning the publishing sources, Tab 2 reports the most influential journals that have collected at least 10 papers on the investigated topic.

Table 2: Distribution of papers over journals

Journal	No. of Art	% tot Art	% Cum tot Art
Sustainability Switzerland	26	6,72%	6,72%
Journal Of Cleaner Production	23	5,94%	12,66%
Applied Energy	15	3,88%	16,54%
Energies	15	3,88%	20,41%
Journal Of Marine Science And Engineering	13	3,36%	23,77%
Ocean And Coastal Management	13	3,36%	27,13%
Journal Of Coastal Research	11	2,84%	29,97%

As can be seen, Sustainability with 26 published papers is the most popular journal, followed by Journal of Cleaner Production (23 publications), and Applied Energy and Energies (15 publications). The top popular journals contribute 30% of the total published papers. This denotes that research streams are focused on a restricted number of journals, generically dealing with sustainability, energy use and management (Sustainability, Journal of Cleaner Production, Applied Energy, and Energies) and, particularly, to maritime industry (Journal Of Marine Science And Engineering, Ocean And Coastal Management, and Journal Of Coastal Research). Another important finding derived from the bibliometric analysis pertains to the most relevant institutions and countries as reported in Tab 3 and 4. Indeed, out of 160 institutions publishing on this topic, the most relevant ones are geographically located mainly in Asia and Europe.

Table 3: Most relevant contributing organizations with at least 5 papers

Country	Art	Country	Art
Shanghai Maritime University	24	National Kaohsiung University of Science and Technology	6
Dalian Maritime University	14	Zhejiang Lab	6
Ministry of Education of the People's Republic of China	7	Dalian University of Technology	5
Delft University of Technology	7	Technical University of Denmark	5

Università degli Studi di Genova	7	Università degli Studi di Napoli Federico II	5
Klaipėdos Universitetas	7	Consiglio Nazionale delle Ricerche	5
Nanyang Technological University	6	Aalborg University	5
The Hong Kong Polytechnic University	6	Univerza v Ljubljani	5
Wuhan University of Technology	6	Ministry of Transport of the People's Republic of China	5
Gdynia Maritime University	6	State Key Laboratory of Coastal and Offshore Engineering	5

Chinese organizations have a predominant role taking the first three places on the list (Tab 3), an aspect highlighted in Tab 4 which illustrates the contribution of the top five countries in which research has been concentrated. According to Argyriou et al. (2022) and Schrooten et al. (2009), ports play a central role in these regions having a major influence on the economy, the environment, and society as well as due to the decisive support for the active policies/incentives of local and national governments.

Table 4: Top five most relevant countries

Country	Articles
China	120
USA	56
Italy	46
United Kingdom	44
Spain	27

This achievement deserves additional clarification. Indeed, the number of papers reported in Tab 5 also takes into consideration potential partnerships between authors from different organizations or countries. Thus, this explains why the USA lacks organizations that lead this research stream (see Tab 4). Nonetheless, its notable contribution to 56 papers is most certainly the result of several academic collaborations throughout the world.

4.Keywords co-occurrence analysis

A co-occurrence keywords analysis is conducted by using the VOSviewer software, which creates a graphical representation to determine the number of times that a keyword occurs and visualizes the inherent relationships between used keywords and their concurrent existence in the same paper. This aids in establishing potential connections between the topics and identifying thematic clusters within the research domain. Here, the performed search for TITLE+ABS+KEY considers all the keywords that Scopus associates to a paper (noted that KEY is the combined field searching AUTHKEY, INDEXTERMS, TRADENAME, and CHEMNAME fields, https://schema.elsevier.com/dtds/document/bkapi/search/SCOPUSSearchTips.htm). The network visualization map of the keywords is reported in Appendix A. According to Perianes-Rodriguez et al. (2016), the full counting approach (i.e., a publication co-authored by three researchers is assigned to each researcher with a full weight of one) is used to build the map, while only keywords with at least 5 relationships are considered. This analysis revealed 4 distinct clusters, each highlighted in different colours and characterized by a central point indicating the leading keywords (Waltman et al., 2010). The first cluster (1, in red colour) labelled as "environmental and social sustainability", contains 24 elements and its main keywords are "sustainable development" (73), "sustainability" (65), and "ships" (60). Besides, in this cluster, there are several references to port activities and geographical location, such as "China" (Chou et al., 2021), "United States" (Harris et al., 2019), and "Europe" (Argyriou et al., 2022). Indeed, it is worth mentioning that every port is distinct in terms of geography, politics, government, community, operations, regulations, and economics thus, there may be specific factors that determine how sustainability measures and initiatives are adopted in different ports. However, it is worth highlighting that existing regulations, such as the international standard ISO 50001, are already used to some extent for energy management in ports, providing organizations with a framework for managing, monitoring, assessing, and improving their energy performance (Iris and Lam, 2019). The second cluster (2, in green colour) labelled as "environmental assessment impact", contains 20 elements and its main keywords are "greenhouse gases (31)", "emission control (30)", and "life cycle (24)". This cluster is mainly focused on ports and maritime emission reduction trends and energy efficiency strategies. Recently, these topics have progressed towards an emerging research stream dealing with the use of electrified port equipment. An increasing number of new equipment types that use electricity as an energy source are replacing fossil-fueled internal combustion engines and generators due to their lower emissions and better cost-effectiveness (Pietrosanti et al., 2020). This cluster also shows two different methodologies: life cycle assessment (LCA) (Mio et al., 2023) adopted to assess carbon footprint and environmental impact, and cost-benefit analysis (CBA) (Sogut and Erdoğan, 2022) adopted to assess the performance of the low carbon port development investments/scenarios and their impact in terms of GHG emissions. The third cluster (3, in blue colour) labelled as "energy efficiency management" consists of 17 elements, whose main keywords are "energy efficiency (74)", "energy management (45)", and "energy (20)". In this cluster, it is evident how the research streams are mostly concerned with (i) energy efficiency port practices aiming at enhancing energy conversion rates and minimizing wasted energy while improving efficiency (Teng et al., 2023), and (ii) the transition to clean energy where the adoption of renewable energy and energy storage systems

allows for reducing GHG emissions (Mio et al., 2023; Yang, 2017).

Finally, the last cluster (4, in yellow colour) labelled as "improving energy utilization", contains 17 elements, with the main keywords being "energy utilization (77)", "optimization (40)", "decision making (33)", and "containers (33)". Moreover, this cluster encloses also keywords like "genetic algorithms", "algorithm", "automation", and "integer programming". The connection between these topics reveals a relevant trend focused on data analysis and algorithms to predict consumption patterns and optimize energy, and the role of automation and robotics for port operations. Many studies focus on container handling optimization, proposing models for energy savings (Wang and Zhu, 2019), different layouts (Xu et al., 2023), and innovative integrations and scheduling (He et al., 2015), using also AI for forecasting (Briatore and Revetria, 2022). In this regard, Industry 4.0 concepts and technologies (AI, IoT, CPS, Big data..) may be the key to enabling the development of an overall energy system model and optimal design of the different technologies within the port's complex architecture (Li et al., 2023).

Appendix B presents the keyword's overlay visualization of co-occurrence based on average publications per year. The comparison between Appendix A and Appendix B concerned with the presentation of keyword usage over the years, shows that the terms of clusters 3 (blue) and 4 (yellow) are the main references for the topics that the current research streams are based on. Especially, the keywords like "simulation", "algorithm", "genetic algorithms", "integer programming", "sensitivity analysis", and "automation" reveal novel and extensive research on port performance optimization using technology-based solutions (Makkawan and Muangpan, 2021; Rolan et al., 2019). This visualization also confirms that the concepts within clusters 1 (red) and 3 (blue) like "hydrogen", "energy storage", "renewable energies", and "alternative energy" have great potential for research improvement. Hydrogen has great potential both as an energy source and as a storage medium to reduce reliance on fossil fuels so, it represents a viable alternative for decarbonizing industrial port areas. For instance, as part of the REPowerEU plan (EU European Union, 2022), the European Union has set as one of the main goals to achieve 10 million tonnes of domestic renewable hydrogen production and 10 million tonnes of imports by 2030.

5.Conclusion

This work presents a bibliometric analysis of energy efficiency assessment and management practices in ports and harbors aiming at examining the current state-of-the-art, gathering and classifying knowledge, and identifying gaps to be filled. The temporal evolution of the research fronts is assessed by analysing the number of relevant papers published yearly and the most active journals dealing with this topic. Geographical indications of the analysed content are also examined by mapping the countries and institutions with a strong interest in this field. To get an overview of the main current and future research streams, keyword co-occurrence analysis is performed to identify significant thematic clusters within the field knowledge base. The four clusters identified capture major topics in investigating energy efficiency assessment in ports with a specific focus on "environmental and social sustainability", "environmental assessment impact", "energy efficiency management", and "improving energy utilization". The analysis contributes to the literature through identification of the conceptual structure of research allowing researchers and practitioners to acquire a thorough understanding of the evolution in energy assessment port development. This research is only preliminary and still has limitations due to inaccuracies stemming from the use of Scopus as the only database, others could offer further insights, and the specificity of the chosen keywords could inadvertently exclude related papers that this keyword structure has not captured. Finally, future review efforts should be focused on extending the current literature review to include a more constructive discussion of the frameworks and methodologies for assessing energy efficiency in ports.

Acknowledgment

This study was carried out within the MOST – Sustainable Mobility National Research Center and received funding from the European Union Next-GenerationEU (piano nazionale di ripresa e resilienza (PNRR) - missione 4 componente 2, investimento 1.4 - D.D. 1033 17/06/2022, CN00000023). This paper reflects only authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

References

Alamoush, A.S., Ballini, F., Ölçer, A.I., 2021. Revisiting port sustainability as a foundation for the implementation of the United Nations Sustainable Development Goals (UN SDGs), Journal of Shipping and Trade. Springer Singapore.

Alamoush, A.S., Ballini, F., Ölçer, A.I., 2020. Ports' technical and operational measures to reduce greenhouse gas emission and improve energy efficiency: A review. Mar. Pollut. Bull. 160, 111508.

Argyriou, I., Daras, T., Tsoutsos, T., 2022. Challenging a sustainable port. A case study of Souda port, Chania, Crete. Case Stud. Transp. Policy 10, 2125–2137.

Balcombe, P., Brierley, J., Lewis, C., Skatvedt, L., Speirs, J., Hawkes, A., Staffell, I., 2019. How to decarbonise international shipping: Options for fuels, technologies and policies. Energy Convers. Manag. 182, 72–88.

Bjerkan, K.Y., Seter, H., 2019. Reviewing tools and technologies for sustainable ports: Does research enable decision making in ports? Transp. Res. Part Transp. Environ. 72, 243–260.

Briatore, F., Revetria, R., 2022. Artificial intelligence for supporting forecasting in maritime sector, in: Proc. Summer Sch. Francesco Turco. Summer School Francesco Turco, AIDI.

Buonomano, A., Del Papa, G., Giuzio, G.F., Palombo, A., Russo, G., 2023. Future pathways for decarbonization and energy efficiency of ports: Modelling and optimization as sustainable energy hubs. J. Clean. Prod. 420, 138389.

Chou, C.-C., Hsu, H.-P., Wang, C.-N., Yang, T.-L., 2021. Analysis of energy efficiencies of in-port ferries and island passenger-ships and improvement policies to reduce CO2 emissions. Mar. Pollut. Bull. 172.

Davarzani, H., Fahimnia, B., Bell, M., Sarkis, J., 2016. Greening ports and maritime logistics: A review. Transp. Res. Part Transp. Environ. 48, 473–487.

Diniz, V.N., Cunha, D.R., Porte, M. de S., Oliveira, M.C.B., Fernandes, F.D.F., 2024. A bibliometric analysis of sustainable development goals in the maritime industry and port sector. Reg. Stud. Mar. Sci. 69.

EU European Union, 2022. RepowerEU.

Harris, T.M., Eranki, P.L., Landis, A.E., 2019. Life cycle assessment of proposed space elevator designs. Acta Astronaut. 161, 465–474.

He, J., Huang, Y., Yan, W., Wang, S., 2015. Integrated internal truck, yard crane and quay crane scheduling in a container terminal considering energy consumption. Expert Syst. Appl. 42, 2464–2487.

Herazo, J.C.M., Castillo, P.A.P., Eras, J.J.C., Fierro, T.E.S., Araujo, J.F.C., Gatica, G., 2024. Bibliometric analysis of energy management and efficiency in the maritime industry and port terminals: Trends. Comput. Sci. 231, 514–519.

International Maritime Organization, 2023. 2023 IMO strategy on reduction of GHG emissions from ships. In: Resolution MEPC, vol. 377.

International Maritime Organization, 2020. Fourth IMO GHG Study 2020. London, UK.

Iris, Ç., Lam, J.S.L., 2019. A review of energy efficiency in ports: Operational strategies, technologies and energy management systems. Renew. Sustain. Energy Rev. 112, 170–182.

Li, K.X., Li, M., Zhu, Y., Fai, K., Tong, H., 2023. Smart port: A bibliometric review and future research directions. Transp. Res. Part E 174.

Lim, S., Pettit, S., Abouarghoub, W., Beresford, A., 2019. Port sustainability and performance: A systematic literature review. Transp. Res. Part Transp. Environ. 72, 47–64.

Makkawan, K., Muangpan, T., 2021. A conceptual model of smart port performance and smart port indicators in Thailand. J. Int. Logist. Trade 19, 133–146.

Mio, A., Barbera, E., Pavan, A.M., Danielis, R., Bertucco, A., Fermeglia, M., 2023. Analysis of the energetic, economic, and environmental performance of hydrogen utilization for port logistic activities. Appl. Energy 347.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., 2010. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. Int. J. Surg. 8, 336–341.

Perianes-Rodriguez, A., Waltman, L., van Eck, J.N., 2016. Constructing bibliometric networks: A comparison between full and fractional counting. J. Informetr. 10, 4, 1178-1195.

Pham, T.Y., 2023. A smart port development: Systematic literature and bibliometric analysis. Asian J. Shipp. Logist. 39, 57–62.

Pietrosanti, S., Alasali, F., Holderbaum, W., 2020. Power management system for RTG crane using fuzzy logic controller. Sustain. EnergyTechnol.Assess. 37.

Rolan, A., Manteca, P., Oktar, R., Siano, P., 2019. Integration of Cold Ironing and Renewable Sources in the Barcelona Smart Port. IEEE Trans. Ind. Appl. 55, 7198–7206.

Schipper, C.A., Vreugdenhil, H., de Jong, M.P.C., 2017. A sustainability assessment of ports and port-city plans: Comparing ambitions with achievements. Transp. Res. Part Transp. Environ. 57, 84–111.

Schrooten, L., De Vlieger, I., Panis, L.I., Chiffi, C., Pastori, E., 2009. Emissions of maritime transport: A European reference system. Sci. Total Environ. 408, 318–323.

Sogut, M.Z., Erdoğan, O., 2022. An investigation on a holistic framework of green port transition based on energy and environmental sustainability. Ocean Eng. 266.

Teng, F., Zhang, Q., Xiao, G., Ban, Z., Liang, Y., Guan, Y., 2023. Energy Management for a Port Integrated Energy System Based on Distributed Dual Decomposition Mixed Integer Linear Programming. J. Mar. Sci. Eng. 11.

UN Climate Change Conference (COP21), 2015. Paris agreement.

United Nations Conference on Trade and Development, 2023. Review of Maritime Transport 2023.

United Nations Conference on Trade and Development, 2022. Review of Maritime Transport 2022.

Waltman, L., van Eck, J.N., Noyons E.C.M., 2010. A unified approach to mapping and clustering of bibliometric networks. J. Informetr. 4, 629-635.

Wang, B., Liu, Q., Wang, L., Chen, Y., Wang, J., 2023. A review of the port carbon emission sources and related emission reduction technical measures. Environ. Pollut. 320, 121000.

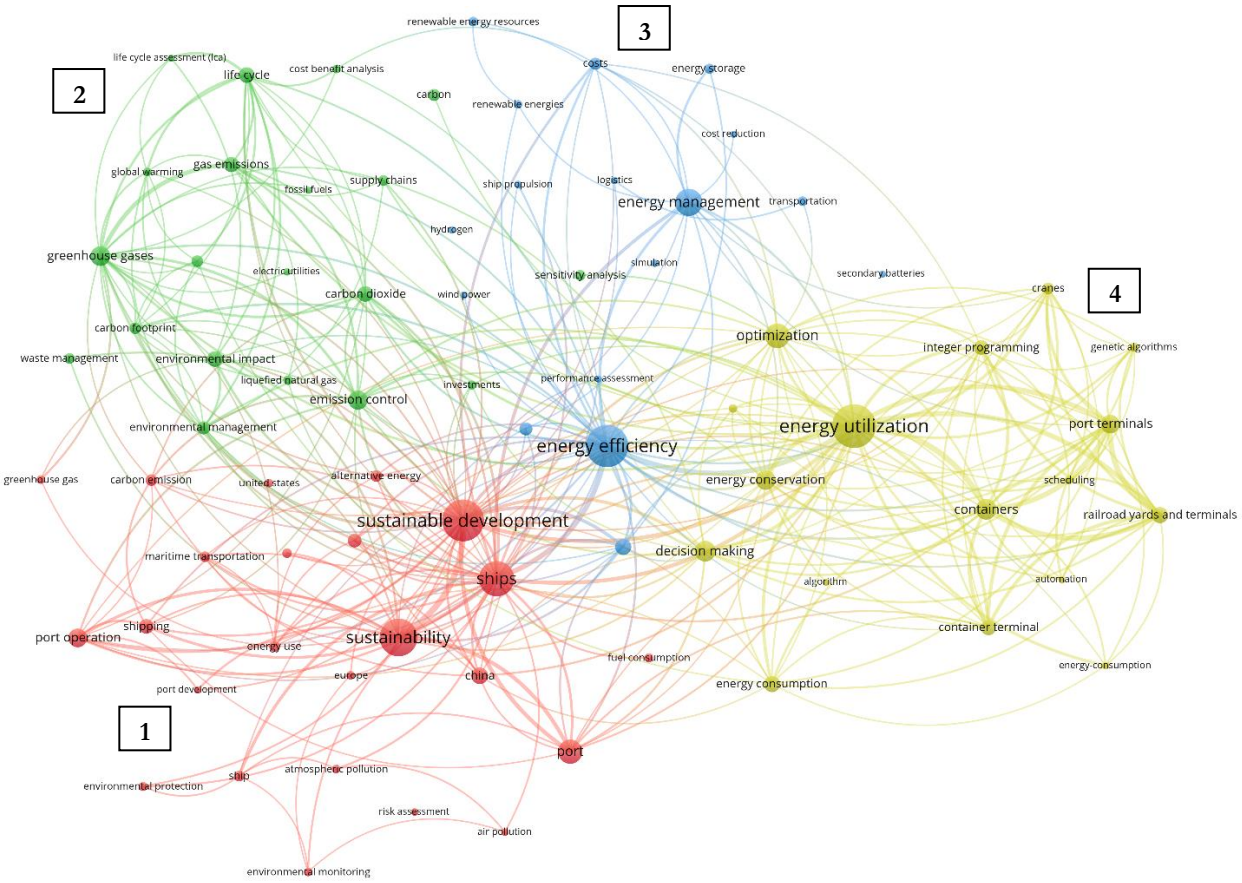
Wang, L., Li, Y., 2023. Estimation methods and reduction strategies of port carbon emissions - what literatures say? Mar. Pollut. Bull. 195, 115451.

Wang, L., Zhu, X., 2019. Container loading optimization in rail-truck intermodal terminals considering energy consumption. Sustain. Switz. 11.

Xu, B., Wang, H., Li, J., 2023. Evaluation of operation cost and energy consumption of ports: comparative study on different container terminal layouts. Simul. Model. Pract. Theory 127.

Yang, Y.C., 2017. Operating strategies of CO2 reduction for a container terminal based on carbon footprint perspective. J. Clean. Prod. 141, 472–480.

Appendix A. VOSviewer key correlation density



Appendix B. VOSviewer key correlation year