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Impact of GHG Regulations at Container Terminals on the Container Handling Equipment Market

Résumé de l'article : Les émissions de gaz à effet de serre du transport maritime constituent une part significative des émissions liées au transport. Contrairement aux émissions provenant des navires, celles des terminaux à conteneurs ne sont pas réglementées par des entités mondiales. Cette absence de réglementation globale entraîne une diversité d'ambitions individuelles, souvent non contraignantes, de la part des exploitants de terminaux, des autorités portuaires et des gouvernements locaux. La fragmentation des efforts rend difficile l'évaluation du potentiel de réduction des émissions combiné des réglementations et engagements individuels. De plus, l'impact sur la demande en solutions technologiques reste incertain. Comprendre cette demande aide à orienter les efforts de développement et à assurer une capacité de production suffisante pour atteindre les objectifs de réduction des émissions. Afin de saisir les efforts actuels et leur impact, les réglementations sur les émissions et les objectifs volontaires de réduction des émissions affectant les équipements de manutention des conteneurs ont été rassemblés. Ces données peuvent servir de point de départ pour une analyse plus approfondie des stratégies de réduction des émissions efficaces. En associant les objectifs de réduction des émissions à la capacité de manutention actuelle dans les terminaux à conteneurs concernés et aux projections de développement du marché, la taille du marché des équipements de manutention de conteneurs sans émissions est estimée. Le modèle prédit qu'en 2030, 250 millions de TEU, soit environ 24 % de la capacité de manutention mondiale, seront traités par des équipements sans émissions. Les engagements de réduction des émissions sont principalement formulés par les exploitants de terminaux privés et les autorités portuaires. Seules quelques réglementations gouvernementales touchent les émissions de la manutention des conteneurs. Comparées aux prédictions de l'initiative Science Based Targets pour le secteur maritime, les cibles actuelles de réduction des émissions ne suffisent pas pour maintenir le réchauffement climatique en dessous de 1,5 °C par rapport aux niveaux préindustriels. Par conséquent, si les gouvernements souhaitent limiter le réchauffement global à 1,5 °C, ils doivent prendre des mesures supplémentaires et exiger la réduction des émissions de gaz à effet de serre provenant des terminaux à conteneurs.

Article's abstract: Greenhouse gas emissions from maritime transport represent a significant share of transport related emissions. In contrast to emissions from ships, emissions from container terminals are not subject to regulations issued by global entities. The lack of global regulation results in a variety of individual ambitions of often non-binding nature by terminal operators, port authorities and local governments. The fragmentation leads to difficulties determining the demand for technological solutions. Knowing the demand helps to guide development efforts and ensures sufficient production capacity is created to meet emission reduction targets. To understand present efforts and their impact, emission regulations and voluntary emission reduction targets affecting container handling equipment have been collected. The collected data may serve as a starting point into further analysis of effective emission reduction strategies. Combining the emission reduction targets with current handling capacity at affected container terminals and market development projections, the size of the emission-free container handling equipment market is estimated. The model predicts that in 2030, 250 million TEU, roughly 24 % of global handling capacity, will be handled by emission-free equipment. The commitments to reduce emissions are predominantly issued by private terminal operators and port authorities. Only a few governmental regulations affect emissions from container handling. Compared with the predictions for the maritime sector by the Science Based Targets initiative, current emissions reduction targets are not sufficient to meet the level necessary to keep global warming below 1.5 °C above pre-industrial levels. Therefore, if governments want to limit global warming to 1.5 °C, they need to take more actions and force the reduction of greenhouse gas emissions from container terminals.

1 Introduction

Ports worldwide have acknowledged their significant impact on the environment and have started to take action to reduce their greenhouse gas (GHG) emissions [1]. In ports a huge share of emissions has its origin in container terminals (CT). In CTs, the biggest GHG producers are container handling equipment (CHE). Different strategies to reduce CHE's GHG emissions, using a variety of different reporting standards and focusing on different sources and technological solutions, have emerged [2]. While GHG emissions from ships are regulated through the International Maritime Organization (IMO), no global regulations for landside operations exists [3]. This leads to a variety of local and global actors defining individual regulations and goals. Current research is focused on comparing and analyzing the impact of the different emission reduction pathways. This research is important because it ensures that emission reduction strategies have a significant impact and effective strategies are known to a wide range of actors. However, the current research neglects to analyze the effect on the demand of emission-free technology. It is important to know when and how much emission-free CHE will be required, to ensure enough development effort is committed to the respective technologies. For this reason, the objective of this work is to create an overview of current GHG regulations and company strategies affecting CHE at CTs. Furthermore, it aims to understand the state of the CHE market and derive its likely development caused by beforementioned regulations and strategies. In the end, following research questions have to be answered:

R 1 Which regulations and strategies require emission-free CHE?

R 2 How will the demand for emission-free CHE be affected by these regulations and strategies?

2 Method

The model of the emission-free CHE market incorporates two aspects, published statements, promotions, regulatory documents, planned investments and mandates to reduce GHG emissions, collectively referred to as strategic objectives, and a general growth prediction of the CHE market. The impact of strategic objectives is determined by combining the results with CHE fleet data of CTs which was predominantly sourced from terminal operators and port authorities. The market growth prediction up to 2030 is based on Global Trade Analytics Suit (GTAS) Forecasting [4] and International Transport Forum [5] onwards.

Collection of Zero-Emission Objectives. The structured review loosely follows the guidelines described by Garius et al. [50] for a multivocal literature review. And is split into three steps: (1) Source collection, (2) quality assessment and (3) data extraction. The source collection itself was divided into two steps. First, entry points were defined, then links from the entry points to other initiatives were followed similar to the snowballing concept used in [6]. This approach was deemed suitable as sharing actions to reduce GHG emissions has inherent value and as a result, initiatives are often connected. For example, global initiatives are often comprised of smaller local efforts. These local efforts in turn might contribute to a variety of larger initiatives.

To acquire a diverse set of entry points, they were gathered from three sources. The first source are important actors in the shipping industry as listed in Drewry's Global Container Terminal Operators [7] and major shipping nations as listed by the United Nations Conference on Trade and Development [8]. A dedicated search for initiatives of these actors was augmented with Google search results for terms related to emission-free container handling. Lastly, initiatives showcased in industry newsletters were used. In a second step, the quality of the sources was assessed and sources with an insufficient quality removed. The quality assessment was based on factors increasing the likelihood that the plans of an initiative succeed, like objectives being published by an entity that has agency over the CHE fleet, concrete implementation steps being published, and progress being demonstrated. For example, while it is likely that regulatory requirements will be met fully, it is less likely that emission reduction goals which are not accompanied by concrete implementation steps will be fulfilled. The categories are regulatory requirement, specific strategy, vague strategy, promotion and planned. For the last two categories, not only the fulfilment of an objective is uncertain but also what the final objective will be. To enable detailed forecasting of the demand of emission-free CHE the relevant emission reduction key characteristics were extracted from the initiatives. Besides the quality assessment, issuer and affected terminals, also the goal, timeline and scope were recorded. An exemplary objective is an 80 % reduction in direct carbon dioxide (CO2e) emissions from RTGs by 2030.

Emission-Free CHE Market Forecast. The market forecast for emissions-free CHE is based on the collected strategic objectives aiming to reduce GHG emissions from CHE, CHE fleet data and forecasts for the growth of the container shipping market. In its essence, the model determines the size of the emission-free CHE market for a given year by mapping the strategic objectives to the affected fleet and accounting for the overall market growth. In the following, three key steps are outlined. Details can be found in [9].

First, the CHE fleet data is pre-processed. In this step missing capacity data for CTs is calculated based on simple models using equipment information and already emission-free CHE subtracted to avoid conversion of already emission-free CHE. Furthermore, the expected container shipping market growth is

incorporated. The main step is the mapping of the strategic objectives to the non-emission-free CHE fleet. Individual terminals may be covered by overlapping objectives, i.e., objectives from the terminal operator might differ from the objectives of the local government. For every year and CT, the most ambitious goal is used. While some objectives only affect certain CHE types, others affect the whole fleet. Besides requirements for individual CHE types, a required emission-free container handling capacity for each terminal is calculated, because for many CTs no detailed CHE fleet information was available. For simplicity, it was assumed that progress towards the objectives is linear and objectives affecting multiple CHE types are distributed evenly onto the types. Finally, the data is aggregated by year, location, quality and issuer. This allows the analysis of the emission-free CHE market growth along the dimensions of location, time and issuer while keeping the quality assessment in mind.

3 State of the Art

Impact of CHE on GHG Emissions. Compared to GHG emissions generated by ships, emissions generated by CHE are relatively small. For example, in Long Beach, USA, CHE is accountable for 12 % of total GHG emissions produced by cargo transport activities. Focusing on CT operations, CHE is responsible for 79 % of GHG emissions [10]. Similarly, in Valencia, Spain CHE is responsible for 81 % of GHG emissions from landside operations [11]. Hence, CHE is the main contributor to GHG emissions from landside operations.

Through these examples it becomes clear that the majority of GHG emissions are emitted by vessels. Thus, its reasonable that a substantial share of maritime emission regulations focus on ship emissions. However, because the majority of landside emissions are emitted by CHE, the transition to zero-emission port operations will also require significant changes to the current CHE fleet. Especially considering that worldwide most CHE vehicles are still diesel-powered nowadays [12].

Emission-free CHE. CHE is considered emission-free when it does not produce direct GHG emissions by a combusting engine. Nevertheless, emission-free CHE can still produce particular matter, noise, or light emissions, e.g. through tires [13]. Furthermore, operating zero-emission CHE can still produce substantial amounts of indirect GHG emissions if the power source, like electricity or hydrogen, is produced in emission intensive processes.

Several examples show that the hurdle to zero scope 1 emissions in CTs is not of technical nature. For example, HHLA CT Altenwerder plans to operate a completely electrified AGV fleet from this year and initiates the electrification of landside operation as well [14]. However, analysis show that full electrification is not yet possible for e. g. straddle carrier, reach stacker or top handler [15, 16]. Hence, the application of fully electrified CHE on a specific CT depends, once adoption is technically and financially feasible, on factors like the operating mode, the utilization of the CHE, the infrastructure [16, 17].

As most CT employ dedicated CHE, the CHE market is closely linked to the number of containers handled. Emission-free CHE still represents a minority of the overall CHE used. Thus, the emission-free market has growth potential even if the overall CHE and container shipping market are constant. Nevertheless, an increase in the overall CHE market is expected to have a positive influence on the emission-free CHE market.

Emission Regulations. A thorough overview of current and future regulations is necessary to give ports the possibility to adjust their development plans according with the described targets and optimize future regulations and targets. Furthermore, summarizing and raising awareness of ambitious emission reduction goals might lead other parties to commit to similar goals. At the moment international public and

private organizations like IMO or ESPO, local actors like port authorities or collectives, or individual companies like terminal operators initiate emission reduction regulations.

IMO and ESPO have recognized the climate change impact of the maritime transport [1, 18], and have introduced measures to reduce GHG emissions into their strategic plans. Most of these measures target ship emission instead of port emissions [18]. The next update on IMO's GHG strategy is scheduled for mid-2023 [19]. The regulation controlling carbon efficiency of ships and their operations entered into force at the start of 2023 [20]. According to the Science Based Targets initiative (SBTi) [21] the IMOs emission regulations are not suited to keep emission below the 1.5° C target. Other international emission-reduction facilitators are the Green Shipping Challenge [22] and the World Ports Sustainability Program [23]. Other organizations like Ports for People evaluate emission reduction strategies and provide guidance on the decarbonization path [24].

In the context of maritime transport, emissions not only play a global role but a further local role as emissions by ships and heavy equipment at port pose a direct health risk when inhaled. Therefore, countries and local governments introduced emission standards. For example, CHE in California needs to comply with the TIER 4 off-road emission standard [25]. To support companies, financial incentives are used to accelerate the adoption of zero- or low-emission CHE [26]. The ports of Vancouver, Seattle and Tacoma consolidate their efforts and understanding the relevant objectives to develop the Northwest Ports Clean Air Strategy [27].

4 Results & Discussion

The collected strategic objectives have a global reach with most objectives being issued by terminal operators followed by port authorities as seen in fig. 1. No current legally binding regulations have been found during the review. Even the objectives posed by city governments are formulated as goals and not regulations. As large parts of the effort are driven by global terminal operators the potential impact does not focus on specific geographic regions. The strategic objectives issued by terminal operators tend to be less concrete than the objectives published by port authorities. Therefore, the actual effort might be lower than promoted.

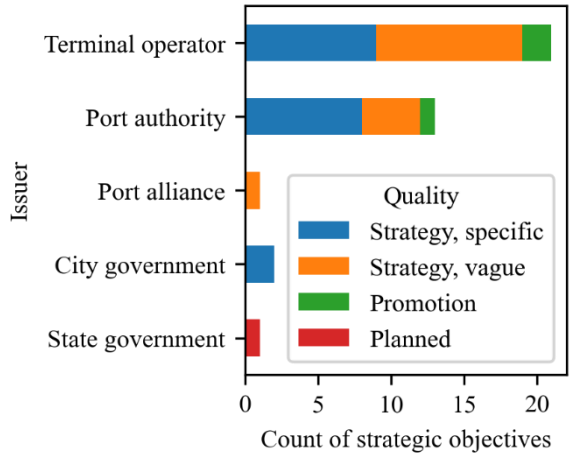

Fig. 1. Count of strategic objective by type and issuer

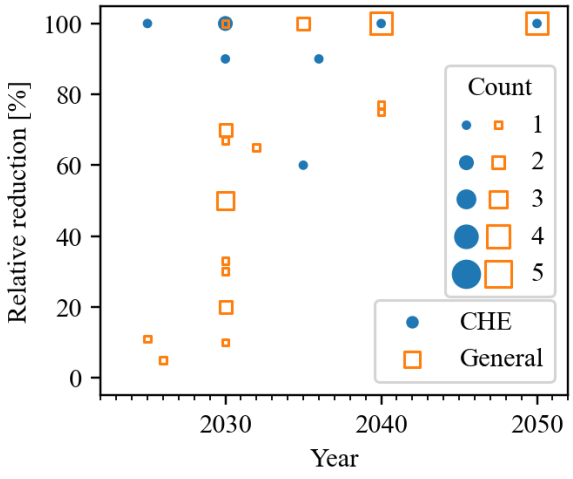

Fig. 2. Development of strategic objectives over time

In general, the goals become more ambitious as time goes on with many initiatives targeting the years 2030, 2040 and 2050 as can be seen in fig. 2. Strategic objectives which only affect CHE opposed to

general CT emissions tend to be more ambitious and short term. This could indicate that issuers see a concrete path to reduce emissions from CHE. Over 90 % of the strategic objectives use 2019 or later as a base year, highlighting the acuteness of the topic.

Most strategic objectives do not focus on particular CHE types and CHE type specific fleet information is only available at less than 30 CTs. Therefore, the analysis of demand for emission-free CHE is performed on a capacity basis. For example, reducing the CO2e emissions of a current CHE fleet handling 1.000 TEU by 30 % may be achieved by replacing 30 % of each CHE type by an emission-free alternative. This corresponds to an emission-free handling capacity of 300 TEU.

The forecast of the container handling capacity which needs to be emission-free to meet the strategic objectives is shown in fig. 3. For comparison, the worldwide handled capacity and capacity of the terminals included in the utilized data base are shown. The highest conversion rate can be seen before 2030, i.e., emission-free CHE needs to become widely available in the next seven years. After 2040 the emission-free capacity is almost parallel to the growth of the referenced CHE fleet data base. This means that no further existing CHE is converted and new CHE is procured to match the current emission-free CHE market share. To achieve this, emission-free CHE needs to be widely available and total costs of ownership of emission-free CHE might be below that of traditional CHE. In this scenario it could be expected that the share of emission-free CHE rises faster than predicted by the model.

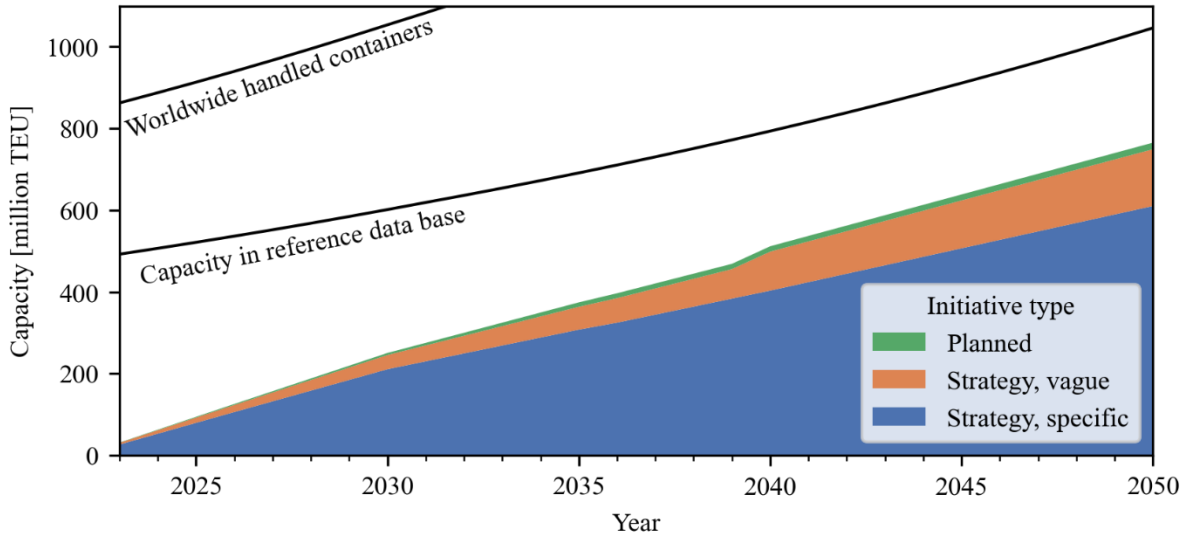

Fig. 3. Demand forecast for emission free container handling capacity

A large part of the forecasted demand is driven by the two big terminal operator's PSA International and APM Terminals. They control a significant part of the global CHE fleet and have set ambitious emission reduction goals [28, 29]. Due to the high share of these two actors, the predictions are sensitive to changes in their respective strategic objectives. The sensitivity to individual actors can also be seen by the jump in 2040. The jump is caused by the misalignment between DP World's year-over-year [30] and their 2040 emission goal [31].

To compare the ambitions expressed in the strategic objectives with the actions required to limit global warming to 1.5 °C above pre-industrial levels, the global share of containers handled by emission-free CHE is considered. The model predicts that 24 % of the global containers handled in 2030 and 37 % in 2040 are handled by emission-free CHE. This is well below the ranges identified

by the SBTi of required emission reductions of 36 %-49 % in 2030 and 75 %-96 % in 2040 based on 2020 GHG emissions [21]. Changing the baseline from the globally handled containers to only the handling capacity accounted for in the terminal data base, leads to 42 % of container being handled emission-free in 2030 and 64 % in 2040. Under this perspective the strategic objectives are in line with required 2030 requirement, but more ambitious goals and efforts are required for 2040. In other words, even if all strategic objectives considered are met and the unaccounted-for capacity is converted at the same rate, emission reduction from CHE will still be below the level required by the maritime transport sector to limit global warming to 1.5 °C.

In summary, the model predicts globally strong growth demanding 250 million TEU emission-free container handling capacity in 2030. Most initiatives focus on reducing emissions from all terminal operations instead of focusing on CHE. The effort is driven mainly by terminal operators acting on a global scale but combined efforts fall short actions required of the target to limit global warming to 1.5 °C above pre-industrial levels.

5 Conclusions & Perspectives

The presented market forecast for emission-free container handling capacity demanded is based on a review of regulations and targets set by governments, private actors and organizations having influence on CHE operation at CTs. To this end, strategic objectives by these actors have been collected, assessed and mapped to the current CHE fleets at affected terminals. Most strategic objectives set goals for 2030 and target general GHG emission reduction as opposed to focusing on emissions from CHE specifically. However, if strategic objectives focus on CHE specifically, they are more ambitious on average. The strategic objectives are predominantly issued by the private sector, especially terminal operators, giving them a disproportionate influence on the forecast. This increases the uncertainty of the model, because private actors are less bound to their self-published objectives compared to law. However, these few actors present an opportunity for further research. Understanding their motivations and approaches could help other actors formulate similar ambitious targets. It could also support policy makers to create reachable GHG emission restrictions. Uncertainty is introduced into the forecast by the variety of reporting standards used by the different actors. Besides different operational and organizational boundaries, different standards for considering negative emissions are used to formulate the reduction targets. Most objectives are formulated broadly, lacking information on individual steps and affected equipment making a detailed forecast and assessment of realizability challenging. It is clear that some CHE types are more easily converted to emission-free versions and will be responsible for a larger share of initial emission reduction. The model predicts that about 250 million TEU will be handled by emission-free CHE in 2030, corresponding to 24% of global containers handled. Even if this goal is achieved, the reductions in GHG emissions are not sufficient to match the level required from the maritime transport sector to keep long term global warming below 1.5 °C above pre-industrial levels as predicted by SBTi. Hence, policy makers not only need to standardize reporting but also participate in goal setting if they want to limit global warming to 1.5 °C.

Data Availability

The used data and code to analyze the data can be provided after request.

6 References

1. Martí Puig, Chris Wooldridge (2022) ESPO Environmental Report 2022
2. Azarkamand S, Wooldridge C, Darbra RM (2020) Review of Initiatives and Methodologies to Reduce CO2 Emissions and Climate Change Effects in Ports. Int J Environ Res Public Health 17:3858. https://doi.org/10.3390/ijerph17113858
3. International Maritime Organisation (2022) MEPC.328(76): 2021 Revised MARPOL Annex VI
4. Katarzyna Skrzypek (2023) Containerized Trade Outlook by GTAS Forecasting. https://www.spglobal.com/marketintelligence/en/mi/research-analysis/containerized-trade-outlook-by-gtas-forecasting-june-2022.html
5. International Transport Forum (2021) ITF Transport Outlook 2021. ITF Transport Outlook
6. Wohlin C (2014) Guidelines for snowballing in systematic literature studies and a replication in software engineering. In: London, England, United Kingdom, pp 1–10
7. Drewry (2022) Global Container Terminal Operators - Annual Report 2016. https://www.feport.eu/images/downloads/drewry---global-container-terminal-operators-annual-review-and-forecast-2016.pdf
8. United Nations Conference on Trade and Development (2022) Container port throughput, annual. https://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=13321
9. Neltner M (2023) Impact of GHG Regulations at Container Terminals on the Container Handling Equipment Market. Master Thesis, Northern Institute of Technology Management
10. Port of Long Beach (2022) Air Emissions Inventory - 2021
11. Martínez-Moya J, Vazquez-Paja B, Gimenez Maldonado JA (2019) Energy efficiency and CO2 emissions of port container terminal equipment: Evidence from the Port of Valencia. Energy Policy 131:312–319. https://doi.org/10.1016/j.enpol.2019.04.044
12. Wieschemann A (2018) Batterie-elektrischer Terminal Truck im Feldversuch: Entwicklung eines batteriebetriebenen Terminal Trucks und Erprobung im Rahmen eines Feldversuchs in einem deutschen Binnenhafen und dem Containerterminal eines deutschen Seehafens, Düsseldorf
13. Song J, Qian H, Zhao D et al. (2021) Particulate matter emission by an isolated rotating wheel. Build Simul 14:1163–1173. https://doi.org/10.1007/s12273-020-0724-0
14. HHLA (2023) HHLA | The gateway to the future. https://cta-klimaneutral.de/index_en.html
15. CK Hutchison Holdings Limited 2021 Annual Report - Solid, Resilient Ready for Tomorrow
16. Tetra Tech, Gladstein, Neandross & Associates (2022) San Pedro Bay Ports - Clean Air Action Plan: 2021 Update: Feasibility Assessment for Cargo-Handling Equipment
17. Mohr A, Kastner M, Jahn C (2023) Groundbreaking Challenges of Deploying Battery-Electric Terminal Trucks in Container Terminals. In: Springer, Cham, pp 183–198
18. International Maritime Organisation (2021) Resolution A.1149(32): Revised Strategic Plan for the Organization for the Six-Year Period 2018 to 2023
19. International Maritime Organisation (2023) IMO progress on revised GHG strategy, Mediterranean ECA adopted. https://imopublicsite.azurewebsites.net/en/MediaCentre/PressBriefings/pages/MEPC-79.aspx
20. (2023) Rules on ship carbon intensity and rating system enter into force. https://imopublicsite.azurewebsites.net/en/MediaCentre/PressBriefings/pages/CII-and-EEXI-entry-into-force.aspx
21. Jean-Marc Bonello, Sophia Parker, Tristan Smith et al. (2022) Science Based Target Setting for the Maritime Transport Sector. https://sciencebasedtargets.org/resources/files/SBTi-Maritime-Guidance.pdf
22. Green Shipping Challenge (2023) Green Shipping Challenge - About. https://greenshippingchallenge.org/
23. World Port Sustainability Program (2023) World Port projects – Climate and Energy. https://sustainableworldports.org/portfolio/type/port-projects/?area-of-interest=climate-and-energy
24. Ports For People (2022) Ports for People RePORT Cards. https://portsforpeople.pacificenvironment.org/policymaker/report-cards/. Accessed 23 Dec 2022
25. California Code of Regulations (2006) Tit. 13, § 2479: Regulation for Mobile Cargo Handling Equipment at Ports and Intermodal Rail Yards
26. Port of Los Angeles (2019) Zero- and Near Zero-Emission Freight Facilities (ZANZEFF) Shore to Store Project
27. Port of Vancouver, Port of Seattle, Port of Tacoma et al. (2021) Northwest Ports Clean Air Strategy 2020
28. A.P. Moller - Maersk (2021) Sustainability Report 2021
29. PSA International (2022) Sustainability Report 2021. https://www.globalpsa.com/wp-content/uploads/PSA-International-Sustainability-Report-2021.pdf
30. DP World (2021) The Smarter Trade Report
31. DP World (2023) DP World commits to CO2 reduction and takes on the Green Shipping Challenge. https://www.dpworld.com/news/releases/dp-world-commits-to-co2-reduction-and-takes-on-the-green-shipping-challenge/