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## WMU roundtable on port energy transition and stakeholders engagement

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# WMU Roundtable on Port Energy Transition and Stakeholders Engagement

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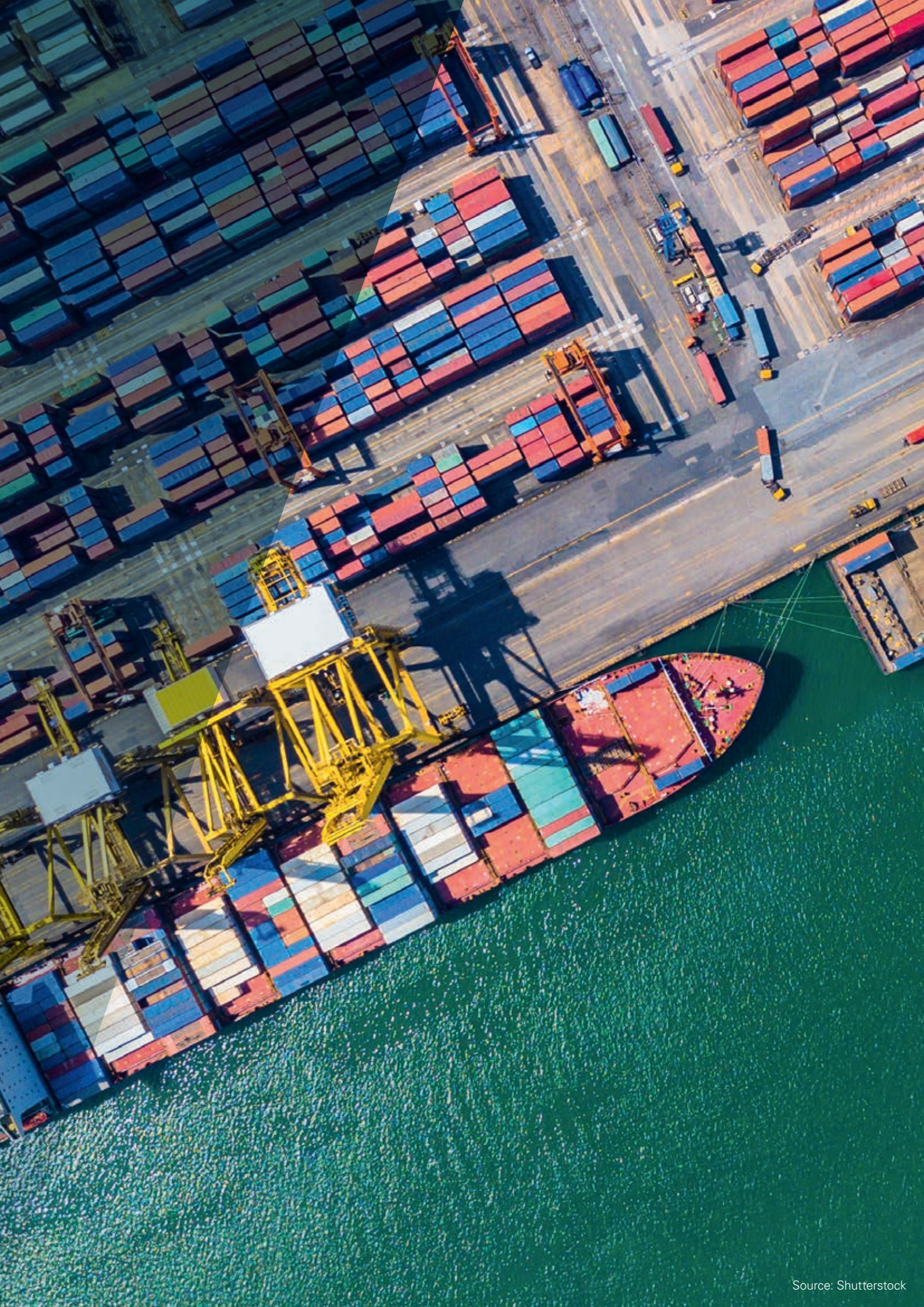
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We are also thankful to Antwerp Port Authority, Baltic Ports Organization, Chalmers University of Technology, Copenhagen Business School, Copenhagen Malmö Port, Dublin City University, the European Environment Agency, the European Community Shipowners' Associations, the European Onshore Power Supply Association (EOPSA), the European Sea Ports Organisation, KEDGE Business School, Lloyd's Register, MTCC Africa, MTCC Asia, MTCC Caribbean, MTCC Latin America, Offshore Wind at Eemshaven, the Port of Trelleborg, Ramboll, RINA Consulting SPA, the Swedish National Road and Transport Research Institute (VTI), the University of Gibraltar, Wärtsilä, and Waterborne Technology Platform, for their valuable insights and feedback at the roundtable; their expertise and guidance have been invaluable. Finally, the academic environment at WMU has been instrumental in shaping the ideas presented in this publication.



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## FOREWORD BY THE PRESIDENT



**Professor Maximo Q. Mejia, Jr.**  
President  
World Maritime University

It is with great pleasure that I introduce this seminal report stemming from the collaborative efforts of the esteemed stakeholders and experts who convened at the World Maritime University's Roundtable on Port Energy Transition and Stakeholder Engagement.

Maritime transport (ports and shipping) is the backbone of the global trade, transporting over 80 per cent of cargo by volume, including vital commodities ranging from medical supplies to essential energy resources. However, the environmental cost cannot be overlooked, as shipping and port activities together account for around 5 per cent of global greenhouse gas emissions, contributing to the imminent climate crisis.

Guided by the Seenergy project's ambition and the expertise of its consortium, this report reflects the conclusion of the vital insights and standpoints of a valued cohort comprising industry pioneers, academics, researchers, port authorities, and international organizations. Together, they explored the multifaceted grounds of technology, policy, business models, and global cooperation; thus they plotted a course in the direction of a decarbonized maritime future.

The Technology Roundtable established a dialogue about the advances of the ports in alternative fuels, electrification, and renewable energy capture, and the potential of ground-breaking technologies. Discussions illustrated the imperative need for infrastructure readiness and financial policies to overcome implementation barriers.

The Policy Roundtable navigated through regulatory realms, calling for attention to dedicated policy frameworks that offer incentives for sustainable port practices. Numerous hurdles that emerged as pressing issues included technical and behavioural barriers, economic challenges, administrative complexities, and the need for heightened awareness: all these need to be addressed through strategic policies.



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The Business Models Roundtable explored a variety of maritime pathways to facilitate the running of business, and underlined their transformative potential toward sustainable port operations. The models include joint ventures, investment partnerships, and innovative maritime contracting. Nonetheless, concerns persisted about port industry pacing, corporate stimuli, and governance, highlighting the need for more cooperative models to strengthen flexibility.

The Global Cooperation Roundtable crystallized the interrelated nature of maritime trade. Global cooperation emerged as the cornerstone of port decarbonization. Discussions underscored the challenges faced by ports in developing countries, and emphasized the necessity for uniform policies and adequate financial resources.

This report is informed by rich knowledge, and put together from the inclusive insights and recommendations uncovered during the discussions. Each voice, each perspective, converges to echo the crucial need for uniform policies, strategic investment, and joint frameworks to drive ports toward sustainable and cleaner futures.

Heartfelt gratitude is extended to the moderators of these roundtables (Associate Professor Dr Fabio Ballini, Associate Professor Dr Alessandro Schönborn, Lecturer Dr Monica Canepa, Research Associate Dr Anas S. Alamoush) and facilitators (Visiting Researcher Dr Levent Bilgili and Ph.D. researchers Peyman Ghaforian Masodzadeh, Natalia Calderón and Zeeshan Baig) for steering the conversations professionally, and to the participating stakeholders whose steadfast commitment and knowledge energized the fruitful discussions. This report stands as a 'testimony to the stakeholders' cooperation and dedication to steering the global maritime and ports communities toward greener and decarbonized horizons.



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# INTRODUCTION

Shipping is the backbone of international trade. With a contribution of more than 80 per cent of cargo by volume and 70 per cent by value, it is the most efficient mode of transportation. The vital cargo it transports includes medical supplies and equipment, as well as food, energy, raw materials, and manufactured goods. At the same time, shipping contributes to approximately 3 per cent of the world's greenhouse gas emissions, a figure that is expected to rise if no action is taken to reduce emissions. The 2023 International Maritime Organization Strategy on Reduction of Greenhouse Gas Emissions sets out a path for shipping to reach net-zero greenhouse gas emissions around 2050. Achieving this goal will be a phenomenal challenge, both in terms of the scale of the transition and in terms of its pace.

The maritime industry is standing at the outset of one of its greatest technological and operational revolutions, as it prepares to transition to a zero and low-emission industry through the adoption of technological innovations. It is a necessary step, as it has been unequivocally proven that the human-made emissions of greenhouses have begun to change our climate and are already affecting our lives in a tangible manner. Recent years have shown a significant increase in the world's surface temperatures, warming of the oceans, sea-level rise, and more frequent floods and fires.

Decarbonization is a global challenge, requiring ships and ports to coordinate their efforts to switch to clean sources of energy. Ports have a key role in global production. Connecting shipping and seaports to the hinterland. The global port and maritime industries facilitate up to 90 per cent of the global supply chain. For instance, in Europe, ports also play a pivotal role in terms of welfare and prosperity, and play a key role in the Blue Growth Agenda, which sets out to make Europe's oceans, seas and coasts healthy and productive.

In the future, ports are likely to act as energy hubs, creating, receiving and distributing energy to the world and to the ships themselves. Meeting this need requires developing sustainable energy sources and appropriate financial mechanisms. Maritime decarbonization needs financial instruments, which most importantly need to take into consideration the needs of developing countries to ensure no one is left behind. Therefore, it is crucial that the selection of financial mechanisms to support the transition of the current and future needs of decarbonizing the maritime sector takes developing as well as developed countries into consideration.

The role of ports in climate change mitigation, through reducing greenhouse gas and particularly carbon emissions, has received significant attention from port authorities in recent years due to increased pressure to improve environmental credibility and relevant policies and regulations. The role of ports has evolved over time. Ports are no longer the maritime service providers of the past; they are multimodal transport and logistics centres, focal points of leisure and tourism, and increasingly also hubs for sustainable industry and clean energy.

Operational and technical measures are not one-size-fits-all, due to the different strategies adopted by ports, their pollution targets, operations and management, type of terminals and additional industry considerations, such as geography, economic conditions, and competitiveness. While port mitigation of climate change is justified, reducing greenhouse gas emissions and improving energy efficiency are key pillars of achieving green and sustainable ports. Various sustainability and green port studies have emphasized this fact.

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Ports also serve as matchmakers, bringing together industries and serving as crossing points for all kinds of activities. They thus play a pivotal role in the global supply chain and in regional economies, positively contributing to greening of the maritime sector and encouraging activities and circular processes toward energy transition. Therefore, ports are important catalysts for greening initiatives, and are ideal places to develop circular economy initiatives. In this context, port energy transition and decarbonization are the core of this round table report. While it is argued that drivers and barriers to technological development exist, it is also apparent that there other policy and regulatory issues also hold back proper and widespread implementation. On another note, most of the studies that address this topic are based on technical reports and academic views with modest Involvement of ports. On this basis, and to cover these gaps, this report takes into account various stakeholders, including ports, and recognizes the power of stakeholders who may have interest in or conflict with port energy transition and decarbonization projects. This report, thus, presents the results of four roundtable discussions conducted to address contemporary issues in port energy transition, based on various stakeholder perspectives, with regard to technology, policy, business models, and global cooperation. This report is structured based on the sequence of these round tables, with the last two sections highlighting collective stakeholders' views on port energy transition and providing conclusions.



Source: Shutterstock

# PORT ENERGY TRANSITION FRAMEWORK

The following Figure presents a port energy transition framework that is utilised as the lens for the round tables. As the Figure shows, ports are seen as energy hubs contributing to the decarbonization of port operation and continuing beyond the port to shipping and the city interface. Ports can utilise the alternative fuels and renewable energy capture (solar and winds) thus combining different technologies to reach the net zero emission goal. It is worth noting that this Figure is also used as the framework for the Seenergy project (Sustainability EducationAI programme for greeNER fuels and energy on ports)



Framework adapted from Alamouh, A. S., Ballini, F., & Ölçer, A. I. (2020). Ports' technical and operational measures to reduce greenhouse gas emission and improve energy efficiency: A review. *Marine Pollution Bulletin*, 160.

# ROUNDTABLES OVERVIEW

## AIM

The aim of this roundtable discussion was to bring together relevant stakeholders to share their perspectives on the main benefits and barriers concerning four broad topics: technologies in port energy transition, policy and legislation, promising business models, and capacity building and global cooperation in maritime decarbonization, from an international and regional perspectives.

## PREPARATION AND DEVELOPMENT

- Step 1:** The WMU team contacted experts interested in the role of green technologies and building capacity in maritime and port decarbonization.
- Step 2:** The objectives, themes, and questions for each roundtable were shared with the participants, to give some guidance for their preparation.
- Step 3:** The agenda was prepared, and the stakeholders were divided into four groups. Moreover, the moderators and facilitators were selected and a notetaking mechanism was established.
- Step 4:** The roundtables were conducted, and the preliminary results were shared, highlighting the main benefits and barriers in each topic.

## PARTICIPANTS

### Roundtable 1. Technologies in port energy transition

Moderator: Alessandro Schönborn (WMU)  
Facilitator: Peyman Ghaforian (WMU)  
European Onshore Power Supply Association  
European Community Shipowners' Associations  
Waterborne Technology Platform  
Port of Trelleborg  
MTCC-Latin America  
Wärtsilä  
Ramboll

### Roundtable 2. Promising business models

Moderator: Monica Canepa (WMU)  
Facilitator: Levent Bilgili (WMU)  
RINA Consulting SpA  
Copenhagen Business School  
Copenhagen Malmö Port  
European Environment Agency  
Swedish National Road and Transport Research Institute  
Lloyd's Register

### Roundtable 3. Policy and legislation

Moderator: Fabio Ballini (WMU)  
Facilitator: Natalia Calderón (WMU)  
Chalmers University of Technology  
Copenhagen Malmö Port  
European Environment Agency  
Dublin City University  
MTCC-Caribbean  
Baltic Ports Organization  
Copenhagen Business School

### Roundtable 4. Capacity building and global cooperation in maritime decarbonization

Moderator: Anas Alamoush (WMU)  
Facilitator: Zeeshan Baig (WMU)  
MTCC-Asia  
Antwerp Port Authority  
European Sea Ports Organisation  
KEDGE Business School  
World Maritime University



# TECHNOLOGIES IN PORT ENERGY TRANSITION

The roundtable was conducted with the participation of maritime experts, including energy suppliers, research and education, port services providers, maritime technologies cooperation centres, and technology developers.

## GUIDING QUESTIONS FOR DISCUSSION

What are the most promising technologies for energy transition, and what are the main drivers and challenges for their implementation?

The comments elucidated from the experts were used to develop an inventory of advanced technologies in ports, including current and upcoming technologies (Figure 1).

**FIGURE 1. TECHNOLOGY INVENTORY**



The next step was to examine the drivers of and barriers to deployment of these technologies at ports as shown in Table 1.

In the final stage of the roundtable, experts provided the main barriers for new technology, implementation and their recommendations on how to overcome the barriers identified (Table 2 and Table 3).

**TABLE 1. DRIVERS OF DEPLOYING TECHNOLOGIES AT PORTS**

**BENEFITS AND DRIVERS**

- Goal setting
- Ambitious goals
- Social image
- Environmental awareness
- Public relations
- Philosophy of sustainability
- Customer pressure
- Port expansion
- Compliance with regulations
- Competition
- Licence to operate
- Noise

**TABLE 2. BARRIERS AND CHALLENGES TO DEPLOYING TECHNOLOGIES AT PORTS**

**BARRIERS AND CHALLENGES**

- Lack of regulatory clarity (risk of “stranded assets” and investments)
- Safety issues for society, port operators, and ship staff
- Lack of space in ports
- Lack of technological maturity
- Human element
- Lack of expertise in port operators



**TABLE 3. RECOMMENDATIONS TO DEPLOYING TECHNOLOGIES AT PORTS.**



**RECOMMENDATIONS**

- Facilitate training
- Enable reskilling
- Invest in infrastructure
- Collaborate
- Promote communication between stakeholders
- Invest in research and development
- Develop incentive programmes in ports and fairways
- Develop business models (for example for joint efforts by ports and fuel producers)
- Support small and medium enterprises (all ports)
- Establish bunkering hubs (in green corridors)
- Share best practices/lessons learned
- Ensure operational optimization
- Utilize financiers
- Encourage contributions from end customers
- Commission pre studies (risk assessment, technical feasibility and economic feasibility)
- Take an ecosystem approach
- Focus on action
- Create the right funding opportunities
- Ensure upstream (fuel supplier) inclusion
- Ensure youth inclusion
- Promote start ups





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# POLICIES AND LEGISLATION

Policy and legislation are pivotal in the pursuit of port decarbonization: they provide a regulatory framework and set clear environmental goals for the maritime and port industries. Governments can establish emission reduction targets and enforce environmental standards, incentivizing ports to adopt cleaner technologies and greener practices. These regulations also enable governments to monitor and penalize non-compliance, creating a strong impetus for ports to actively work towards decarbonization.

On the other hand, policy and legislation play a critical role in fostering innovation and investment in sustainable technologies. Governments can offer financial incentives, tax benefits, and subsidies to encourage ports to invest in renewable energy sources, electric cargo handling equipment, and other eco-friendly solutions. Additionally, carbon pricing mechanisms can internalize the environmental costs of carbon emissions, further motivating ports to reduce their carbon footprint. Overall, well-crafted policies and legislation are essential for shaping the strategic direction of port decarbonization efforts and aligning them with broader climate goals.

## GUIDING QUESTION FOR DISCUSSION:

What are the major challenges and barriers to designing and implementing an energy policy toward the decarbonization of port sectors?

Two broad topics (drivers/benefits and barriers/challenges) were discussed, and the main contributions are presented in Table 4.

**TABLE 4. DRIVERS AND BARRIERS OF POLICIES AND REGULATIONS FOR PORT DECARBONIZATION.**

### DRIVERS AND BENEFITS

- The importance of implementing national and international legislation to reduce carbon emissions in ports
- The potential of partnerships to facilitate the greening of the shipping sector
- The role of national policy in promoting green transition in ports
- Improving procurement strategies in public ports
- Involving additional stakeholders in policy design
- Designing well-structured collaborative projects for a green transition
- Exploring opportunities for methanol and ammonia production

### BARRIERS AND CHALLENGES

- The need for cooperation with various stakeholders to decarbonize the port sector
- Challenges in decarbonizing shipping due to lack of market availability of suitable fuels and government priorities
- Complexity of regulation and accountability in developing countries that are major flag states but not necessarily beneficiaries of shipping state interests
- The importance of identifying the volume of finance required to support the decarbonization process
- The need for consistency in policies at local and international levels, and the importance of solving global-level problems at the global level





The roundtable focused on the challenges and opportunities in the decarbonization of ports and shipping, particularly on policies and regulations. The participants represented various stakeholders such as: the research and education sector, port management bodies, and international organizations. The discussions highlighted the importance of stakeholder engagement, the need for a business model that supports decarbonization, and the potential benefits of greening ports. In addition, the complexity of stakeholder analysis and the need for cooperation and collaboration were emphasized.

Moreover, the role of national and international legislation was discussed, along with the need for green infrastructure in ports. The meeting discussed the challenges and opportunities in transitioning ports to greener operations. The roles of governance, regulations, and stakeholder involvement were highlighted as key factors. The following actions were recommended by the stakeholders for the development of policies and legislation in port decarbonization (Table 5).

**TABLE 5. RECOMMENDATIONS FOR POLICIES AND REGULATIONS**



#### **RECOMMENDATIONS**

- Ensure consistency and uniformity in policies at local and international levels
- Meet the need for creating a green infrastructure in ports
- Estimate the public financing needed to create infrastructure in ports for the zero-carbon transition of the shipping sector
- Promote national policy for green transition in ports
- Develop a variety of strategies for private and public sector ports to move towards decarbonization
- Explore ways to incentivize green transition among stakeholders

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# PROMISING BUSINESS MODELS

There has been a notable transition towards more advanced and decentralized energy systems, to promote the global adoption of sustainable energy transitions. This transformation aligns with the emergence not only of suppliers but also of consumer-centric markets, and has ushered in new value streams in the energy sector.

Improving connections and collaboration between ports and neighbouring urban areas brings specific benefits to urban ports. This cooperative effort fosters the creation of an integrated energy system that facilitates the exchange of energy resources between various stakeholders. Furthermore, it encourages innovation and the creation of new business models, thus strengthening the resilience competitiveness of the port sector. New business models should be adopted along the entire value chain.

The round table was conducted with the participation of maritime experts (from research and education, energy transition facilitators and technology developers).

It was concluded that developing appropriate business models for the green transformation process depends on the individual stakeholders involved. Ports are facilities that provide services in multiple dimensions – such as social value, local economic development, and facilitating connectivity – and should be modelled accordingly. The requirement that each port must operate within the laws and local practices of the country in which it is located leads to severe limitations in the implementation of uniform business models.

## GUIDING QUESTIONS FOR DISCUSSION

What are the most promising business models for ports to successfully transition towards energy sustainability, and what are the key benefits and challenges associated with their implementation?

During the discussions, it was evaluated that the existing ports appeared to be limited due to the European Union stopping use of fossil fuels. There were also concerns that the green transformation was lagging behind other processes in the ports. Another limitation raised was that large oil companies could potentially slow down the green transformation.



It has been stated that ports are not desirable structures for the residents around the port because of pollution. Nevertheless, they create employment and offer various opportunities for the local community. As a result, a consensus was reached on the outputs as shown in Table 6.

**TABLE 6. RECOMMENDATIONS ASSOCIATED WITH PROMISING BUSINESS MODELS**



#### RECOMMENDATIONS

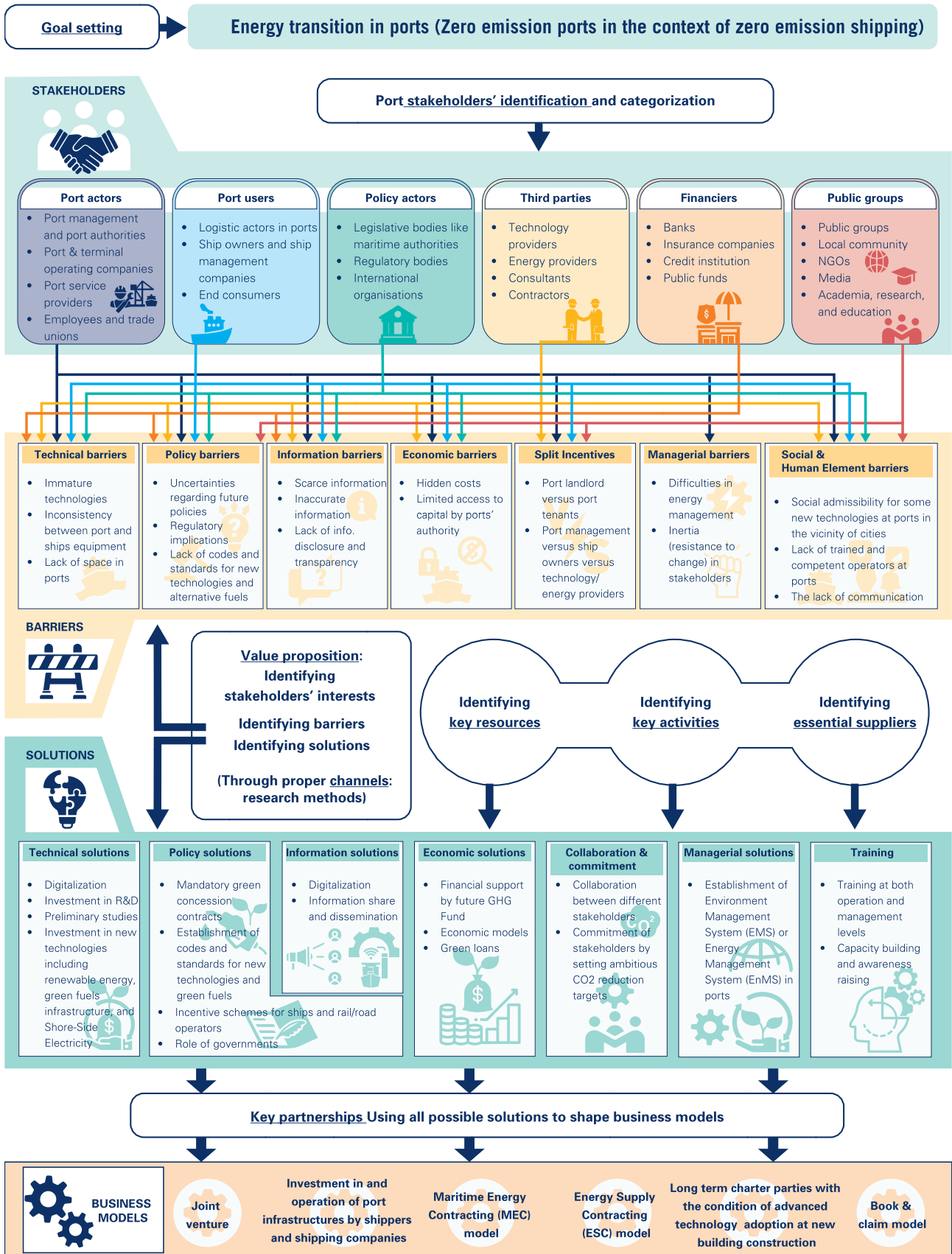
- Manage ports with a proactive model, in which the local community and port stakeholders can participate more in the processes (it should be highlighted that local laws and the lack of a mindset prioritizing maximum social benefit rather than maximum profit are key shortcomings).
- Identify the future stakeholders in new business models, to accelerate the green transformation and encourage more stakeholders to be included in the process (however, cultural differences, the fact that ports do not have much of a place in the final consumer's perception, and the slowing effect of large oil companies were evaluated as significant constraints).
- Shape business models according to local needs; this transformation could pave the way for ports to become energy hubs (I resistance of the port management to changing its mindset has been determined as a constraint).
- Consider transporting offshore electricity production through ports as another business model, as this process can increase the efficiency of the ports (it has been predicted, though, that there may be difficulties due to the need for more space and the high initial investment cost, and It is also possible that the process will progress slowly as more cooperation will be required).

As a result of brainstorming at the various roundtables, port stakeholders were recognized, barriers to port energy transition were identified, and solutions were offered. Then the following steps in design of a business model were taken: goal setting, identification of stakeholders, value proposition, identifying barriers and solutions, identifying key resources, key activities, essential suppliers, and as a final step, key partnerships. Based on the results of this activity, different business models, as shown in the following figure, were recommended and discussed.



Source: Shutterstock

# PROMISING BUSINESS MODELS



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## PROMISING BUSINESS MODELS

### Joint ventures

A joint venture is a form of corporate cooperation in which two or more independent organizations establish and maintain a separate legal organization in order to collaborate for mutual strategic interests and based on equity arrangements. As an example, joint-venture terminals are the result of close cooperation between port terminal operators and shipping lines.

### Investment in and operation of port infrastructures by shippers and shipping companies

Shipping companies can invest their technical expertise and capacity in the development and even operation of port infrastructure that aligns with the equipment onboard their vessels. In this model, even shippers (cargo owners) can invest in port infrastructures.

### Maritime energy contracting (MEC) model

Even though this model is the result of close cooperation between technology providers and ship owners, technology providers can at the same time invest in port infrastructure to ensure consistency between ship and port technologies. As a result, shipowners can be reassured that new technologies installed onboard are compatible with port equipment and, in addition, port management can maintain loyal customers for their energy efficiency investments.

### Energy supply contracting (ESC) model

In the ESC model, energy is provided at the consumption point (such as the port) by energy providers (producers and transporters) to clients (for example the ports) that are economically less powerful and are not motivated to invest in such a distribution network.

### Long-term charter parties

It is typical for long-term charter agreements to be conditional on the shipowner's commitment to adopting energy efficiency measures or alternative fuels (these are ships engaged in trade between specific ports). Therefore, for the feasibility of this model, it is crucial that these ports be compatible with the technologies installed on the ships and provide alternative fuels for them.

### Book and claim model

The book and claim model refers to a system where renewable energy certificates, such as clean propulsion or sustainable shipping practices, can be traded independently from the physical energy consumption. Using this system, shipowners and fuel providers can build up a business model for decarbonizing shipping by developing early demand from shippers, even when there is no established fuel pathway. By implementing the book and claim model, the gap between supply and demand for alternative fuels can be bridged. As a result, alternative fuels are consumed where there is supply, and their benefits and costs are dedicated to those areas where there is demand. Ports have a significant role in the design and implementation of this model, due to their contribution to the energy supply chain and the geographical scattering of supply points.

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# CAPACITY BUILDING AND GLOBAL COOPERATION IN MARITIME DECARBONIZATION

Capacity building and global cooperation are essential elements in the pursuit of port and maritime decarbonization. The former ensures that stakeholders – from industry professionals to policymakers – are trained with the knowledge and skills they need to handle the complexities of their decarbonization goals. This knowledge transfer is essential for effective implementation of new technologies, and implementation of new operational procedures. Moreover, global cooperation facilitates the exchange of best practices, innovative solutions, and resources on the national, regional, and international scales. Ports and maritime entities collaborating globally can create collective expertise, share knowledge and advancements, and address common challenges. In a field as interconnected as maritime transport, encouraging a collaborative global milieu through capacity building is fundamental to achieving meaningful progress towards decarbonization goals.

Despite understanding the relevance of capacity building and global cooperation, several stakeholders highlighted the difficulties of this joint work. Currently some countries, especially in the European Union, have ambitious goals to reduce greenhouse gas emissions almost to zero by the year 2050. Although these requirements are difficult to meet in developed countries, the challenges are multiplied from the perspective of developing countries, where the cost of borrowing is usually higher than any projects developed, for example, in the European Union or the United States, and technology is often not available.

## GUIDING QUESTIONS FOR DISCUSSION

What are the main drivers and barriers for implementation of energy transition?



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The panellists proposed several solutions and recommendations for maritime and port decarbonization, as is shown in Table 7.

**TABLE 7. SOLUTIONS AND RECOMMENDATIONS FOR DECARBONIZATION.**



**RECOMMENDATIONS**

- Develop regulations as a backstop.
- Cooperate at local, regional, sub-regional, and international levels.
- Share information based on knowledge.
- Share awareness.
- Develop an inventory for effective measurement.
- Utilize green finance.
- Engage with stakeholders.
- Streamline issuance of permits.
- Provide financial support.
- Strengthening governance institutions.
- Explore new business models.
- Secure political commitment.
- Conduct ESG analysis.
- Building the resilience of ports to shocks.

Currently the maritime sector is facing a complex set of challenges and opportunities. Key issues include the need for decarbonization efforts, capacity building, and international cooperation. For instance, the unique nature of Caribbean shipping has been emphasized, along with the importance of data collection and technology demonstration projects. The speakers underscored the need for a unified voice to advocate international financing for climate change. Challenges in safety and quality standards, limited space and efficiency for implementing new technologies, and obstacles to accessing climate finance due to low demand were highlighted. The inability to enforce maritime conventions due to gaps in domestic law and the proposal for a new global financing pact for climate change add to the intricate landscape.

Among these challenges, there are opportunities for decarbonization through digitalization, electrification of ports, and consensus building at the IMO and regional levels. Investment should be secured in electrification of ports and maritime infrastructure, with a particular need for private sector involvement and stakeholder leadership. The proposal for a new global financing pact for small island developing states (SIDS) and least developed countries (LDCs) was reiterated, underlining the importance of international cooperation and collective responsibility for addressing climate change.



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# ANALYSIS OF STAKEHOLDER VIEWS ON PORT ENERGY TRANSITION

At the end of the roundtables, a questionnaire was passed to all the stakeholders, intended to collect data and insights from stakeholders in the ports industry regarding the energy transition and decarbonization efforts in ports. This analysis focuses on the stakeholders' views on various aspects of port decarbonization, and the following points provide a summary of their responses.

## Prioritizing technology

The stakeholders were asked to rank the technologies that ports should focus on to start the transition to decarbonization. The responses signified that there was an equal emphasis on shifting to alternative fuels and electrification of equipment, with renewable energy capture also considered important. This suggests that stakeholders should acknowledge the need for a multi-faceted approach to achieve decarbonization in ports.

## Barriers to port decarbonization

Stakeholders were requested to rank the barriers to port energy transition and decarbonization. The responses highlighted six main barriers: regulatory, social perceptions, economic, administrative and managerial, information and awareness, and technical. The stakeholders ranked regulatory and social perceptions as the lowest barriers; and emphasized the importance of addressing economic challenges, improving administrative and managerial processes, and raising awareness and knowledge about decarbonization.

## Level of decarbonization in port agenda

Stakeholders were questioned about the level of decarbonization included in the port agenda. Stakeholders acknowledged the importance of integrating decarbonization efforts at higher levels of the port agenda, indicating a commitment to long-term sustainability goals.

## Separate department for port decarbonization

Stakeholders were asked if they believed port decarbonization should be addressed in a separate energy department. Most respondents expressed the view that port decarbonization should be separate. This suggests that stakeholders recognize the need for dedicated focus and expertise to effectively drive the energy transition in ports.

## Priority areas for ports

Stakeholders were requested to prioritize areas that ports should focus on and reform to expedite decarbonization implementation. In the responses stakeholders emphasized managerial aspects, business models, widening cooperation and collaboration, energy production, and financial instruments. While this highlights that stakeholders prioritize collaborative efforts, it indicates the need for comprehensive strategies, long-term planning and financial support to accelerate the decarbonization process in ports.

In conclusion, analysis of the stakeholder views captured through the questionnaire reveals a collective emphasis on technology adoption, addressing key barriers, integrating decarbonization into port agendas, considering establishing a separate department for decarbonization, and prioritizing specific areas for expedited decarbonization implementation. These insights provide crucial guidance for establishing effective strategies and a roadmap for achieving carbon neutrality and sustainable operations in the ports industry.

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# CONCLUSION

The roundtables served as a forum for in-depth discussions of drivers and challenges in the pursuit of port decarbonization, as well as potential courses of action encompassing technology, business models, policies, and regulations. During the sessions, participants highlighted the following key issues:

- Addressing port decarbonization requires a comprehensive approach that brings together various stakeholders and strategies.
- Collaboration is of key importance, and can enable partnerships between the private and public sectors to combine resources and expertise.
- Measures such as tax breaks, subsidies, and financial support can incentivize the adoption of environmentally friendly practices.
- Investment in technology and infrastructure is essential to reduce emissions in port operations. The development of comprehensive decarbonization strategies that encompass both the private and public sectors is crucial for a cohesive and effective approach, in addition to local, regional, and global cooperation.
- Research and development initiatives are vital, and should be accompanied by training programmes.
- Stricter regulations, effective monitoring systems, voluntary agreements and cooperation are vital to enable the transition towards cleaner ports.
- Market-based measures and investments in green finance offer benefits by incentivizing emissions reduction.

Participants emphasized the need to adopt a multifaceted approach to achieve port decarbonization. This approach will be pivotal for overcoming the six primary barriers faced by port stakeholders: regulatory, social perceptions, economic, administrative and managerial, information and awareness, and technical challenges. The involvement of stakeholders in decision-making processes plays a critical role. It is imperative to integrate and engage managerial levels with a long-term commitment.

This approach is intended to establish a clear and adaptable business model, which has been identified by participants as one of the highest priorities for ports. Recognizing the role of port stakeholders in climate change mitigation is a crucial pillar. Their active involvement contributes significantly to enhancing environmental credibility and shaping impactful policies and regulations towards the decarbonization of the shipping sector.

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