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Circular Economy in Maritime Logistics: Evaluating End-of-Life Strategies of Vessels and Comparing Turkey to Western Europe

By

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Acknowledgments

It is hard to believe that just a year ago, I packed up my life and moved to the Netherlands; this year was full of personal and professional growth and extraordinary experiences.

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To my fellow MEL students, thank you for the shared experiences and support. You made this journey both enriching and enjoyable. I really appreciate all your support in the past year. To my family and friends, thank you for believing in my work and for helping me to be realistic about my successes and failures.

To my family and friends, thank you for believing in me and keeping me grounded through the highs and lows of this journey. It has been almost five years since I took an exam, so I know I sounded dramatic throughout this year, but in the end, I did it.

Lastly, I dedicate this thesis to all those working towards a sustainable and circular economy in the maritime and logistics sectors. I dare hope that, although this may sound very cliché, this research will assist in making this world a greener planet.

Abstract

This thesis delves into implementing circular economy (CE)principles in maritime logistics, explicitly focusing on the end-of-life (EOL) recycling of vessels and a comparison to Turkey and Western Europe. The goal of the study is to evaluate the viability and effectiveness of recycling vessels, choose the best methods for improving practices.

The maritime industry is challenged when dealing with EOL vessels, which pollute the environment and waste resources. This paper discusses how industry can lessen waste and minimize its detrimental effects on the environment and how to recover the commodities using a circular economy approach. It analyses EOL recycling processes in Turkey and Western Europe. It highlights best practices and areas for improvement.

The research method involves both a qualitative and quantitative approach, which includes recycling methods, industry analysis, interviews, surveys and questionnaires. Information on the environmental and economic effects of vessel recycling is used to evaluate activities in these areas and to outline further improvements.

The findings also show that maritime logistics poses several challenges in recycling processes and, at the same time, features various opportunities for sustainability improvements. When comparing Turkey and Western Europe, disparities exist in the level of efficiency and sustainability impacts, which indicates the potential for cross-culture knowledge transfer to encourage better practice.

On that note, this thesis offers policy, industry, and research recommendations on how the circular economy could be promoted in maritime logistics. By embracing these principles, industry can move towards more sustainable practices, contributing to global environmental goals and economic resilience."

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List of Abbreviations

Abbreviation	Meaning
CE	Circular Economy
GSDR	Global Sustainable Development Report
PMEH	Program on Pollution Management and Environmental Health
PROCLEAN	Program on Pollution Management and Circular Economy
BIMCO	Baltic and International Maritime Council
CEAP	The EU Circular Economy Action Plan
WCPO	Western and Central Pacific Ocean
EOL	End of Life
SBRI	The Ship Scrapping and Recycling Industry
MEPC	Marine Environment Protection Committee
SSI	Sustainable Shipping Initiative
EU SRR	European Union Ship Recycling Regulation
LCA	Life Cycle Assessment
ELV	End-of-Life Vehicles
IHM	Inventories of Hazardous Materials
LDT	Light Displacement Tonnage
ISRA	The International Ship Recycling Association
IMO	International Maritime Organization
EPR	Extended Producer Responsibility
R&D	Research and Development

Chapter 1: Introduction

The research method involves a qualitative and quantitative approach, including industry analysis, ship recycling methods, interviews, and questionnaires. Information on the environmental and economic effects of vessel recycling is used to evaluate activities in these areas and to outline further improvements.

It is also noticeable that the findings show that maritime logistics poses several challenges in recycling processes and, at the same time, featured various opportunities for sustainability improvements. When comparing Turkey and Western Europe, there are disparities in the level of efficiency and sustainability impacts, which indicates the potential for cross-culture knowledge transfer to encourage better practice. This thesis offers policy, industry, and research recommendations on how the circular economy could be promoted in maritime logistics.

This thesis explores the adoption of CE principles in maritime logistics with a specific emphasis on vessel EOL recycling. It assesses the sustainability, economic feasibility and environmental effects of the present ship recycling techniques and establishes a comparison with Turkey and Western Europe. The paper will focus on shipbreaking industry generally and later on focusing on Western Europe and Turkey. The research objectives of the current work are to find out the best practices and present recommendations for enhancing the CE approach in the maritime sector.

Several key questions guide the study:

- How strong are the current ship recycling practices regarding sustainability and economic feasibility?
- What lessons can be learned from Turkey and Western Europe's strategies to create a more CE approach?
- How can CE principles be better integrated into the maritime sector, especially shipbreaking practices, to provide better environmental and economic outcomes?
- What is the difference between the CE approach from Turkey and Western Europe?

These questions are crucial to the maritime industry, policy makers, other players in the industry, and researchers because they are faced with the challenge of establishing and

encouraging better sustainable and efficient ship recycling methods. With the above background provided, the following questions have been formulated to guide this research with a view of coming up with valuable and practical recommendations that can help to improve the economic performance, implementation of CE and therefore sustainability of the industry.

With the purpose of providing policies and implications for policymakers, industry actors, and researchers, the research questions of this thesis focus on opportunities and challenges of CE adoption. Finally, the overall purpose of the book is to promote the improvement of the ELV management so as to have a positive impact on the environment and the economy of the ship recycling industry. Some possible enhancement to the CE include; The environment may be conserved, resources may be used in the right manner, the economy may be boosted.

Section 1.1: Background

Maritime business is one the most vital sectors of the global economy since four-fifth of the world trade by volume is via the world's sea. But there remains a big question mark on environmental impact in this industry, particularly on the management of ship recycling towards the end of its useful life. These ships are usually broken down in the third world and this is dangerous because they are toxic to the environment and sensitive health of human beings. After all, proper safety measures are not followed during the disposal of the ships, and waste is poorly handled. This is a significant environmental risk that must be addressed and solved as soon as possible, especially in maritime activities. Since the world is progressing towards decarbonization, recycling is inevitable in the maritime industry. Recycling vessels and the integration of circularity, which is CE, will be the main concern of this study. Labeling old vessels as waste is an incredibly wasteful concept. In this paper, we will look at how we can improve on the recycling of ships with an emphasis on the safety of the environment and workers.

As a result of the current hurdles; the CE has emerged as a new model, which can assist in solving the issue more effectively and especially with a focus on sustainability. Unlike the 'Linear economic model' where resources are taken, transformed into products and then disposed off, the CE focuses on renewability, restoration, recovery and remanufacture of products. In essence CE approach seeks to minimize the harm of the environment, and magnify

the amount of materials that can be reused in order to provide value. The possibilities the CE can offer the maritime sector are enormous and encouraging.

In order to grasp the possibilities for enhancing the efficiency of maritime logistics one has to know how different countries and approaches are. For example, in Western Europe the ship recycling practices involve dry-docking while in Turkey, the ship recycling practices involve the landing method. We will discuss various practices and contrast them according to economic, environmental and sustainability.

It is possible to apply the CE principles in the context of maritime logistics and it is also rather crucial. This programme is a complete one since it embraces a number of activities that revolve around the vessels including the designing of the vessels up to the disposing and recycling of the vessels. The idea is to create a loop reactor that may recycle all the material from the ships which are to be scrapped so as to reduce the impact of the industry on the environment. This paper is concerned with CE principles which are deemed important.

One of the major aspects of CE in the maritime industry is the Longevity of ships and ships that can be easily disassembled and or recycled. This means that it is possible to give disposable parts and design features and components that can be easily disassembled and reused. It also contributes to conservation of the vessels and can also facilitate the recycling hence decreasing on wastes and pollutions.

The GSDR pointed that the maritime industry is lagging in achieving the sustainable development objectives. This paper also looks at another problem, which has hampered the increase in the sustainability rate in the maritime industry.

Increase of CE practices in maritime logistics requires that certain legal and policy measures be put in place. The Hong Kong International Convention and other international conventions are formed with the purpose of improving the ship recycling frameworks. However, these regulations do not have a clear and strong stance on the importance of strengthened international cooperation and effective compliance measures; in this paper, we will focus on the EU and Turkey’s approach to the CE and what can be learnt from other sources of regulation such as the Hong Kong International Convention.

This thesis will assess the current practices of ship recycling in terms of sustainability, economic efficiency, and environmental effects and contrast Turkey to Western Europe. In this

way, the research wants to contribute relevant findings concerning the identification of the application of CE in the field of maritime logistics. The thesis will cover shipping practices in general and then focusing on Turkey and Western Europe.

Section 1.2: Research Question, Sub-Research Questions, and Objectives

Research Question:

What are the circular economy strategies that can be adopted in the maritime logistics with regard to Turkey and Western Europe?

Sub-Research Questions:

1. Where do we stand today in terms of management and difficulties of recycling of vessels at the end of their life in the context of maritime logistics?
2. What is the difference between environmental and economic consequences of vessel recycling methods?
3. Which of the existing ship recycling practices can be effectively used to increase the effectiveness of maritime logistics?
4. Which legal and institutional arrangements are in place for the advancement of circular economy in ship recycling and how efficient are they?
5. What are the challenges, which hinder the implementation of circular economy concepts in the sphere of maritime logistics?

Objectives:

1. To evaluate the existing vessel recycling practices globally and the problems and shortcomings of the process.
2. To compare and assess the effect of environmental and economic costs on the recycling of the end-of-life vessels from Turkey and Western Europe
3. Describe the current regulations for providing legal backing to CE activities in ship recycling including the ‘Hong Kong Convention’ as well as the EU’s, ‘new Circular Economy Action Plan’.
4. The objective of this study is to explore the factors that enhance and hinder the adoption of circular economy in maritime logistics, problems that persist and how they can be addressed.

5. Thus, the directions for the subsequent chapters of this work will be recommendations for policymakers, industry members, and researchers regarding the application of a circular economy in maritime logistics.

Section 1.3: Research Design and Methodology and Data Collection Methods

The present work has both quantitative and qualitative research methods incorporated in the framework of the study. The use of mixed methods is to understand how the CE principles are applied in maritime logistics, particularly in vessel recycling.

1. 3. 1 Literature Review

• Objective: To provide a basis for understanding circular economy concepts, their evolution, and their implementation within different industries, including the maritime sector. To understand current regulations and compare them.
• Scope: Peer-reviewed articles, scientific papers, industry publications, official guidelines, and publications from recognised CE institutions.
• Method: Therefore, an extensive literature search and review of the information sources were conducted to establish important terms such as CE, practices, advantages, disadvantages, and possible solutions.

1. 3. 2 Surveys

• Objective: To analyze the cases of CE application in maritime logistics and compare Turkey to Western Europe.
• Participants: The surveyors are chosen from respondents in the maritime industry, including captains, ship recycling companies, ship builders, and regulatory bodies.

• Method: The questions to be put forward during the survey will be five in number:

The participants briefly tutored about CE and what CE practices are, clarifying any confusion regarding the survey.

1. What are the significant activities and difficulties involved in the recycling of ships at the end of their useful life?
2. What are the differences in the impact of the recycling of recycling ships to that of recycling of land vehicles?
3. What measures in respect of recycling of land vehicles may be beneficial for ship recycling?
4. To what extent have the current laws and policies successfully contributed to the circular economy in ship recycling?
5. What are the most significant barriers to implementing a circular economy in maritime logistics?

1. 3. 3 Interviews

• Objective: To get information from the targeted groups, including shipbuilders, scrap yards, governments, and other interested parties, about the current state of CE in maritime logistics and the problems and prospects for its further development.
• Participants: The target population will include stakeholders and gurus in maritime logistics, especially those who specialize in recycling. To maintain anonymity all participants of the interview were assured that their identity would remain unknown to any third party. In any section of this research, no names, jobs or other features that can point towards the subject are provided. All material gathered from the participants of the interview was confined to the study; hence any work done on their response was done anonymously.
• Method: Semi-structured interviews may be face-to-face, telephonic or video interviews. All the interviews are audio-taped and then written down for analysis.

1.4 Data Analysis

• **Qualitative Analysis**: Thematic analysis of interview transcripts and current data of Turkey and Western Europe to identify current issues, opportunities, and solutions.

• **Quantitative Analysis**: Statistical analysis of survey data quantifies recycling practices and CE impacts. Comparative analysis elucidates differences and similarities between Western Europe and Turkey.

• **Synthesis**: Utilize qualitative and quantitative findings to holistically comprehend CE in maritime logistics and compare it from Turkey to Western Europe.

Chapter 2: Literature Review

2.1: Definition of Circular Economy

The CE model is an economic model that focuses on reducing environmental burdens and increasing circular and reusable resources. The aim is to reduce resource use, waste generation, emissions, and energy consumption by designing products with long lives and maximum utility from the design stage up to the EOL.

The CE is rooted in several principles to ensure the development of a sustainable economic system. The Ellen MacArthur Foundation (2013) outlines three core principles:

1. “Design Out Waste and Pollution: Rethinking and redesigning products and processes can minimize waste and pollution.”

2. “Keep Products and Materials in Use: Extending the lifecycle of products through reuse, repair, refurbishing, and recycling.”

3. “Regenerate Natural Systems: Enhancing natural capital by returning valuable nutrients to the soil and other ecosystems.”

The concept of the CE has emerged as the best way of addressing the environmental and economic issues of the linear economy. To make future consumption patterns more sustainable, we must shift from the ‘take-make-dispose’ model to the ‘reduce-reuse-recycle’ model. This review aims at identifying the major ideas and discussions on CE and its implementation within

different industries with special emphasis on maritime logistics.

It is possible to identify the CE as a development of the sustainability discourse. Stahel and Reday (1981) proposed the concept of 'closed loop' economy in their work on the performance economy that provided the foundation for today's CE as we know it. Braungart and McDonough's (2002) 'Cradle to Cradle' concept, which 'seeks to eliminate the negative and create the positive' also played a key role in the advancement of CE by providing the design of products that are in a continuous loop, and safe for people and the environment.

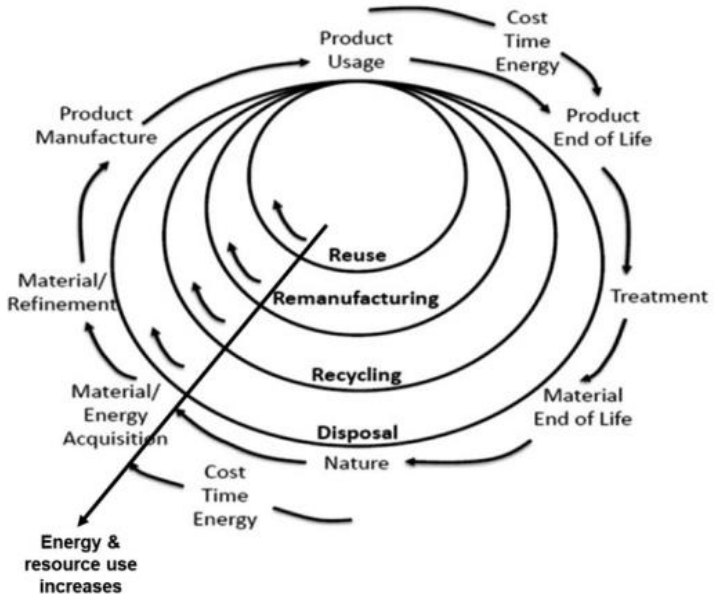


Figure. 1. The current concept of circular economy (for the graph, see Mihelcic et al., 2003).

Increase of CE practices in maritime logistics requires that certain legal and policy measures be put in place. The Hong Kong International Convention and other international conventions are formed with the purpose of improving the ship recycling frameworks. However, these regulations do not have a clear and strong stance on the importance of strengthened international cooperation and effective compliance measures; in this paper, we will focus on the EU and Turkey's approach to the CE and what can be learnt from other sources of regulation such as the Hong Kong International Convention.

According to Taylor&Francis(2023), the leading advantage of implementing a circular economy in maritime logistics is the minimization of negative effects on the environment. Some of the circular economy strategies include the three R's, which include recycling, refurbishing, and reusing materials in order to cut down waste and conserve natural resources. For instance, recycling end-of-life vessels helps avoid ocean pollution by substances such as asbestos, heavy metals, and oil residues. Also, it helps to minimize the carbon footprint by reducing the amounts of new materials and energy used in the manufacturing processes.

D.Razmjooei(2024) mentioned that; it is, therefore, important that circular economy models be adopted since they are likely to result in lower costs in the future. This way recycling of materials and components assists companies to reduce the use of new and expensive inputs. Some of the parts that can be recycled include steel, copper and aluminum used in the ship for instance, it not only reduces the cost of acquiring the new ones, but also opens the market for secondary products. Also, the reduction of the costs that are associated with the disposal of wastes and the fines that come with the improper disposal can only be seen as a positive for the financial aspect of companies within the maritime industry.

According to The Sustainable Shipping Initiative(2023), adopting circular economy principles in the maritime logistics system may assist in increasing the useful life of vessels and other related facilities. To this end, through implementing measures like refit, retrofit, and upgrade, ship owners can enhance the number of years of service of their vessels, hence deferring the capital outlay that comes with new constructions. This also enables companies to retrofit previous ships in order to conform to existing regulations or new technologies without having to spend for new vessels.

This paper shows that adopting circular economy strategies sparks innovation in the maritime industry. Those companies that adopt circularity are more likely to experiment with new business models; for instance, they can offer ships as a service or create new recycling solutions. This is because it will make them stand out in the market as the leading companies in sustainability practice. Furthermore, since more and more regulatory authorities and consumers pay attention to sustainable approaches, embedding the circular economy principles can enhance a company's standing in the market.

The awareness and concern about sustainability and increased stringency of laws and standards on waste disposal and emissions make the circular economy model strategic for organizations to

implement. Thus, the advance adoption of circular economy principles can help maritime organizations prevent the consequences of legal violations, including fines and sanctions, as well as the loss of the company's reputation.

This can bring about increased social benefit, for example, through job creation in the recycling, remanufacturing, and refurbishment sectors. It also helps in improving the company's relationship with its key stakeholders, such as customers, investors, and regulatory agencies, as the firm shows its concern for the environment. A company considered a sustainability leader will be trusted by the public, get talented employees, investors and customers.

2.2 The Problems of Circular Economy in Maritime Logistics

The industry and the related business are conducted through a long supply and distribution chain, including shipyards, shipping lines, ports, recycling facilities, and various agencies. In such a network, everyone has to work in harmony and coordinate well to achieve circular economy practices. It is hard to guarantee the clear and tangible tracking of the materials as they move through the supply chain, especially when the business has an international dimension and is subjected to different sets of rules.

According to Dogancan Okumus and co authors (2023), some regions have supportive policies for circular economy approaches while others have no clear or strict policies that may hinder innovation. This is because circular economy practices may differ from one country to another depending on the prevailing laws, and this creates a challenge for the companies in the maritime sector. In addition, the present legal frameworks are mostly based on the conventional sequential approach and may not easily harmonise with the circularity concepts like product service schemes or ship material passports.

University of Warwick(2024) mentioned that; however, the technologies being available today may not cover all the aspects of the circular economy in the maritime industry. For instance, the recycling of some of the materials used in ship construction such as composite materials has not been well developed. Also, there could be a problem of inadequacy of tools and equipment used in determining the state of parts of the ship and their suitability for reuse hence creating inefficiency or loss of potential in the recycling process.

From the above analysis it is clear that the circular economy has been evaluated to be based on market mechanisms. For instance, the volatility of the prices of the recycled materials affects the outcomes of the recycling process. Also, the demand for secondary resources and remanufactured goods could be unpredictable and this is a threat to circular economy firms that depend on such sales. This ambiguity is not advisable because it discourages organizations to adopt circular economy models in the future.

It is necessary to change the mentality and structure of organizations and societies and move from the linear "take-make-dispose" model to the circular one according to Pınar Ozkan (2020). This can be quite complicated in an industry such as maritime logistics, where there are set procedures and rules. Some of the challenges may include employees' and management's reluctance to change due to fear, inconvenience, or lack of motivation.

According to Mihelcic(2003), circular economy practices are not always easy to implement in the shipping industry, and this is where close cooperation between shipping companies, ports, recyclers, and regulators is crucial. Despite this, it is possible to observe that there is not always a high level of cooperation and communication between these parties. The circular economy calls for public-private cooperation to build such partnerships, yet divergent goals, adversary objectives, and skepticism can stifle

such collaboration.

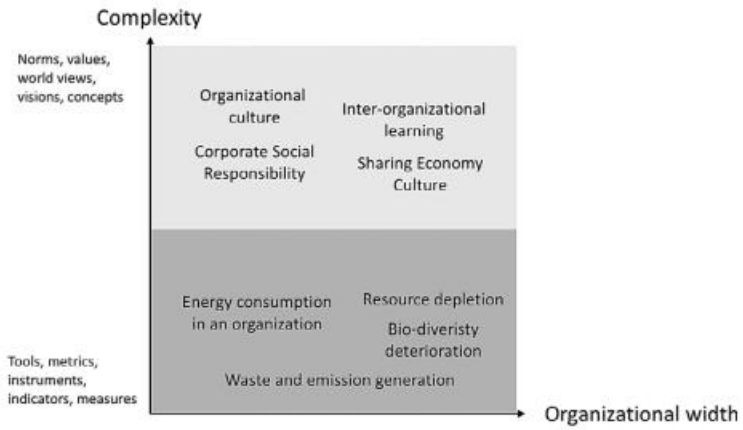


Figure 2. The current concept of circular economy (for the graph, see Mihelcic et al., 2003).

BIMCO(2022), explains the recycling process of vessels as follows: "Like our cars, all ships have a life cycle, a time when they become uneconomical and uneconomical to run" . In this vein, this approach is most suitable in the maritime industry because a lot of material things are

used in constructing and using ships. The application of CE concepts can help the maritime industry to minimize its adverse effects on the environment and tap business opportunities in dealing with Ship and Barge Recycling Opportunities. This review will also identify the opportunities for the European Union (EU) in the advancement of circular economy principles within the maritime industry so that there is hope for the future.

The CE is advantageous to the maritime industry because it affects a lot of parts which are used in ships and barges. Some of the ways through which companies can implement CE practices include; incorporating green materials in the production of ships, designing ships with the aim of disassembling them easily and recycling the components and products created during the ship's lifespan. This shift is also important because it not only minimises wastage but it also helps in the retrieval of resources.

Rehmatulla and co-authors (2017) show that CE can lead to significant reduction in the use of resources and waste generation especially in the maritime transport. They underscore the importance of cooperation of the industry and the supportive measures for such change.

The CE has been supported by the EU, for instance, through the Circular Economy Action Plan, which seeks to encourage sustainable practices in different sectors including the maritime transport sector. The EU Ship Recycling Regulation which was implemented in 2018 requires that all large vessels flying the EU flag must be recycled in facilities that are environmentally and safely sound.

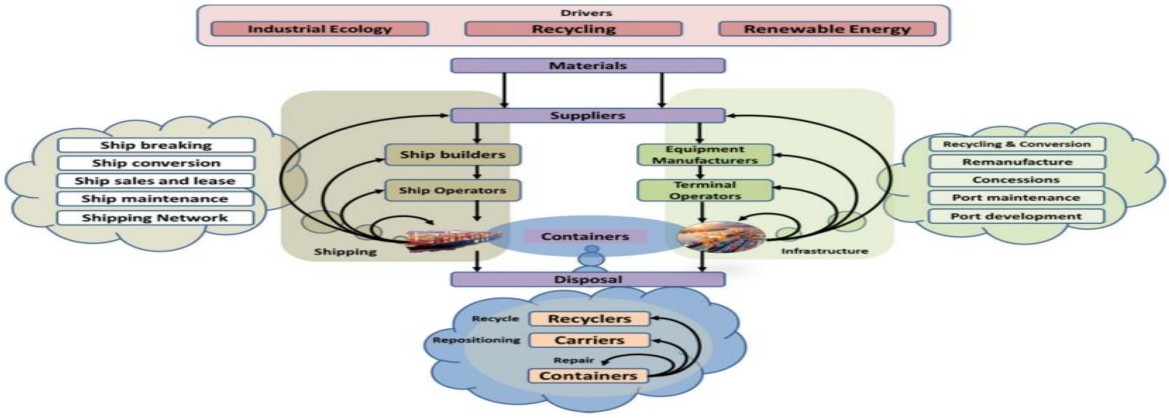


Figure 3: Circular Economy in Ports (Notteboom,2022)

2.2.1 Conclusion of Circular Economy in Maritime Logistics

Although there are many advantages of circular economy practices in maritime logistics, including environmentalism, costs, and creativity, challenges must be considered. Such factors as financial constraints, legal restraints, technological hindrances, and organizational culture can also be mentioned. All these can only be achieved by the involvement of all the stakeholders, strong policies, funding for technology and infrastructure, and a change of attitude towards sustainability.

According to Notteboom(2022), some of the challenges that come with adopting CE practices in maritime transport include high initial costs for green recycling facilities, regulatory hindrances and technology advancement. However, the EU has put in place policies that support research and development; offers incentives for sustainability; and has set policies that promote innovation.

According to J Barona(2023), CE principles need to be applied to maritime transport to increase the values of environmental and economic efficiency particularly for disposing ships and barges.

Section 2.3 End-of-Life Processes for Vessels

The EOL phase for ships is recycling, breaking, and decommissioning of the vessel. EOL vessels target recycling materials with the least possible adverse effects to the health of human beings and the environment. The beaching method is the most popular method used to dismantle vessels valuable parts of vessels. Despite being the riskiest procedure, two-thirds of the ships are recycled under this process. Pham The Quyen(2019) mentioned that the other common management practices of EOL vessels are either dry docking or dismantling. However, Dry Docking is relatively more eco-friendly than the conventional methods but as for the cost, it is not the most efficient. The other one is alongside dismantling, which is done when a vessel is stripped down while still anchored to a pier, and this requires certain facilities. Since labor costs are comparatively low in developing countries, the most frequent approach taken is beaching, which is the most dangerous to health and the environment.

As according to Notteboom et al. (2019), green ship recycling is taken into consideration that is safe and environment friendly according to international standards. They note that positive

changes are observable especially in countries such as India and Bangladesh, which are leading in ship recycling. According to the EU Ship Recycling Regulation, at the EOL, every ship has to confirm the presence of hazardous materials on board, display a plan on how to manage them and submit a document which contains information on the materials used in the construction of the ship.

According to GSDR(2022), the pollution is ranked highest with the usage of the beaching method especially as it relates to the release of hazardous materials. Nevertheless, it remains the most frequent despite the fact that there are no containment centers.

There are no rules that have been set and as such, countries in the Western and Central Pacific Ocean (WCPO) are still using the beaching method. On the same note, Europe and North America are more controlled in this aspect and their primary objective is on environmental issues as well as labor issues.

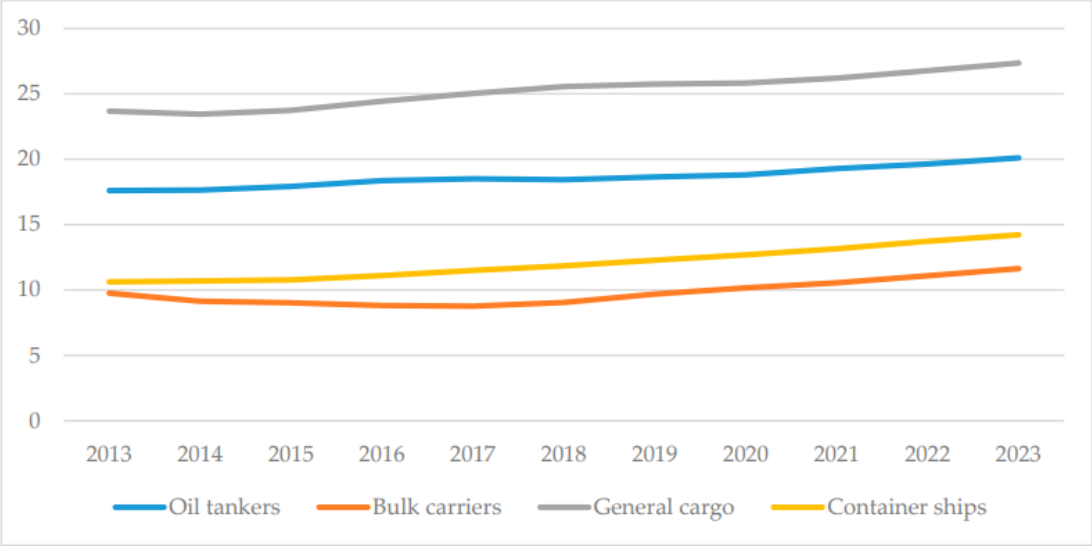


Figure 4: World merchant fleet age by ship types, An Approach to Advance Circular Practices in the Maritime Industry through a Database as a Bridging Solution, 2024

Section 2.4 Overview of Ship Recycling Methods

Ship dismantling or ship destruction is the process of disposing of the useful parts of the ship as well as other out of service ships. The process is important in the maritime industry as it ensures the CE by reducing the impacts of man on the environment as well as promoting the reuse and recyclability of materials that are crucial. There are also different methods of ship recycling and each of them has its advantages and disadvantages. Here we will consider the most common ones and will be more particular with the ones we use in Turkey and Western Europe. According to the IMO(2022), there are over 15 000 ships that can be recycled in the next ten years; instead of money, people and environment will get a chance; the existing practices will be discussed, works done in the last decade and plans for the next decade will be introduced.

The recycling of ships also known as the Ship Scrapping is one of the most lethal industries in the world. But as many as 80 percent of all ocean-going vessels are still being scrapped on the beaches of Asia.The Hong Kong Convention and new EU regulations are trying to regulate the industry by introducing new regulation: Ship Recycling Regulation which is concerned with the protection of environment and labor.

The EU Ship Recycling Regulation is related to the Hong Kong Convention, which they eventually want to regulate under the same motivation: Thus, it must be sustainable and environmentally friendly. During the ship recycling/breaking process the ship may contain from 1% to 10% of the weight of the vessel in the form of asbestos, heavy metals or oils. This is because there are about 15,000 ships according to NGO SHIPBREAKING PLATFORM(2020), that are expected to be recycled/broken in the next ten years and thus the regulation plays a very big role in ensuring that the process is carried out in an environmentally-friendly manner.

According to the European Commission report (2021), there are 34 yards from the EU approved list of ship recycling facilities located in 16 member states of the European Union, six of these are in Turkey and one is in the United States. From the 1.536 EOL vessels only 3% are recycled/broken in facilities listed by the European Commission.

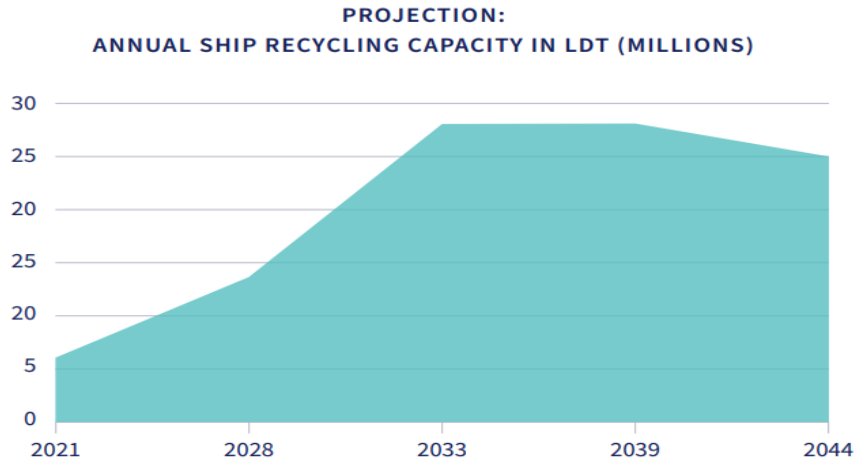


Figure 5 Projected need for ship recycling between 2023-2044 (UNCYAD, Hoffman, 2020)

2.4.1 Beaching (Ship Scrapping on the beach)

Beaching or ship scrapping on the beach is a process for marine vessels that have reached the end of their lifecycle. The process starts with running a vessel ashore onto a tidal beach during high tide, using the natural tidal forces to do the rest; once the tide recedes, the ship is now grounded and ready for the dismantling process and then dismantling by manual labor. This practice seems the most cost-effective if labor prices are relatively low. While beaching is one of the most hazardous practices for vessel recycling, some countries, such as India and Bangladesh, still use this method, and it is not illegal in all regions of the world. More than %70 of this process takes place in developing countries,

Maruf Hossain(2007), mentioned that the beaching method can be traced back to the 1960s when a Greek ship accidentally beached itself during a cyclone. The vessel could not operate or refloat for several years, and Pakistan decided to disassemble it on the shores of Sitakunda, Chittagong. After the accident, the WCPO countries saw this as an opportunity and started disassembling the vessels using the beaching method.

According to Knowledge of the Sea(2019), the beaching of a vessel is open nature, as shown in Figure 6, and if it is uncontrolled, the release of hazardous substances such as oil, asbestos, and heavy metals can easily mix with the ocean. Despite being cost-effective, the beaching method is criticized for its safety shortcomings and might be the oldest practice in the system. Another reason for criticism by the authorities for the beaching method is that it needs to be adjusted to

the Basel Convention fully. This international treaty aims to control the boundary of waste movement and the dissolvement process, as well as shipbreaking and ship recycling activities. The European Union Ship Recycling Regulation (2013), mandates that ships flagged under EU member states must be recycled in facilities meeting environmental and safety standards. However, many ships that operate within the EU are not flagged under the EU flags, which means these regulations do not bind them.

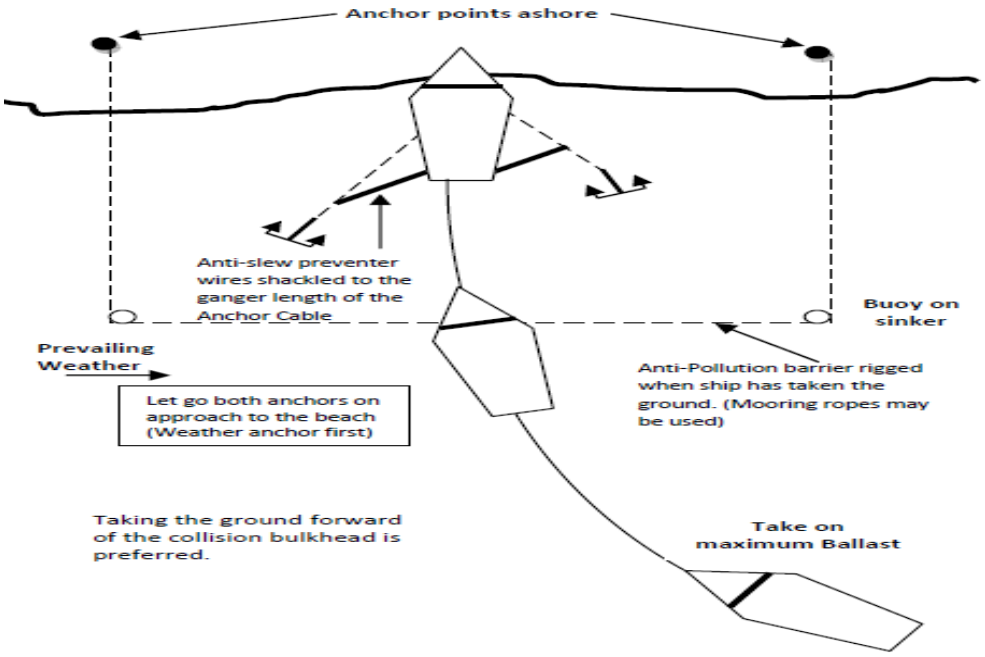


Figure 6. Beaching/Ship Scrapping on the Beach (Knowledge of the Sea) 2019

Pham The Quyen(2019) states that beaching practices are not standard in the EU. Under the EU Ship Recycling Regulation, every ship that comes to EOL must declare the presence of hazardous materials on board, show a map of how to deal with them and provide a document that includes information on the materials used in the construction of the ship.

The environmental and health consequences of beaching are concerning. EOL vessels are mostly scrapped on the beaches near communities where they can easily be reached for cheap labor, which is hazardous to the environment since they carry asbestos, heavy metals, and oils.

While discussing the other recycling/breaking process of EOL vessels, let us remember that two-thirds of the current EOLs still use the beaching method.

According to the NGO Ship Breaking Platform(2024), 8221 ships have been beached since 2009, causing 449 deaths and 412 injuries. These are the numbers that we see in the official reports; the environmental damage is yet unknown.

2.4.2 Pier Breaking/Alongside

Pier Breaking or pier dismantling is a method for ship breaking/recycling. The vessels quay in calm waters, and then a crane removes the materials piece by piece until the vessel can be lifted to a dry dock for final cutting. Pier breaking practice is mainly used by Chinese yards and a few recycling facilities in Turkey. This method is mainly used because they don't require dry docking.

According to Delft Research Portal(2024), pier breaking/alongside can be categorized into four phases: mooring the vessel, dismantling in phases, cutting, and removal, and waste management. Unlike the beaching method, the ship is securely moored to a pier or a dock.

First, the vessel's mooring occurs; the vessel remains afloat, allowing stability during the ship-breaking process and making it relatively easy to access the materials and parts of the ship.

Dismantling in Phases allows the ship recycling facility to remove dangerous substances such as oil and fuel to prevent environmental contamination. This process also allows the facility to carefully disassemble the most valuable parts, such as electronics, engines, and reusable parts.

Waste management is a must for the pier-breaking method. The controlled process allows the facility to prevent the contamination of the environment with hazardous materials. Spills or releases of toxic substances are precluded since the vessel is stable and the process goes step by step.

Delft Research Portal(2024) mentions that the pier breaking method is relatively safer for laborers. The stable and controlled environment allows the facility to obey the safety protocols and reduces the likelihood of accidents. Since hazardous materials are controlled, exposure to this type of material is prevented.

This method complies with the regulations provided by the Hong Kong Convention and EUSRR. The controlled environment also allows the facility to recover materials better, which improves recycling efficiency.

Although the pier-breaking method is relatively safe and more efficient, the higher cost of specialized equipment, the need for skilled labor, and improved infrastructure increase the cost of the shipbreaking process. The pier-breaking method is limited to handling a specific ship size; due to docking limitations, it is not very suitable for large vessels.

2.4.3 Dry Dock Recycling

The Dry Dock recycling method involves pulling the ship out of the water and waiting until the water is drained, leaving the vessel in a stable and controlled environment. It is the most environmentally friendly approach to ship recycling/breaking. According to Sudripto Khasnabis (2019), the process begins with the vessel being guided into a dry dock for ship breaking. Although the method involves removing the vessel from the water to a dry environment, the preparations for the operation are both time-consuming and high-cost.

World Maritime University(2019) mentioned that, materials can be carefully segregated from the vessel for the disassembly and recycling. Hazardous materials can be safely separated and handled under the environmental regulations set by the Hong Kong Convention and EUSRR. Dry dock facilities have the most regulated and advanced waste management systems, with no containment of hazardous materials in the environment. The process is very efficient for recyclable materials.

Dry Dock facilities are mainly located in regions with technology-developed and advanced industrial areas, such as Europe and North America. Dry dock practice is considered the gold ship recycling/breaking industry standard. However, the limited facilities and high costs prevent this practice from becoming more common. With the environmental regulations becoming stricter for the most hazardous vessels, dry dock practice will become more common shortly.

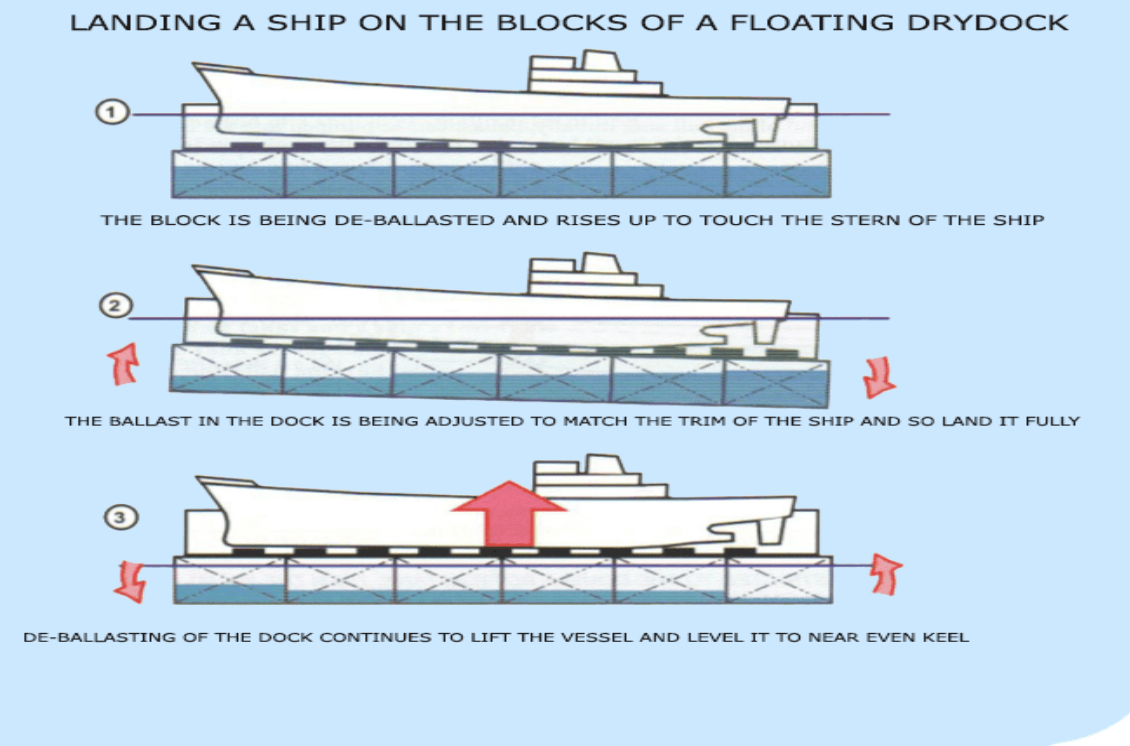


Figure 7 Understanding Ship Stability During Dry Dock, Sudripto Khasnabis, 2019

2.4.4 Landing

Landing is a recycling technique that applies in regions where there is no tidal variation so that the beaching technique cannot be adopted. The ship is then towed to the shoreline and then it is dragged on to a concrete slipway or a ramp which plunges directly into the water. Unlike beaching, the ship is not beached but rather is manoeuvred and partially flooded onto the slipway. Once the ship is on the slipway it is moored so that access can be made from the shore but the ship is still supported on the water. The gradient of the slipway enables gradual movement throughout the various compartments of the ship while dismantling the structure. The workers dismantle the ship from the top deck down while still floating the ship so as to control the weight as sections of the ship are scraped off.

Big parts that are to be eliminated are usually worked on by heavy machinery and cranes that carry them to recycling facilities nearby.

The landing method is safer and more effective than beaching especially in regard to exposure

to environmental threats. It is usual that the slipway design incorporates containment features to avoid discharging of oil and hazardous substances and debris into the environment. It also increases the safety measures of the workers as compared to beaching.

2.4.5 Conclusion of Shipbreaking Practices

After Analyzing the current recycling practices the **conclusion** is:
The method of dry dock shipbreaking is however more preferable compared to other methods of ship breaking such as the following.

Dry Dock vs. Beaching: Beaching on the other hand is much less standard in that ships are taken to a shore and then dismantled in the open. The whole process of dry dock recycling provides better protection to the environment and the workers who handle the vessels as compared to the other methods, but it is costly. Beaching, on the other hand, is cheaper, it creates major environmental and safety consequences.

Dry Dock vs. Pier Breaking/Alongside Breaking: Pier breaking and alongside breaking also provide controlled environment as such they do not offer the same protective feature of a dry dock. Dry docks provide full support and separation from the marine environment hence more accurate and environmentally friendly dismantling process is undertaken.

Dry Dock vs. Floating Dock Recycling: Floating recycling is closely related to the dry dock recycling but the ships are recycled on floats not on docks. Although floating docks afford some flexibility of location they are not as stable and cannot control their environment in the same way as dry docks.

Dry dock recycling can be said to be the epitome of ship dismantling and recycling processes considering that it is environmentally friendly, safe for workers and successful in recovery processes. However, due to the high costs associated with and scarcity of dry docks and necessity to beach ships commonly in cheaper environmentally unfriendly methods this method is limited. In the future, as environ-mental restrictions around the globe increase in stringency, the reuse of dry docks can be anticipated to rise particularly with vessels known to contain dangerous materials or those that are owned by managers and operators that act more in accordance with the principles of the green economy.

Section 2.5 Regulatory and Policy Frameworks

2.5.1 The Hong Kong Convention

The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ship, is another international tool to address the recycling issue of ship. The IMO established the convention and it has to make certain that ships that are meant to be_retired after their useful life is over do not pose danger to many aspects of human life and to the environment. Aim of the present paper to achieve your thesis and, therefore, there is a need to discuss the Hong Kong Convention in the aspect of its scope, aim, and the requirements in the context of circular economy of maritime logistics.

According to IMO(2024), there is currently much debate as to what to do with a ship once that vessel has come to the end of its working days. From time to time, around several hundred larger vessels are removed from the world's fleets and are disposed off as scrap. Blank Rome(2024) mentioned that, majority of the recycling of such products has occurred in south Asian region especially India, Bangladesh and Pakistan where standards of environmental and safety are not as high as those of the developed world. This has led to so many incidents involving workers including accidents and even deaths, contamination of environment through some dangerous chemicals such as asbestos, PCBs, heavy metals and wastes disposal.

To this end, the IMO launched measures to elaborate a comprehensive set of regulations that would specify basic requirements for the recycling of ships in a safe and environmentally friendly manner across the globe. It produced the Hong Kong Convention, which was signed in May 2009 after the three-year of negotiations.

According to IMO(2024), the following are the aims of the Hong Kong Convention;
Enhance Safety to ensure that the environmental degradation which is characteristic of the ship recycling activities does not involve risks which are not necessary when it comes to protection of people's lives. This includes the development of standards that can be employed in order to guarantee that shipyards, ship recycling facilities and the shipping industries deal with the hazardous materials properly. Protecting the Environment, thus, in order to minimize the impact of ship recycling on the environment it is essential to regulate and reduce the dangerous materials' emission to the environment. It means establishment of the international standards that

should apply to all the ship recycling activities irrespective of place which will help to eliminate the emergence of the lowest standards agenda and foster the action of the best practice.

The Hong Kong Convention provides a general regime which covers the whole life of a ship, starting from the ship's construction and ending with its recycling. Key provisions include:

The Convention has an impact on ships of 500 gross tonnage and above which are used in international trade and these include cargo ships, oil tankers, passenger ships and other ships. It does not apply to warships, naval auxiliary ships or government owned non-commercial vessels. The convention also includes the ship recycling facilities that are involved in the recycling of the said ships. These facilities need to adhere to set standards in order to achieve the set objective of safety as well as environmental conservation. All the ships that are governed by the Convention are supposed to have an IHM on board. This inventory must also set the location and the amount of hazards materials which are used in the construction of the ship, its equipment and fittings at any time in its life.

IMO mentioned that, the IHM has to be kept UpToDate and as such it has to be verified by a competent authority or a recognized organization during the ship's service. It must also be produced for consideration at various life cycle of a ship such as the recycling stage.

Thus, the Ship Recycling Plan or (SRP) has to be developed by the ship recycling facility before the said ship can be recycled. The SRP has to be ship specific and has to be endorsed by the competent authority of the recycling country. Some of the aspects that should be included in the SRP include dispositions such as, that how the hazardous materials would be disposed… or the recycling would be done in a safe manner, and those measures that would be taken in order to avoid the occurrences of the adverse effects.

Recycling facilities have to be licensed by the competent state authority of the state of operation of the facilities. It is an authorization which is obtained and has to do with compliance to the terms of the convention on ship recycling as well as the ability of the ship to manage the hazardous materials and effectively implement the SRP.

Workers should also find facilities that have measures on health and safety of the workers, safety of the environment, and preparedness in case of an emergency.

Ships must undergo various surveys to ensure compliance with the Convention's requirements: Initial Survey is performed prior to the deployment of the ship or prior to issuance of a new IHM in order to confirm the contents of the inventory as well as its accuracy. Renewal Survey which

is done from time to time to make sure that the inventory is well updated. Final Survey is done before recycling of the ship in order to verify IHM, to also determine if the recycling facility is complaint with the requirement of the convention and if it has developed an SRP and found it satisfactory.

It is compulsory for the ships to have Ready for Recycling Certificate after the final survey so that the ship can be recycled safely and with a focus on environment protection.

The Convention has directed the ship recycling facilities to provide for the health and safety of the workers and also to provide them with personal protective equipments, safety training and medical treatment.

These must have the risk management systems which are likely to be required in ship recycling for example, emergency contingency and integrated management of accidents.

IMO mentions that, the Convention states that hazardous materials are to be dealt with in such a way that shipping is environmentally friendly the construction of the ship and the recycling of the ship as well.

Such objectives are as follows; proper disposal and management of wastes through the provision of the appropriate waste disposal amenities aiming at avoiding pollution and in the proper handling of wastes and hazardous materials such as asbestos, heavy metals, PCBs and hydrocarbons.

For the Hong Kong Convention to enter into force, it requires ratification by at least: In order for the Hong Kong Convention to come into force it needs to be ratified by at least 15 States; This will be appropriate given the current situation in which close to 40% of the world merchant shipping is represented by gross tonnage.

IMO states that, with a combined maximum annual ship recycling volume of not less than three percent of their combined gross tonnage respectively. Currently, there is a list of the countries that signed the Convention and several of them are the ship recycling states such as India, Bangladesh and Turkey, but more countries should join to make the Convention operational. Moreover, more measures are still being pursued by the IMO and other players to get even more number of countries to join the Club since recourse has to be made to better current practices in ship recycling.

IMO mentions that, thus, the Hong Kong Convention can be referred to as a significant step toward the advancement of safety and sustainability of ship recycling. It seeks to minimize the

adverse effects on human health and the environment from ship recycling especially in countries which have not had strict standards and rules on ship recycling. Inventory management, safety training and handling of hazardous materials are the major concerns in the ship recycling industry which are covered by the Convention.

Regarding the legal act, it can be noted that the Convention aligns well with the model of the circular economy since it promotes the correct recycling and reuse of parts of ships. It also assists in the return of material such as steel, copper, aluminium etc through the Inventory of Hazardous Material and the ship recycling plan while at the same time it reduces the likelihood of polluting the environment.. This leads to a more circular approach to the disposal of EOL ships and thus enhance resource efficiency and waste minimization in the maritime industry.

The Convention promotes the harmonization of legislation as well as enhances cooperation between countries and prevents the so called ‘regulatory chill’/race to the bottom in which countries compete by having the poorest environmental and safety standards. It promotes the implementation of proper management and practices by the ship recycling facilities as well as the ship owning companies thus improving the quality of the ship recycling industry.

The implementation of the Hong Kong Convention means that shipowners and recycling facilities must spend resources in acquisition of new technologies and methods that will effectively and safely deal with hazardous materials. This in turn leads to innovation in ship design, recycling of ships and management of waste. For example, the requirement for proper and frequent reviews of hazardous materials has led to the advancements in digital inventory management systems as well as automated inspection systems.

According to Blank Rome(2024), while the Hong Kong Convention has been widely praised for its comprehensive approach, it has also faced several challenges and criticisms: Nonetheless, the Hong Kong Convention has been accused of having some lacuna and faced some criticism as follows:

Slow ratification process, it has not yet entered into force because some of the world's most influential states have not signed the Convention. This has led to the following questions on the convention's effectiveness in changing the ship recycling industry.

Blank Rome(2024) mentions, the compliance and enforcement issues, this being the case, even if the convention comes into force there are questions as to how it will be implemented especially in a country with a poor regulatory framework. The attainment of compliance will be

resource demanding, will need capacity development and will entail international cooperation. Limited scope and coverage, the above stated is however somewhat of a disadvantage since the Convention does not apply to small ships or ships within domestic waters. Furthermore, it does not respond to all environmental issues that come with ship recycling including air pollution.

According to IOP Science(2022), economic burden on developing countries, there are certain costs involved, which may be quite expensive especially for recycling facilities in developing countries where infrastructure might be lacking. It has been feared that these countries will be affected the most by the convention as most of the ship recycling happens in such countries.

2.5.2 The EU Circular Economy Action Plan

The Von der Leyen Commission unveiled the European Green deal on December of 2019 as the EU four-year political together with an economic investment plan to turn the union's economic green as well as make her citizens prosperous.

Therefore, the European Green Deal is Europe's twin plan for the future, which would allow the continent to achieve climate neutrality, becoming the first such region in the world with an inclusive transition. Nevertheless, the process that led to the development of this new growth strategy was protracted, which can be seen as a sign of change in the European Commission's approach and a sequence of policy initiatives starting from 2011. This particular case study reflects on the actions that the European Commission has taken in order to shape the global CE policies. It goes as far as the shift from the enhancement of resource productivity to the definition of growth that is both social, environmental and economic. The CE thus offers the possibility of decoupling resource consumption from economic development, thus possibly decreasing the EU's dependence on imported and primary materials, and its exposure to price shocks of natural resources, while opening new business models.

The EU Circular Economy Action Plan (CEAP) (2015), was a package of legislative and non - legislative measures aiming to move the European economy from a linear to a circular model. Outlining 54 measures and four legislative measures on waste, the Action Plan contained targets for landfill, reuse and recycling for the years 2030 and 2035 together with new requirements for the separate collection of textile and biowaste. It spanned across policy"; It encompassed policy domains, materials management, and industries as well as measures that were designed to enable

change through innovation and investment. Also, it presented the plastics sectoral strategy with more than €10 billion to be spent on the transformation until 2020. All the 54 actions either have been adopted or put into practice by the end of 2019.

According to The Von der Leyen Commission, the EU has become regarded as the world's leading policy maker in circular economy. The waste legislation has been passed in the year 2018 following the decision-making procedure with the European parliament and the council of the European union. Following this, data from Eurostat suggest that the number of jobs that are related to CE activities increased by 6% in the EU in the period between 2012 and 2016.According to the action plan, at least, 14 MS, 8 regions, and 11 cities were invited to propose CE strategies.

According to Mia Pantzar(2022), The first set of measures presented by the European Commission in March 2022 is in line with the EU's 2050 climate neutrality target under the Green Deal to facilitate the transformation towards the CE as per the Circular Economy Action Plan. This involves measures such as boosting of sustainable products, consumer education for the green shift, revisiting the construction product regulation and policy on sustainable textiles.

In November 2022, the European Commission came up with the new EU-wide regulation on packaging which includes redesign of the packaging, clear and understandable labeling, promoting reuse and recycling and the use of bio-based, biodegradable, and compostable plastics.

On the 9th of February 2021 a resolution was passed that called for increased and mandatory recycling policies as well as targets to be met by 2030 in regards to material usage. In October 2022 the Parliament approved modifications in the laws regulating Persistent Organic Pollutants so as to reduce the use of hazardous substances in waste and production. This means that there are measures that limit the amount of the pollutants that can be used, some chemical cannot be used and to ensure that pollutants are not included in the recycling process.

The production process which is the conversion of raw materials was greatly affected by the Covid-19 outbreak especially in the supply chain. In 2021 members of the European Parliament have demanded a critical raw material strategy for EU with regard to the sustainability of sourcing and compliance with environmental and human rights standards. It is designed to cut down on the EU's reliance on a limited number of Non-EU countries and in addition, enhance the recycling and recovery of these materials.

Towards the creation of an EU market for sustainable products which are climate-neutral and resource-efficient, the Commission has proposed the following: extending the Ecodesign Directive to non-energy using products and developing Digital Product Passports. These passports are supposed to contain all the required parameters at all the steps of product's life cycle. Consumers and MEPs also stand against planned obsolescence and therefore for the extension of the product and their repairability and the consumer's right to repair. They have pointed out that consumers should be given the permission to receive truthful information on the environmental impact of the goods and services being purchased and have urged the Commission to ponder on how to deal with greenwashing.

2.5.3 Basel Convention

This convention for the Control of Transboundary Movement of hazardous wastes and their disposal was approved by UNEP on 1989. It was the first conference to establish the international regulations concerning the hazardous wastes management and its transport. The Conference of the Parties, responsible for shaping the convention's policies, set out three objectives: The Conference of the Parties (COP), responsible for shaping the convention's policies, set out three objectives; Hazardous wastes were minimized in their production and the need to dispose them as is required, preventing the movement of wastes across the borders of different countries, developing a set of legal instruments for the situations when transboundary waste movement is permitted.

According to UNEP, the convention prescribes the course of action that the parties must take with regard to different kinds of waste including toxic, poisonous, explosive and inflammable waste. It seeks to standardize the management of toxic imports in the world so as to enable their proper disposal without harming the environment. Although the convention tries to control the flow of hazardous wastes, its objective is not to eliminate the cross-border transfer of toxic substances. As stated earlier some international critics have noted that the convention does not go far enough in this regard. However, the Basel convention is the only convention which sought to enhance the protection of people's health and the environment by controlling the movement of hazardous wastes. Signed by 188 countries of which the United States is a signatory but not a ratifying country, the treaty establishes the duties and mechanisms for the reduction of the

transfer of hazardous wastes between states and their disposal as follows: as close to the source as possible.

Katharina Kummer(2000), mentioned that, the exporters and the importers of these covered wastes must therefore establish a channel of communication in order to explain on the production and transfer of these toxic wastes.

Import of the covered wastes must be authorized by the Parties and the latter have the right to ban import of hazardous wastes. Also, the waste should be disposed of in an environmental friendly manner since waste has been identified as one of the biggest threats to the environment. The shipment of waste to and from third countries in also banned under the treaty and any shipment is considered as unlawful.

In addition, both sides need to have legislation that would prohibit and penalize the traffic of hazardous materials.

2.5.4 The European Union Ship Recycling Regulation

EU SRR, the Ship Recycling Regulation was enacted by the European Parliament and the Council of the European Union on 20th November 2013 to decrease the adverse environmental and safety effects of ship recycling. Since 31 December 2018, every commercial ship with the GT more than 500, flying the EU flag is required to be recycled in the listed European ship recycling facilities only Each EU Member State has to submit its list of permitted ship recycling facilities to the European Commission that updates the Register on regular basis to include the compliant and delete non-compliant facilities. The current facilities consist of those located in the EU, Turkey and the US.

According to the European Parliament(2013), ES-BA has safety and environmental standards to be met by any ship recycling facility for it to be included in the European List irrespective of the location of the facility. The facilities located in the EU member states are authorized by the national authorities whereas any application from the third country facilities are decided by the European Commission. Membership in EU List is a powerful competitive advantage for the yards that managed to fulfill the requirements of occupational safety and environmental conformity. Besides, the EU SRR corresponds well to the requirements set by the 2009 Hong

Kong Convention but at the same time contains added safety and environmental precautions. It also banned the beaching method and include rule regarding downstream management of toxic wastes and labour. Also, EU- listed ship recycling facilities go through thorough checks, that involve third party certification and audits. Also, the NGOs have the right to present complaints if they think that the listed facility is violating the Regulation. According to the European Parliament and the Council of the European Union , these safeguards are not available under the Hong Kong Convention regime hence EU listing is the only assurance of independent certification and auditing against acceptable standards.

Because of the need to reduce complex regulations and bureaucratic burden, the new legislation exempts ships that it covers from the Waste Shipment Regulation. Nonetheless, vessels flying a non-EU flag and hired for scrapping purposes within the geographical region of Europe are still Governance by the Waste Shipment Regulation. Foreign ships including those which are European and flying the flag of a third country are expected to have an IHM while in an EU port or anchorage European Union Ship Recycling .

2.5.5 Regulation vs the Hong Kong Convention

In this section we will place the EU SSR and the Hong Kong Convention in the broader perspective worldwide.

Specification of the Hong Kong convention is the necessity for initial, periodic and final surveys; and additional it requires a Ship Recycling Plan for every ship. The banned materials which include hazardous material will also be removed safely by Ship Recycling Plan and in the detailed ship recycling completion report.

The EU SSR has provided that in the EOL all vessels flying the EU flags must be recycled in the ship recycling facility enlisted in the European list of ship recycling facility. The EU SSR adds to the requirements given by the Hong Kong Convention and also outlines other safety and environmental rules including toxic waste disposal as well as labor norms. The EU list of ship recycling facilities confirm that independent certification system can be used and the list can be audited by third party.

The strict EU SSR may lead to the ecology unfriendly act of shifting of their flag to a non- EU flag to enable them disassemble their vessels in WCPO countries. The latter might be one aspect

of the EU SSR to pass a law that would encourage shipowners to use EU accredited recycling facilities which eliminated the option of flagging out.

Shipping industry and its common practice of shipbreaking causes a ravaging effects to the environment. Even though these practices have existed for decades, the problems connected with them have emerged recently only. Although some regulatory measures have been put in placed, they lacked sustainable awareness so that they could be reviewed. The process of recycling of ships is not only costly, but also very much inclined towards labor force.

Whereas in this dismantling process, the impacts of costing and time, efficiency, and knowledge gaps exposed to the environment, especially polluting air and affecting sea creatures. Sustainable ship recycling practices need to address the following common environmental impacts of end-of-life ships: management of generation of hazardous waste, negligence in waste management that has resulted in depletion, and conditions of work that are hazardous to the health of the workers. A lot of waste is produced during the dismantling of vessels and it is not well disposed of, hence leading to depletion and high influence on the environment. Initiating awareness on the technical systems necessary in the disposal of wastes is part of the understandings that are important when it comes to environmental and health protection. These working conditions are actually dangerous to the workers, and this plus deterioration of environmental quality makes its impact even worse. Regular dismantling of large vessels cannot be discounted since its consequences in the environment are always dire. The impacts are in the areas of land degradation, air borne pollutants and marine environment.Lack of proper waste disposal during dismantling results in damage of land resources and several toxins which affect the quality of air that human beings and marine lives breathe.

Ship recycling sometimes requires investment in Integrated Environmental Management System, safety and Health protection and environmental protection systems. However, the main issue that the corporations encounter is that they need to make a profit and reduce expenses at the same time which may lead to negative impacts on sustainability standards. The challenge which is set before the management is that of finding a middle ground between the environmental responsibilities and the floundering enrichment.

The total focus on profitability may bring immediate benefits by employing rather cheap, though highly toxic for the environment, methods of ship recycling. However, this is quite contradictory to the main goal of ensuring sustainability in the natural resource in future and this

may speak ill of the company. Management faces the challenge of making decisions with immediate monetary returns measurable in short-term as opposed to sustainable profits in the long-run together with ethical issues concerning the image of the company.

This is possibly the case in highly competitive markets because firms might ignore the environment so as to compete better with rivals who employ cheap but harmful techniques. This is one kind of pressure, companies are under pressure to cut the cost, even if there are detrimental effects on the environment.

Chapter 3: Methodology

Section 3.1 Research Design

This paper has a mixed method research methodology that discusses both the qualitative and the quantitative method of researching the change towards to CE principles and recycling in the maritime sector especially on the EOL recycling of vessels. The research method includes literature review, current practices, interviews and surveys, which allow for understanding the current practices, legislation and stakeholders' viewpoint. This paper will analyze the current position of Turkey and Western Europe after that authors will provide five questions and interviews to the stakeholders among the representatives of ship recycling expert, authorities, shippers and captains. Upon deriving the findings of survey and interviews this paper will shift its attention to how the CE principles can be incorporated into the maritime industry.

Section 3.2 Data Collection Methods

3.2.1 Literature Review

After defining the current methods and regulatory frameworks with a literature review, the paper will now focus on the current situation of ship recycling practices, throughputs and regulatory frameworks focusing on Turkey and Western Europe. After analyzing the current situation, surveys and interviews will be conducted to collect quantitative data to understand how much the stakeholders in the sector are aware of CE practices.

The paper will now focus on the analysis of the current situation in Turkey and Western Europe and then move on to surveys and interviews to deeply understand the current situation. After discussing the current methods and regulations, the paper will focus on Western Europe and Turkey to function a cross-culture similarities and differences to find the best solution for CE applications.

3.2.2 Analysis of the current situation in Turkey and Western Europe

3.2.3 Ship Recycling Practices in Turkey

According to NGO Shipbreaking Platform, the ship recycling industry in Turkey ranks fourth in the world while the country is also a large importer of scrap steel. There are 22 ship dismantling plants and scrap suppliers to the steel mills in the region that locate in the town of Aliağa in Izmir. However, this sector has lately being under pressure because of the many accidents and related-causes, pollutions of the coastal areas, exposure to dangerous products like asbestos and inadequate handling of dangerous wastes.

Ship recycling yards in Turkey have mostly been functioned without much public oversight though there have been increasing demands for openness. Since 2018, the European Union has endorsed that its Member States can only recycle their ships in yards which are registered with the EU Ship Recycling Regulation EU SRR. Some yards in Aliağa has applied to be on the EU List and this has help in identifying gaps and conditions in the yards and acting as a driving force for change in the yards. All nine ship recycling facilities in Aliağa, Turkey has registered their names in the EU List.

The authorities that are competent in Turkey are Ministry of Environment, Urbanism and Climate Change (Ministry of Environment), Ministry of Labor and Social Security (Ministry of Labor), Ministry of Transport and Communications (Ministry of Transport) and the Harbor Master.

The Ministry of Labor regulates the state of occupational health and safety that includes managing of asbestos, working with dangerous substances, and working conditions. The Operation Permit of the ship recycling yards is issued by Ministry of Environment and Ministry of Transport. The European Commission carries out inspections of ship recycling yards in

Turkey which have applied for EU authorization under the EU Ship Recycling Regulation (EU SRR). The very first visit of the EU inspectors in Turkey happened in 2018. In this regard, the European Commission checks if the yards conform to the environmental, safety, and labor standards set by the EU SRR. New EU regulation of Recycle-ling stipulates that EU- flagged comercial vessels with a Gross Ton (GT) above 500 can only be Recycling in EU approve Recycling facilities. Ship Recyclers' Association of Turkey has been the voice of the industry since it was established in the year 2001, it created a Waste Management Center in 2004 which was issued with Asbestos Removal Permit and Temporary Storage Permit from MoE. Until 2021 all wastes which are generated from the ship recycling activities shall be managed, temporarily stored and disposed. The association also offered several services to the facilities such as training, seawater measurements, first aid, firefighting support, and workers' health check-up.

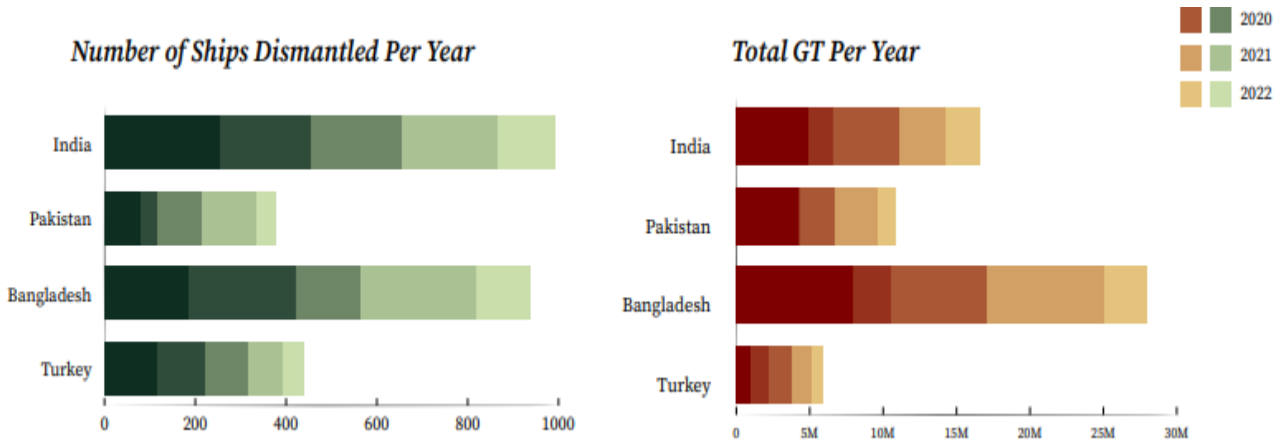


Table 1: Number of Ships Dismantled Per Year, Ship Recycling in Turkey,2024

Turkey is also among the top four countries for ship scrapping, after Bangladesh, India and Pakistan. Total ship dismantling in Turkey has continued to increase since 2009. The number of vessels rose to 776 million GT in the year 2020, and the highest number of ship dismantling, that is 281, was reported in the year 2012. The table showing the Total Light Displacement Tonnage (LDT) of Ships Dismantled in Turkey also shows the annual records. Data for the total LDT of dismantled ships was derived from three sources while preparing this report. SRAT data and the

answer to the FOI request were also close. In the meantime, Reaching and Accessibility in Turkey have given a different set of figures, especially between the years 2019 and 2021.

The Turkish ship recycling yards use the so-called landing method. The forward part of the boat is in contact with the shore at least the keel is while the other end of the boat is still in the water. The blocks are then lifted with the use of cranes on to a dep water and proofed working platform or floor. None of the yards use the gravity method, which is, dropping weights, or blocks into the water or on the beach. The negativity associated with the type of landing is without doubt more than the process of recycling in an enclosed space. The Platform pointed out that the use of the landing method in Aliağa should be gradually reduced and there should be improvement on the use of fully contained areas since the Turkish facilities lack improvements.

The ship-breaking activities that are carried out at the Aliağa yards and the absence of adequate measures for protection of the workers have been the subject of criticisms from local organizations and non-governmental organizations for a long time.

Greenpeace's report on the Aliağa ship recycling sector also came into light in 2002 and the organisation found out that the workers were facing poor conditions and there were environmental concerns as well. Waste water, soil and insulation materials taken from the area were analyzed and asbestos as well as mineral oil and heavy metals were identified to be present. The researchers found that the facilities failed to protect the workers and had not put in place sufficient measures to stop contamination of the environment.

Other sources of pollution that have been highlighted to have adverse impacts on the region include the oil derived solid and liquid wastes from ships, bilge water, ballast, sludge, slop and residue oil. The disposal of wastes oil and fuel from the dismantled ships into the sea has been taken to court as a deliberate act on several occasions and this has led to several trials.

The Ministry of Environment has sanctioned several facilities administratively in the past owing to pollution of the environment found along the coastlines. Even with the increased improvements over the years pollution remains a real problem. As it was established by the Ministry of Environment in a study conducted in 2019, the area together with the surrounding environment is highly contaminated with such substances as heavy metals, polyaromatic hydrocarbons, TBT, dieldrin among others. It has also been ascertained of the high concentration

levels of heavy metals in the ground at the ship recycling yards in Aliağa and the source has been established to be the ship paints.

The inspection reports in the EU revealed that there was intense particulate matter and heavy metal pollution in the air, especially in the region where ship dismantling activities are conducted, reaching unsustainable levels for Aliağa and its immediate surroundings.

The EU SRR prescribes implementation of environmental monitoring and management program encompassing water quality assessment for pollution and contamination; air quality; noise quality; soil and sediment quality. Recycling yards that are on the process of seeking approvals on the EU list have hired private laboratories to sample and analyze the air, soil and sediment in the yards for compliance to the EU SRR. However, the first EU reports presented the fact that while all the requisite parameters of environmental sea, soil, and sediment monitoring had been defined, not all of these parameters were being measured.

In the spotlight in recent years have been several ships brought to Aliağa for dismantling. Concerns have been raised about the import of ships like Sea Beirut, Otapan, Ethan, Alba, Kuito, and São Paolo due to hazardous substances onboard and irregularities in their Inventory of Hazardous Materials (IHM). For example, it was discovered in the case of Otopan that the ship actually contained 60 tons of asbestos, despite being initially declared as having only one ton. In response to opposition to importing large amounts of asbestos-contaminated materials, the ship was sent back to the Netherlands, its original exporter.

After protests and its banning, consent for importation of the ship was provided by Ministry of Environment which led to the São Paulo ship s being taken back to Brazil only to be sunk by the Brazilian navy. The protests and the ban raised awareness of further environmental violations and strict working conditions in the sector of ship recycling in Aliağa and initiated the release of several reports of different institutions on the problems of the ship recycling sector. The government of Turkey through its Ministry of Transport has Standard for Ship recycling from known as the Ship Dismantling Regulation and other local laws such as Environmental Law, Occupational Health & Safety Law etc. These regulations address authorizations and the methods of assessment of the sector and compliance with organizational dangerous substances control.

That is why there are significant gaps in the legislation’s content and its implementation. These

shortcoming can be said to raise questions over the authorities' capacity to properly oversee and enforce environmental and occupational health and safety standards.

The Ship Dismantling Regulation outlines requirements and a general framework for measures to be observed during ship recycling activities, including the following:

• Ships can only be dismantled up to three meters above sea level and only little ships can be dismantled on such level, while the gross vessels can be dismantled on a higher level than that.
• Moving liquids on the ship at least ten meters above the shoreline in a scrap part counting as disposal, which is confirmed by an examination by the Port Authority as to cleanliness.
• Such liquid wastes from scrapped ships must be dumped in a floating pontoon or in a liquid waste collection tank near the scrapped ship and subsequently put in a licensed temporary depot for purification via a refinery process. These barriers should be established before dismantling in order to avoid spilling of the material over the sea.
• During the dismantling process, general yards are supposed to practice environmentally appropriate waste disposal and are obliged to prepare a Waste Management Plan.

Measures have to be taken and immediate action has to be taken in case of possible contamination in order to avoid polluting the environment. Since the individuals have started investing in Ship recycling infrastructures from the early 1990s, these infrastructures include Excavation, rock filling, water wells, and machinery parks. Some concrete areas have also been built, there are also new cranes, lifting and pulling equipment. Recent years have witnessed changes in the general structure of yards so there is incorporation of OHS specialists, environmental engineers and sub-contract services among others. Further, since the formation of sector in Turkey, the Regulation on Health and Safety Measures in Working with Asbestos and the drainage systems were developed later on.

Thus, none of the facilities had any hazardous waste inventory on their locations. In 2021, there has been a requirement for facility to store the hazardous temporary wastes separately and thus, the facilities have put in place the temporary hazardous waste storage facilities and assumed the role of the removal and arrangement of the wastes.

The Aliağa Chamber of Commerce is as follows that measuring capacity at its facilities is the subject matter. However, the Ship Revoking the Authorization Certificate, that was issued by the "What intensity is not defined in the Ministry of Transport." The number of the yards should of

course be clear as well as how the capacity is. Where it could be measured was not identified. A comparison of some of the official data that are usually provided by the Ministry of Transport. Which suggests the overall capacity of the facilities whereby every facility has higher than before 2017.

The size of a facility defines the number of beds that a particular health facility is able to accommodate of the employees, the technique and tools used in the course of the also, the cutting process and the waste management that has been prepared for it. Among other factors. Although ship recycling industry have expanded their capacities close to twofold during the last couple of years with due for the mechanization and transportations which have been rolled out in many organisations across the globe vehicles, it remains unclear how that capacity is calculated.

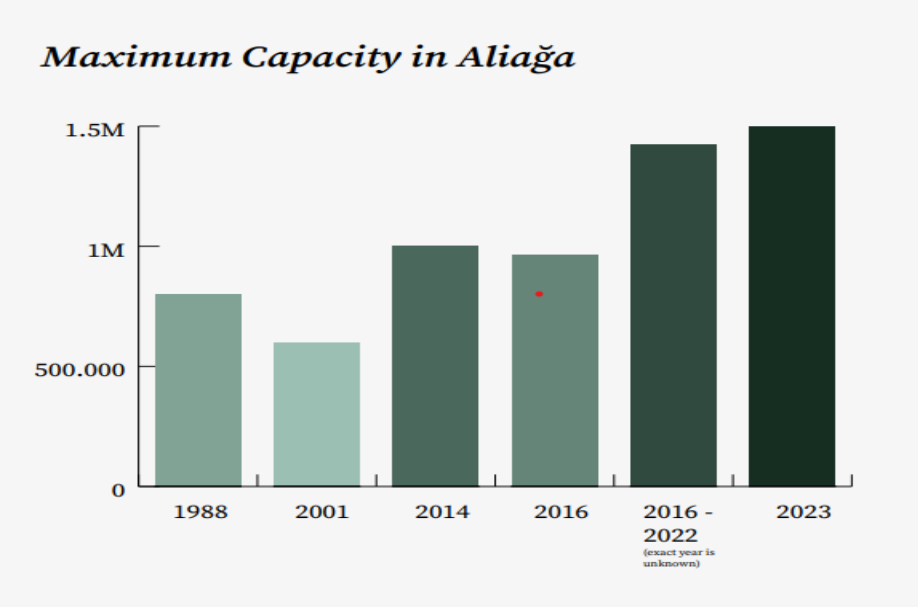


Table 2: Ship Recycling in Turkey, NGO Shipbreaking Platform, 2023

3.2.4 Ship Recycling Practices in Western Europe

The ship recycling industry of the Western Europe is not so huge compared to the South Asia but the major feature of almost all the recycling companies over there is that they follow environment safety requirement strictly. Western Europe has especially large share due to the companies' environmentally friendly approach and high quality of the dismantling process.

Other important countries concern Belgium, Denmark, France, Germany, the Netherland, Spain and the United Kingdom. As per the information available, in the year 2023 around 15% of the total ship recycling market has been occupied by Western Europe and stands third among South Asia, Turkey.

Most of the Western European yards have adopted safe and eco-friendly methods of recycling such as dry dock ship recycling and alongside ship breaking. These methods include ship recycling that is done in facilities that are enclosed and properly monitored so as to reduce the pollution of environment while aiming at reclaiming material that can be reused.

Major laws and regulations to be addressed while formulating compliance standards

The said EU SRR requires EU-flagged ships with more than 500 GT to be scrapped only in the green-listed recycling yards. It is always monitored throughout frequent assessments and that is by the national surveillance as well as the European Maritime Safety Agency (EMSA). It also complies with the provisions of the Hong Kong International Convention but contains some requirements characteristic only for the EU.

According to EU List of Ship Recycling Facilities, there are 48 recycling facilities which are located in Western Europe by the year 2024. All of these facilities have to prepare an up-to-date IHM and prove correct usage, shelving, and elimination of hazardous elements such as asbestos, lead, and PCBs. The facility's inclusion in the following list is also reassessed every three years, to check the continuous adherence to EU regulation.

There are today a considerable number of major ship recycling yards and practices where the removal or scrapping of ships is done systematically.

Belgium; The Galloo Recycling Yard in Ghent is one of the most sophisticated recycling yards in Europe, that use dry dock recycling techniques making sure that all the dismantling of the ships occurs in fully sealed enclosures to avoid any spilling or polluting into the … This yard deconstructed about 50 ships in 2023 out of which 1. 2 million GT.

France; The Naval Group's facility in Brest also uses NSMs with utilizing the pier breaking techniques together with the profound environmental monitoring devices. The disassembly of vessels in 2023 in this facility was 95000 GT out of which dismantled 42 vessels. According to the site, recycling processes which have yielded the material recovery rate of over 98%.

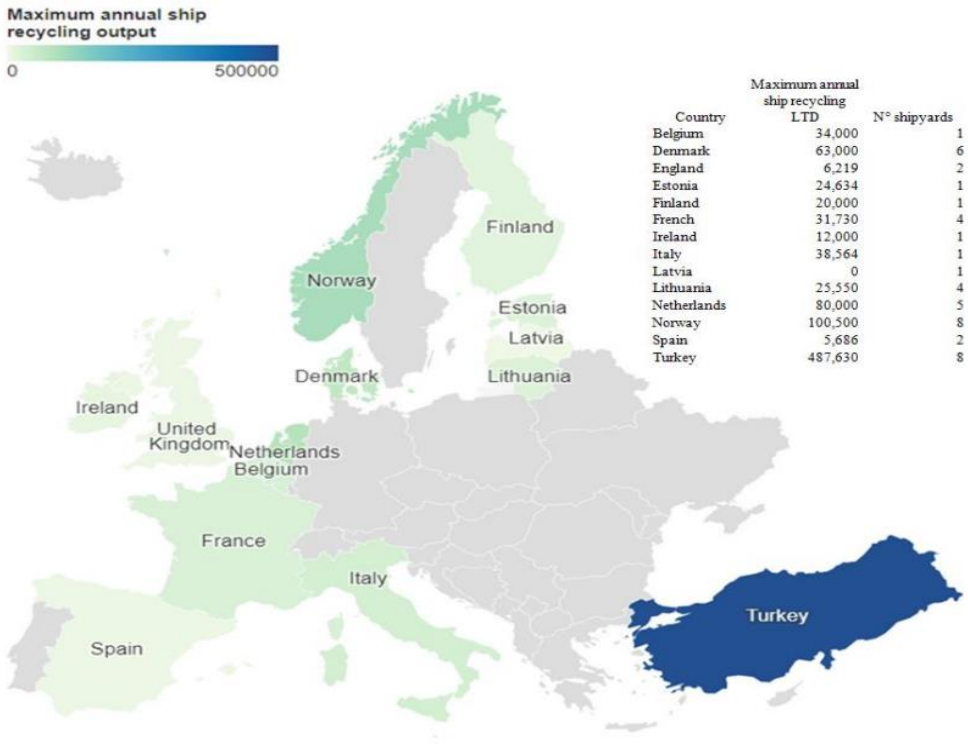
Germany; The Recycling Yard in Hamburg undertakes the decontamination and dismantling

services of complicated structures including navy vessels and offshore structures. In 2023 the Hamburg yard carried out demolition of 37 ships totaling 850’000 GT with a specific emphasis on safe asbestos removal and/or containing and handling other hazardous substances.

Netherlands; Damen Shipyards located in Rotterdam offers sustainable shipbuilding solutions, and the company is on the use of modern technology in its work. The former year, that is 2023, was marked by dismantling of forty-five vessels, which in sum corresponds to 1. 1 million GT. The yard practice is in conjunction with ship breaking techniques when a ship is stripped at a quay and all scrap is managed and disposed of within the yard.

Market share and volume in 2023, about 3 per cent of total recycling operations were reported to have taken place in Western European ship recycling facilities. 5 GT million of ships, which is approximately 15 percent of the entire world market that deals with the dismantling of ships.

Material recovery rates as of now, the material recovery rate of different yards located in the Western Europe region is 95%, though a few advanced yards are able to record a figure between 98-99%. Such high recovery underlines the effectiveness and eco-friendlines of the recycling activity in the territory.



Country	Maximum annual ship recycling LTD	N° shipyards
Belgium	34,000	1
Denmark	63,000	6
England	6,219	2
Estonia	24,634	1
Finland	20,000	1
French	31,730	4
Ireland	12,000	1
Italy	38,564	1
Latvia	0	1
Lithuania	25,550	4
Netherlands	80,000	5
Norway	100,500	8
Spain	5,686	2
Turkey	487,630	8

Figure 8: Recycling Capacity in LTD in European Countries, Perspectives for the Development

of a Circular Economy Model to Promote Ship Recycling Practices in the European, Francesco Tola, 2023

Employment and economic impact of ship recycling industry of Western Europe has the employment of over 4000 direct workers and contributes to further 15000 related industries including waste disposal industries, steel manufacturing industries, and transporting industries. It is greatly involved in the local economies; especially in regions like Flanders or the Atlantic ports of Brest, Ghent and Rotterdam.

Western European yards have to have management of environmental systems which are certified according to international standards of 14001. These systems encompass:

Air quality monitoring is the daily monitoring of concentrations of particulate matter (PM10 and PM2.5) and volatile organic compounds so as to observe the lawful limits set by EU on air quality. The EU has set maximum permissible limits with regard to the particulate matter that the facilities have to adhere to and according to the 2023 data, the concentration of particulate matter in the facilities is lower as compared to the prescribed limits.

Water quality monitoring is the sampling of water and sediment from and around the recycling yards at least once in a week. In 2023, heavy contamination of metals of the water and sediment at Brest facility was detected to be below 0. The level of 1 mg/L complies with all the regulatory requirements set for the metal.

Noise and soil quality monitoring is when there are concerns on noise where capacity has to be exercised in order not to endanger neighbouring villages, towns or cities and the sea and soil pollution which has to show levels that would not lead to toxicity in the event of seepage. The Hamburg yard noted its noise level as being below allowable limit- 55dB during daylight and 45 during the night.

Behind all these, there stands the issue of worker safety and labour practices. There is the European Framework Directive 89/391/EEC on Safety and Health at work and all the ship recycling facilities in Western Europe are bound to observe this policy. Key measures include;

The training to the personnel’s should include at least the following topics; frequency of exposure to hazardous material, responding to hazardous material related emergency situations and utilization of PPE. Throughout the year 2023, more than 1200 employees received the safety as well as the emergency response training at all EU accredited yards.

Health risk assessments must be conducted for all employees that are susceptible to the risks posed by materials including asbestos or lead. workers health problems were only insignificant that welfare examinations carried out among Naval Group Brest employees in 2023 revealed that 98% of the workers had minor health issues only.

An environmental culture that disallows any occurrence of accidents and/or incidents which have report and investigation measures in place and are implemented as soon as possible. It is worth noting that in 2023 Western European yards indicated an accident rate of less than 2 per 100000 hours worked, which is rather low in comparison with the overall tendency.

Despite its high standards, Western Europe's ship recycling industry faces several challenges; High operational costs, for above is that as the company is required to meet and maintain high standards of environmental and safety compliance its cost can be three to five times more than what it is in South Asia thus the strategic position of unable to compete on price is upheld.

In the present context, the Western European facilities are capable of handling only a very limited portion of the global demand and a number of shipowners have been driven to find recycling facilities beyond the region.

Even though the EU SRR has higher standards it is optional and its enforcement depends on specific country. As per the observations made by EMSA in 2023, it has been seen that, there is some disparity in the observation of the risky materials handling and the subsequent reporting of the same among certain facilities.

This is with the European Commission having made new amendments to the EU SRR, which will result in the enhance standards coupled with promotion of investments in green technologies. As 2024, several of the Western European yards revealed intentions to increase their existing capacities and invest in new equipment to increase competitiveness and ensure an ecological nature.

In Denmark for instance the government encouraged the yards to implement robotic dismantling techniques for safety measures and efficiency. In France, new PPS scheme was initiated to encourage new technologies in the recycling sector and more specifically the decommissioning of offshore structures.

Country	Key Facility	Ships Dismantled (2023)	Total GT Dismantled	Material Recovery Rate	Notable Practices
Belgium	Galloo Recycling Yard, Ghent	50	1.2 million	96%	Dry dock recycling, enclosed dismantling
France	Naval Group, Brest	42	950,000	98%	Pier breaking, advanced waste management systems
Germany	Recycling Yard, Hamburg	37	850,000	95%	Decontamination, safe asbestos removal
Netherlands	Damen Shipyards, Rotterdam	45	1.1 million	97%	Alongside ship-breaking, green passport certification
Spain	Navantia Shipyard, Ferrol	32	900,000	96%	Controlled dismantling, energy recovery from waste

Table 3: Key Facilities and Notable Practices, prepared by the Author

Section 3.2.5 Surveys

· Purpose: This paper evaluate real life applications of CE practices in maritime logistics comparing Turkey and Western Europe

· Selection Criteria: The selection of cases was done through the consideration of the following factors: relevance of the cases, accessibility of information, and the ability to demonstrate CE practices.

· Approach: To this end, the selected cases will be analyzed in details to find the success, problems and results. Data collection will involve the use of company documentation, industry

journals, and interviews with shipyards, ship recycling companies and organizations that seeks to implement better and sustainable methods in recycling ships.

A large-scale study was conducted of the practices in the maritime logistics industry related to the circular economy and strategies for the disposal of vessels, including 33 professionals with an average of 14 years of experience in the field. The figure below shows the distribution of the respondents based on the different stakeholder group which include the captains, shipowners, shipyards, recyclers, and policymakers. Thus, the involvement of decision-makers in organizations helped to obtain the views of those who hold key positions in organizations and of those who set the trends in the industry. Including these decision-makers increases the effect of the study in the formulation of future maritime logistics policies and strategies involving circular economy practices.

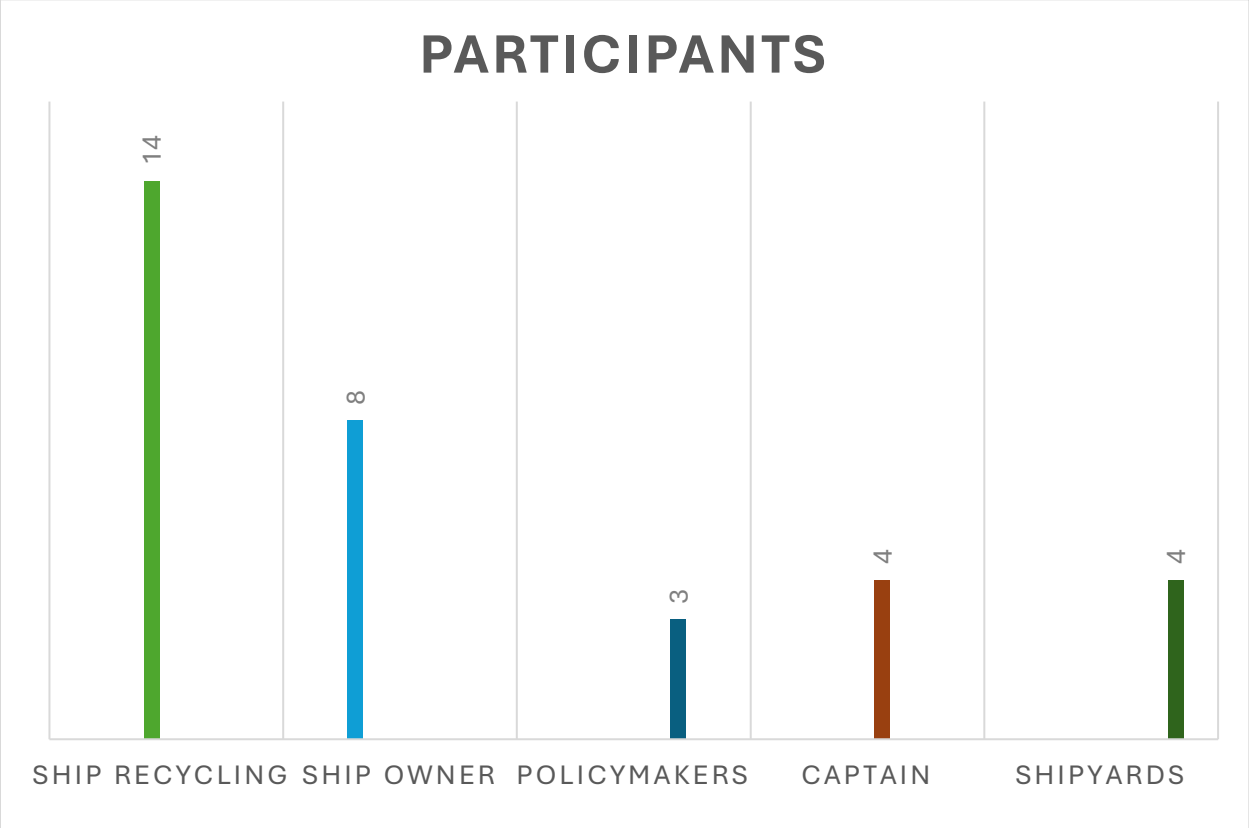


Table 4: Participants for the Survey, Author based on participants

The survey findings show the challenges that slow down the shift towards a circular economy but at the same time, show that change is possible. Interestingly, the OEMs that responded to the survey displayed a good understanding of this possibility and a willingness to spend on R&D to uncover more about circular economy concepts. In addition, the survey revealed that the stakeholders are in agreement that cooperation between the different actors in the maritime sector is critical in the realization of circularity measures.

The participants briefly tutored about CE and what CE practices are, clarifying any confusion regarding the survey.

1. What are the significant activities and difficulties involved in the recycling of ships at the end of their useful life?

a. Many practices have been implemented, and only a few issues have arisen.
b. Some practices: Despite the many such efforts that have been made, there are still many challenges.
c. There are many challenges, but there are few practices.
d. Other (please specify)

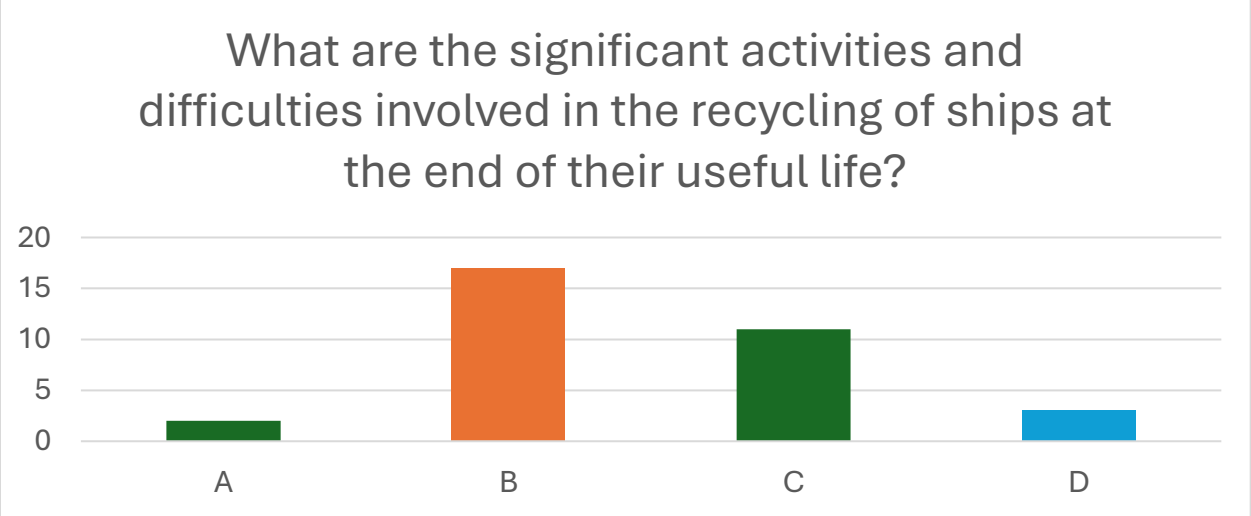


Table 5: Results of Question 1, Author based on results

As shown in the results, the majority of the stakeholders (52 percent) agree that although some measures are taken, many issues still affect ship recycling. A third (33%) of the respondents agree that there are many difficulties, but few measures are available to cope with them.

2. What are the differences in the impact of recycling ships' recycling from Turkey and Western Europe?

a. The problem of sustainability needs to be improved in Turkey.
b. The problem of sustainability needs to be improved in Western Europe.
c. Impacts are similar
d. Not sure

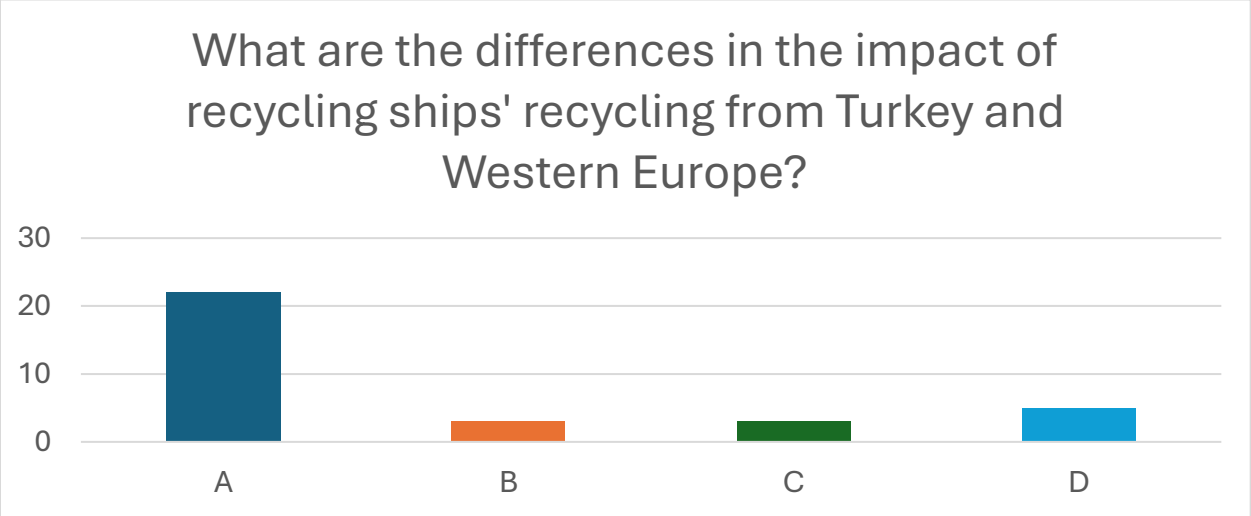


Table 6: Results of Question 2, Author based on results

The findings of the survey indicate that majority (45 percent) of the experts think that sustainability of ship recycling needs more enhancement in Turkey than in Western Europe. This finding is in line with the argument that Turkish recycling facilities though showing signs of improvement suffer from some important constraints including strict regulatory requirements, technological development, and environmental management.

3. What measures in respect of recycling of land vehicles may be beneficial for ship recycling?

a. Better waste management
b. Improved ways of decommissioning the system.

c. Stronger regulatory compliance

d. Other (please specify)

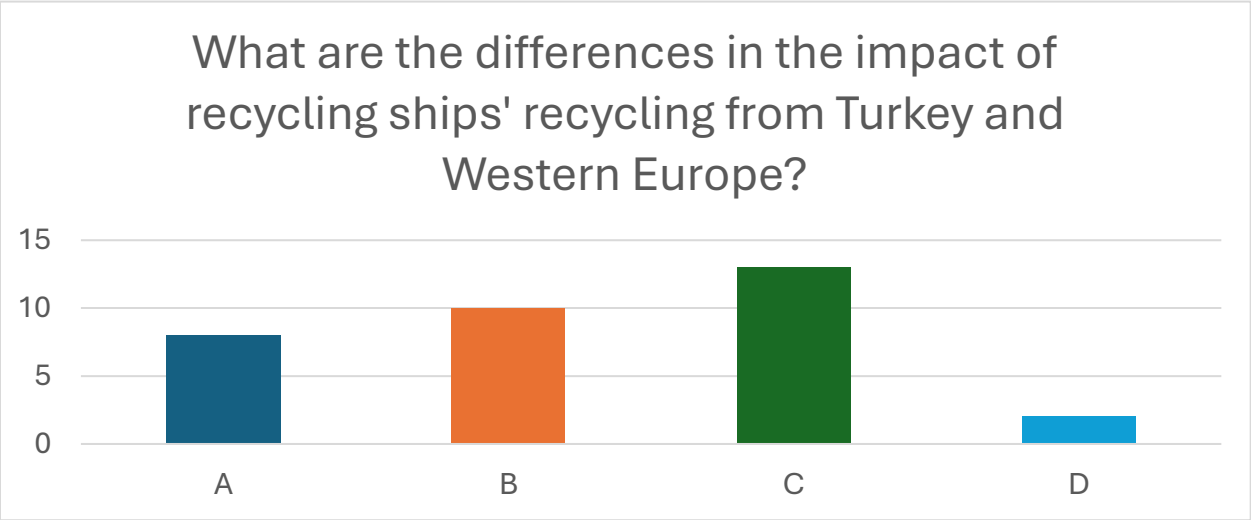


Table 7: Results of Question 3, Author based on results

A majority (39 percent) of the respondents suggested that enhancing regulatory compliance is the most crucial improvement measure for ship recycling, which points to the necessity of stricter rules as in the case of car recycling.

4. To what extent have the current laws and policies successfully contributed to the circular economy in ship recycling?

a. Very effective

b. Moderately effective

c. Slightly adequate

d. Not effective

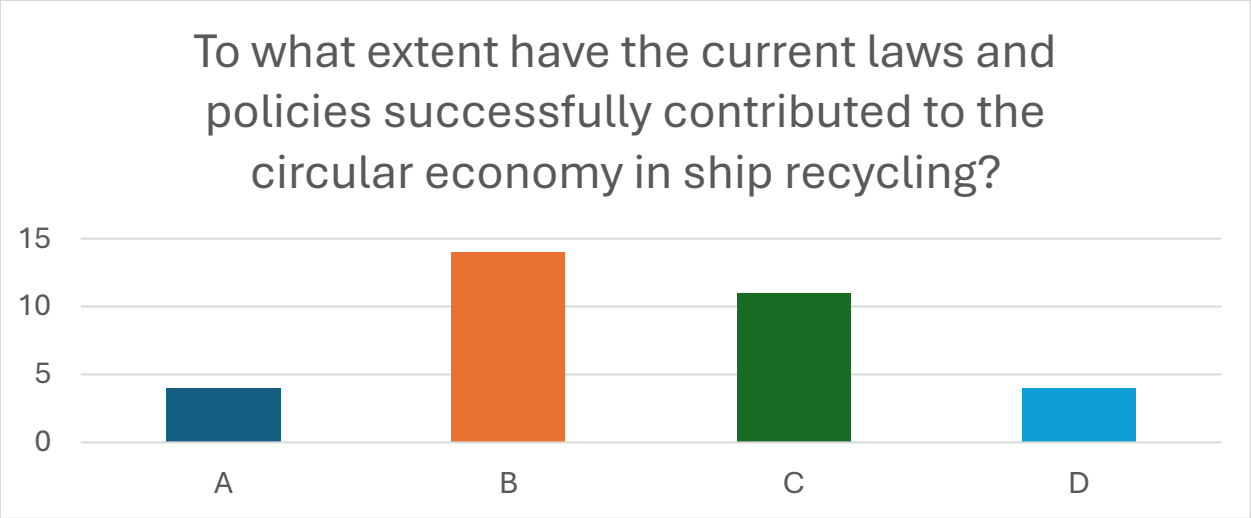


Table 8: Results of Question 4, Author based on results

A majority (42 percent) of the respondents think that the existing laws and policies are quite useful to promote circular economy in ship recycling. Although, a third of the participants regard them as somewhat useful, thus there is still much to be desired.

5. What are the most significant barriers to implementing a circular economy in maritime logistics?

a. High costs
b. Lack of regulation
c. Studying for the need for more awareness or knowledge.
d. Other (please specify)

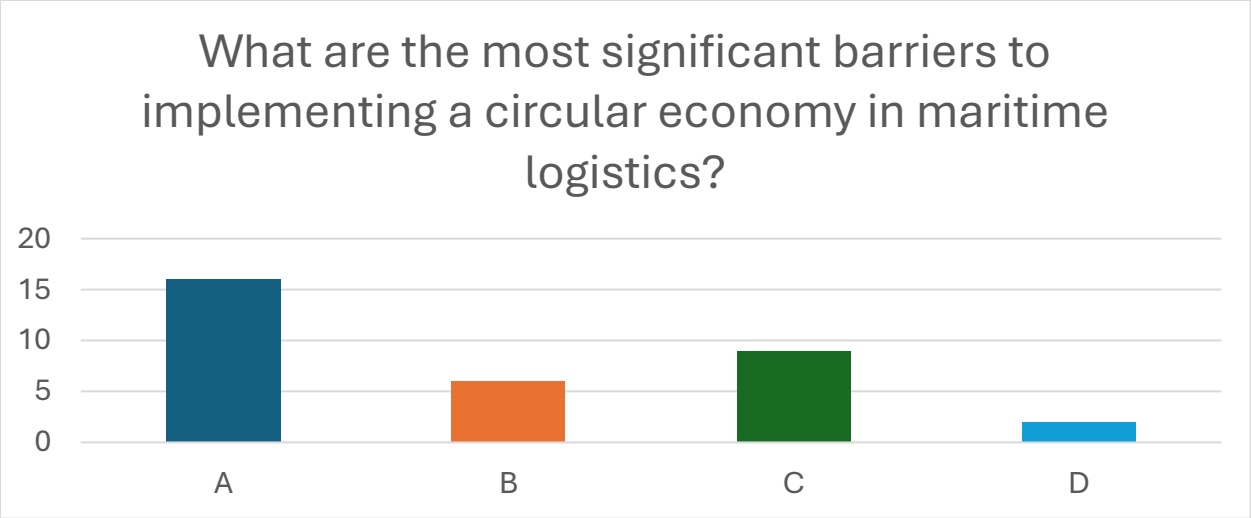


Table 9: Results of Question 5, Author based on results

According to the survey, the main challenge towards circular economy in maritime logistics is the high costs which was mentioned by 48% of the respondents, this is followed by lack of awareness/ knowledge at 27%.

Stakeholders understand that this process is not without some form of challenge though some practices exist in ship recycling. There is a controversy on the extent of impact between ship recycling and land vehicle recycling but most observe the impacts to be similar. The present laws and policies are considered as relatively good but there is the need for strengthening and enforcement. Huge costs are the major impediments, coupled by poor enlightenment and policies.

Section 3.2.6 Interviews

• Purpose: To identify the current situation, problems, and potential of CE in maritime logistics from the perspectives of industry specialists, regulators, and practitioners.
• Participants: Maritime logistics, ship recycling organizations, , as well as regulatory authorities.
• Approach: Data collection tool that is used is semi-structured interviews which may be done face-to-face, through telephone or video conferencing. All the interviews conducted are taped and later on transcribed for the purpose of analysis.

The interviews will have the same ten rigid questions and the information gathered will be

included in the result section. Thus, to maintain anonymity all participants of the interview were assured that their identity would remain unknown to any third party. In any section of this research, no names, jobs or other features that can point towards the subject are provided. All material gathered from the participants of the interview was confined to the study; hence any work done on their response was done anonymously.

Specific questions for the interviews were developed for various groups of stakeholders to gain understanding of the barriers and opportunities for the shift to circular economy in the maritime sector from the standpoint of their position in the field. This approach was to provide a detailed insight into the challenges faced by different stakeholders that include shipbuilders, ship recycling facilities, port authorities and shipping companies. This provided a rich picture of the areas that are considered to be most important in order to facilitate a seamless transformation of the maritime industry through the application of sustainable and circular practices.

For General Understanding and Current Practices, the following questions were asked to the interviewer.

- What measures are currently being taken for ship recycling in Turkey and other countries of Western Europe?

Ship recycling in Turkey is largely confined to the Aliaga area and facilities here employ the 'landing' technique. Although Turkey has made a lot of progress in this aspect, the process is still not perfect and has some drawbacks especially in containing pollution and handling of hazardous substances. In Western Europe, on the other hand, the process of ship recycling is done in dry docks or specially designated ship recycling facilities that use more organized and mechanized approaches, including the use of cranes and cutting tools. These methods are more eco-friendly than the conventional ones, and they follow EU regulations such as the EU Ship Recycling Regulation.

- Which techniques are mostly applied in Turkey for ship recycling and how they vary with those of Western Europe?

Turkey mainly employs the landing technique in which each part of the ship is removed one at a time after the ship is taken to the shore. This approach is cost-effective and facilitates many

vessels to pass through at once. However, it has one major disadvantage that has to do with the environment since it creates a risk of spills and the release of toxic substances. On the other hand, Western European facilities prefer the dry-docking or floating dock systems, which offer better containment of pollutants, enhanced safety of workers, and proper waste management. These methods are consistent with the higher level of environmental norms that are mandated by laws in the European market.

- On what basis do you evaluate environmental and safety standards of ship recycling in these regions?

The environmental and safety features of the Western European countries are comparatively better than those of Turkey. The provisions of the EU regulations, such as the EU Ship Recycling Regulation, require that recycling be done only in the selected safe and environmentally sound facilities. Such standards are maintained through periodic checks and audits and certifications. In Turkey, although some improvements have been made in conformity with the international conventions such as the Hong Kong Convention, problems persist in the areas of compliance and enforcement. Nevertheless, Turkey is gradually implementing the measures that can raise its environmental standards and occupational health and safety, for instance, through technological upgrade and increasing the role of regulation.

For Regulatory Frameworks and Compliance, the following questions were asked to the interviewer.

- What is the difference between the Turkish and Western European ship recycling regulatory actions?

EU member states follow the EU Ship Recycling Regulation which mandates that all EU flagged ships be recycled in the EU approved facilities even if located outside the EU. This regulation has very specific measures on environmental protection and safety of the workers in handling wastes, hazardous materials and pollution. Turkey is not an EU member state but has signed up to the IMO's Hong Kong Convention, which also seeks to enhance the safe and environmentally sound recycling standards. Nevertheless, it is necessary to note that Turkey has a more permissive legislation system than the EU and offers more possibilities in some aspects,

especially regarding facility approval and compliance. The authors also found some differences in the two legal systems, specifically Turkey's being more flexible in certain aspects such as facility approvals and monitoring facilities' compliance.

• What do you think the legal framework of Turkey and Western Europe is concerning the environment and waste management? Why or why not?

This is so because western Europe is one of the most regulated regions in the world and has adequate measures for enforcing the regulations. This is however a challenge in the implementation across all the EU member states and its facilities. However, there are still certain areas within the legal system of the Turkey which needs further enhancement especially in terms of monitoring, enforcement and compliance with the best practice standards that are prevailing globally. This will include enhanced accountability, severe consequences in case of violation of the set rules and improved capacity of the regulating authorities to enforce the rules and encourage good and green practices.

• Among the current Western European regulations or policies which of them can be relevant for Turkey to enhance the ship recycling regulation?

This is because some of the aspects of the EU Ship Recycling Regulation if implemented in Turkey may be of advantage to the country for instance the certification and approval of recycling facilities that ensure that safety and environmental standards are met. Other measures that can also be of great benefit to the ship recycling practices in Turkey include; proper measures in handling and management of hazardous waste, safe handling of workers and materials used in the process, and frequent checking and examination of the ship recycling yards. It would also help Turkey in the international recycling market especially with the shipowners who are more conscious of the environment friendly methods.

For Challenges and Barriers, the following questions were asked to the interviewer

- What are the differences between the issues that the ship recycling facilities in Turkey encounter and those in Western Europe?

Another problem that faces Turkish ship recycling facilities is how to increase their economic efficiency while at the same time enhancing environmental and safety performance. It has also been noted that the costs of upgrading facilities in order to match international standards can be quite high. Moreover, Turkey struggles with the lack of compliance of all facilities due to the problem of resources and the capability of the regulatory body. On the other hand, Western European facilities are relatively better technologically endowed and have better infrastructure; however, some of the issues they experience include high costs of operations and complexities of regulation, which may affect their bottom lines.

- What are the economic, social, and political factors that affect ship recycling in these regions?

Economic factors are the most important in Turkey as the recycling of ships is one of the major employers and income generators, especially in areas such as Aliaga. Nonetheless, there is a conflict between economic sustainability and the enhancement of environmental and safety standards. From the social perspective, there is a growing concern and demands from local communities and international bodies to improve the standards of practice. On the political front, Turkey's desire to meet EU norms and standards is a key factor that has to drive the reforms. In Western Europe especially, the focus is on sustainability and compliance with the European Union directives due to the political agenda of environmental conservation and the circular economy.

- In what extent are challenges preventing from shifting to more sustainable or, at least, circular economy–oriented ship recycling in Turkey and Western Europe?

Indeed, there are several barriers. In Turkey, lack of finance and the requirement of a large amount of capital for the improvement of infrastructure and technology are the main barriers for the adoption of more sustainable strategies. More attention also needs to be paid and more training should be given on the circular economy concept. In Western Europe, the legal and policy context is favorable for sustainability, but the cost of compliance is relatively high and there are few opportunities to recycle. Also, the ship recycling sector in Europe operates under

pressure from fewer-cost structures in South Asia, where the same rules do not always regulate the recycling process.

For Best Practices and Innovations, the following questions were asked to the interviewer.

- There are various measures of environmentally sound ship recycling that have been implemented in Western-European countries and which could be adopted in Turkey?

The best practice that Turkey could have taken from Western European countries when it comes to recycling of ships is the use of dry docks since this can help in containing hazardous wastes and minimize pollution. Also, improving on waste management practices such as segregation and disposal of waste would also improve on environmental results. Other measures that can also be adopted in the Turkish facilities include; worker safety programs like safety drills, trainings and the use of personal protective equipment.

- Of course, there is a question whether there is any new method or tool available in the market in Western Europe which is not used in Turkey, or there is the method or tool which is used in Turkey and not in Western Europe?

There are new trends that are being embraced in Western Europe for the handling of hazardous materials through digital technologies in managing inventories and automation of dismantling processes. These technologies are not very widespread in Turkey and the country still relies on the manual approach. On the other hand, Turkey has recently started to adopt some recycling schemes into the framework of circular economy principles including metal recovery and reuse that can be expanded to western European region.

- What part does certification or international standards have in formulating ship recycling practices in both regions?

Certifications and international standards, for example, the EU Ship Recycling Regulation and the Hong Kong Convention, act as drivers of ship recycling practices. They offer a way of meeting the legal requirements, provide a measure of uniformity in safety and environmental performance, and add to the market value. For the Turkish entities, compliance with these standards is getting more important as the country aims to capture international business,

including the European shipowners who are required to adhere to very stringent legal guidelines.

For Future Outlook and Recommendations, the following questions were asked to the interviewer.

- What are the future trends of ship recycling methods for Turkey and Western Europe?

More stringent measures are expected to be implemented in both regions owing to the changes in regulations and competition in the market. In Turkey, this may entail a deeper commitment to improve facility investments, the adoption of superior technologies and EU standards. In Western Europe, it is possible to expect the further consolidation of recycling facilities for their economic feasibility and the further evolution of recycling and circular economy.

- In light of the above findings, what measures should be taken to improve the current Turkey's Western Europe relation to improve on-ship recycling?

This can be done by sharing of information and data, collaboration in research and development and provision of technical support. It will be possible for the European Countries to provide financial and technical support to Turkish establishments for their compliance with the new standards. Sometimes there is a need to have collaborative structures for instance the relationship between Turkish and European recycling facilities.

- What could the policymakers or industry stakeholders of both the regions do, in order to enhance the sustainability of the recycling procedure of these ocean-going vessels?

It is therefore important for the policy makers to come up with policies that will ensure that facilities adopt the best practices and are able to fund cleaner technologies. This would also assist in the implementation of the set standards by increasing supervision thus to ensure that the set standards are followed. Industry stakeholders should therefore focus on formulate new policies that can enhance the environmental and economic performance. This will also be in line with circular economy principles like material recovery and reuse and thus aid in the fight against global sustainability.

Chapter 4. Analysis of Surveys and Interviews

·Qualitative Analysis: Applying content analysis to the interview transcripts in order to code and analyze the data and find out emerging themes and patterns.

· Quantitative Analysis: This makes use of data from surveys to establish the perception, adoption and effects of CE. Cross tabulations will also be done in order to compare and contrast the two sectors.

· Synthesis: Combining of the qualitative and quantitative research data for the overall analysis of CE in maritime logistics and its comparison with other transport sectors.

These data analysis techniques will be interviews and surveys to relate the regulatory authorities and present practices.

Based on the survey data, the paper identifies a number of findings about the practices, issues, and possibilities associated with ship recycling as a part of circular economy. Based on this study, information that is useful to gain an understanding of the present state of ship recycling activities in Western Europe and Turkey has been elicited, the strengths and the challenges emanating from the two regions.

4.1 Challenges in Ship Recycling

According to view respondents have shown in the survey, more responses (52% of the total) have agreed with the statement that though there are practices followed in ship recycling still there are many problems. This is an indicatives of the current situation whereby while there has been some improvement there are still a number of issues that need to be dealt with when it comes to the proper practice of sustainable ship recycling. Stakeholders also understand that there are discrepancies between the planned results of the existing procedures and the real consequences, especially for the environmental and economic effects.

In addition, 33% of respondents claim that there are many issues, but there are not many practices to tackle them. This means that awareness and regulation for instance as provided by the EU Ship Recycling Regulation are insufficient to manage the real-life issues within the industry. These may be reasoned as for example, the lack of infrastructure that supports recycling, the inability to access the technologies that may be required in the recycling process and the lack of incentives for the adoption of best practice.

4.2 Cross-culture sustainability improvements

In general, the survey shows that there are perceived differences in the sustainability of ship recycling between Turkey and Western Europe and both regions have the potential to improve. Turkey, in particular, may need to enhance and implement stricter regulations and integrate innovative technologies to meet sustainable development standards. On the other hand, Western Europe also needs to streamline more its practices in order to eliminate the current gaps and aim for the highest level of sustainability in ship recycling.

4.3 Adapting Practices from Land Vehicle Recycling

One of the findings from the survey is that 39% of the respondents indicated that improved regulatory compliance as the greatest lesson that can be learned from land vehicle recycling that can be applied to ship recycling. This implies that the stakeholders appreciate the need to have stringent rules and regulations that set standards, safety measures and environmental protection. If the ship recycling industry were to adopt and enforce more stringent regulations as are the case in the automotive industry, then there would be consistency in operations and results.

Also, 30% of the respondents believe in the need of better ways of decommissioning the ships which goes on to show the need for better methods that are more efficient and safer as far as dismantling ships are a concern. This is in line with the general policies of trying to find new ways of recycling the structures including the use of robots or other forms of automation in handling large structures in a safe and efficient manner. Other measures that received 24% of the participants' attention include better waste management practices that exemplify the need for proper segregation, handling, and disposal of waste materials that can lead to environmental pollution, and increase the value of recycled ships.

4.4 The Role of Laws and Policies at the Current State

On the extent to which the current laws and policies do indeed help in the enhancement of circular economy in ship recycling there are different opinions. However, as stated by the

respondents, most of these policies are only moderately effective with 42% of the stakeholders agreeing while 33% agreeing that these policies are only slightly adequate. This shows that even though efforts have been made in establishing such regulations such as the EU Ship Recycling Regulation and the Hong Kong Convention there seems to be little implementation and enforcement in some instances.

4.5 Barriers to Implementing a Circular Economy in Maritime Logistics

The major challenge that has emerged based on the views of the stakeholders is high costs; 48% of the respondents considered this as the main issue. This finding is in line with the high financial costs of adopting sustainable recycling practices including purchasing of new technologies, compliance with strict legal requirements and handling of dangerous substances. The high costs remain a major challenge especially to small scale recycling plants or those based in areas with little or no financial support from government or international organizations.

However, only 73% of the respondents have knowledge regarding the concept and its potentials and this is a key factor that calls for more awareness on circular economy principles in the maritime logistics chain. This literature gap may be a major challenge in the way of effectively implementing new practices that have the potential of improving the recycling result and at the same time lowering the cost in the future.

4.6 Broader Implications and Future Directions

The following are the major issues that could be identified in this survey to address in order to support the CE in ship recycling. First of all, more emphasis should be made concerning the importance of increasing the level of compliance with standardization requirements and make sure that all the stakeholders are aware of the standards that have been set. Second, the issue of the possibility of sustainable recycling measures needs to be questioned through funding sources such as partnership with private sector or grants or tax incentives that will help in the procurement of equipment and hence make the plans for sustainable recycling more sustainable.

4.7 Overall Analysis of Surveys and Interviews

Analyzing the studies of ship recycling practices in Turkey and Western Europe, the reader will find that the field is full of diversified approaches caused by the varying legislation, economic strategies, and problems with the environment. Within the practice of ship recycling on the Turkish territory, the constant application of the landing technique points out to economization and environmentalization at the same time. But still, Turkey has to struggle with a number of issues in improving its compliance effectiveness, inspecting and regulating the shipping industry safety and environmental standards that still remain low even with the recent efforts for being in accordance with the international standards including the Hong Kong Convention. The lack of technological advancement and improvements in enforcement regulation require large capital investment to push for improvement in the current standards of ship recycling industry.

Contrarily, Western Europe, especially, the area governed under the EU Ship Recycling Regulation, has proved to be extremely rigid concerning environmental and safety benchmarks. Recycling facilities of ships in this region are comparatively more systematic and utilize modern technicalities in the context of recycling such as dry-docking method which in actuality has less detrimental repercussions on environmental degradation and worker's safety compared to other methods. However, these methods also increase operational costs, they erode the competitiveness of European facilities especially in view of cheap and relatively unrestricted regions like South Asia.

The conclusion of the study is that there are certain unique challenges for both the regions but there are good possibilities for regional convergence. Turkey, for instance, may bring up on best practices to western Europe that include better and efficient waste management methods, better protection of the workers in the ship recycling industry as well as better technologies for recycling. On the same note, Turkey's western counterpart; Western Europe could stand to adopt Turkey's initiatives in EMs and the CE of metals since they are gradually transitioning to sustainable economy practices.

For the right developmental progress of sustainable ship recycling both in the regions, a synergy is needed. Thus, the Turkish government and partners should concentrate on fortification of regulation, development of financial and technical support and cooperation between Turkey and European representatives. Through such strategies as material recovery and reuse, Europe

have the potential to enhance their resources efficiency, and consequently environmental and economic impacts on the global level.

Chapter 5. Conclusion

In the adoption of sustainability and CE in the shipbreaking industry there are short-term effects such as the cost of setting up new green facilities and protective clothing for workers. Developments in the shipbreaking yards in the form of new docks, antifouling equipment and safer protection gear will be costly, and therefore increase the cost of dismantling ships. Moreover, the compliance cost for unqualified ship recycling facilities is likely to rise from 0% to around 50%; this situation may cause a decline in the number of EOL ships that South Asian ship recycling facilities receive and would affect the economy of the area.

Also, it can lead to the shortage of steel and non-ferrous metals provided to the ship breaking countries in South Asia in the short run due to the reduction in orders. However, the shift to green ship recycling may prove to be beneficial for employment and the workers' safety. Some of the environmentally and safety-challenged shipbreaking yards may shut down thereby reducing production capacity and employment but on the other hand, it may lead to the development of green industries such as green technology research and development, anti-pollution facilities, safety protective gears manufacturing, waste reprocessing and recycling industries. This could thus lead to the generation of more green jobs, which could replace the conventional jobs within the sector.

Also, strategic improvements in the ship recycling industry could cut down the chances of death and injury in accidents besides reducing accidental ship damages. For that reason, the green transformation is significant for the ship-breaking industry in the future. The unqualified ship breaking yards which are currently operational should therefore shift their operations to green ship breaking so as to avoid the situation where there are no ships to be demolished due to the expanding regulations and broader country coverage. As the shipbreaking activities are very intensive and the number of EOL vessels is expected to rise in the future, cooperation is needed. In this analysis, we reveal the rather moderate advantages of the EU SRR.

The shipbreaking industry's transition to developing nations has significantly bolstered their economies. As 4th biggest ship recycling country, Turkey plays a pivotal role in the world

especially in Europe.

For countries lacking mineral resources, the shipbreaking industry serves as a hidden boon. The dismantled ships supply raw materials for steel mills, steel plate re-manufacturing, asbestos re-manufacturing, and also cater to the needs of local industries such as furniture, paint, electrical equipment, and lubricants. The ship recycling industry enhances the economies of developing nations in various ways:

Ship dismantling requires a large workforce for cutting, salvaging, and processing various materials. Developing countries with abundant inexpensive labor can benefit from increased job opportunities and reduced unemployment and poverty rates.

The various recycled industries stimulate foreign investors and buyers who want to purchase the recycled products hence contributing positively to the balance of trade and strengthening the worth of the country's currency.

Ship recycling business pays green taxes, fees and licenses to the government to support national development and also, fund social services, physical infrastructure, education, health, and other socio-economic activities.

The economic effects of the ship recycling industry also work on the other subtle levels, influencing the local supply chain, kicking off the creation of spin-off industries, encouraging innovation, and on how the industry is advanced and improved as a whole.

Setting up a shipbreaking yard requires a vast coastal area, making infrastructure availability crucial for profitability. Proper regulatory frameworks are necessary to facilitate smooth ship recycling operations and reap economic benefits. Shipbreaking operations are usually carried out on a large scale, requiring thorough preparation to yield substantial revenue.

Several economic factors are associated with adopting CE principles in maritime logistics, including initial capital investments, long-term benefits, market conditions, and policies. Knowledge of these economic factors is vital to stakeholders in evaluating the viability and sustainability of shifting from the conventional 'linear economy' of 'take-make-dispose' to a circular economy. The next sections uncover different economic factors critical to the realization of circular economy principles in maritime logistics.

Chapter 5.1 Key Takeaways

Key Takeaway 1. Initial Capital Investment

A major challenge is the cost implications of changing from a linear mode of operation to circular one. This means that the management of circular operations could require new investments in technology, assets and systems in maritime logistics companies. This may include:

Creating new or enhancing ship recycling yards that meet better environmental, and safety standards requires much investment. To conform to the circular economy, recycling processes must be in conformity with the best technologies used in product and waste dismantling, waste processing, and materials recovery.

This refers to the need to invest in research and development (R&D) to develop new circular economy practices, such as new biodegradable materials, ships designed for easy disassembly, or new uses for recycled material. It is the role of R&D to address challenges hindering the applicability of circularity and check the viability of circular approaches.

Likewise, companies need to spend resources in training and developing relevant competencies among their employees. This entails education on ship design for sustainability, recycling procedures and business strategies linked to circular economy system.

The high capital investment required for implementing a circular economy may discourage small enterprises, especially in the capital-intensive industry of maritime logistics. Such costs have to be compared with the possible long-term effects on a company's performance and revenues, which may differ significantly depending on numerous factors, including market trends, legal and regulatory environments, and technological innovations.

Key Takeaway 2. Efficiency and Reduction of Cost

Some of the most important business cases for CE are related to cost reduction and optimization of resource use. Reduction of waste, reuse, and recycling at EOL are a part of circular economy and which can in the long term be cost-saving.

On the same note, by recycling, firms are a able to save on raw materials such as steel,

aluminium and copper which may be expensive and vary in the market. For example, steel from dismantling of ships can be utilized in the production of new ships or other products alike, thus avoiding spending on a new steel.

It also minimizes the costs incurred in disposing of waste. By ensuring that ship components are recycled and reused appropriately, the volume of waste that has to be dumped or treated is reduced, which could prove expensive and/or heavily regulated.

Ship upgrading, repair, and preservation help prolong the life of existing ships, so there is no need to invest in a new one. This is because the useful life of vessels and equipment can be extended, and thus, companies can achieve higher ROI and minimize the costs of new builds. Practices of circular economy are known to enhance energy efficiency in most cases. For example, the energy to recycle products is required to extract and refine new raw materials and this is not the case with recycling. Also, the ships would be constructed in a manner that they could easily be disassembled and recycled and this would also go along way in cutting on the costs of maintenance and increase the fuel efficiency thus cutting down on the costs.

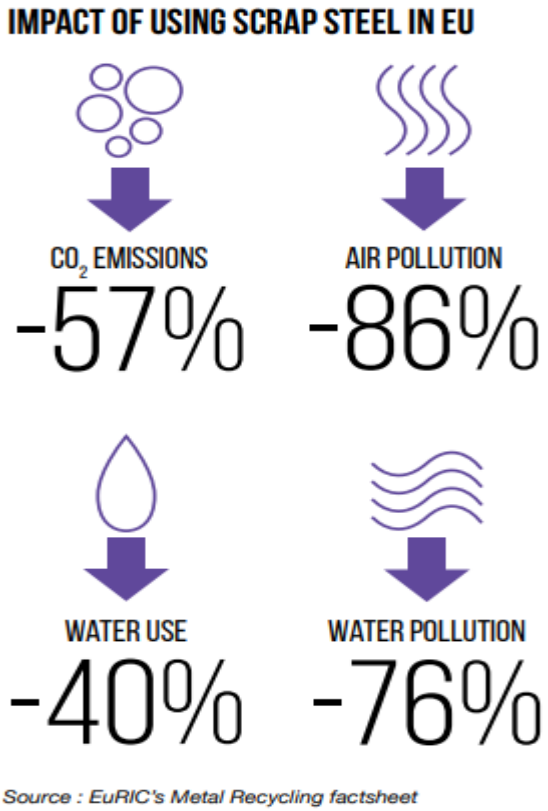


Figure 9: EURIC's Metal Recycling Factsheet, 2022

Key Takeaway 3. Market Trends and Consumers' Desire for Recycled Products

The CE business models depend heavily on the market forces, especially the demand for recycled goods. Several factors influence this demand.

The extent of profitability of recycling is hinged on the price spread between recycled and virgin materials. If the price of raw materials is high, then the recycled material becomes relatively cheaper, which offers great economic motivation for recycling. Nevertheless, when the prices are low, the economic rationale of recycling is less compelling and may decrease the demand and discourage investments in recycling facilities.

By developing second hand markets, circular economy practices are only sustainable if there are well-established secondary markets for recycled products and remanufactured goods. These markets rely on demand from industries that are likely to consume products made from recycled material: construction, automotive, and manufacturing industries, for instance. If a secondary market is well developed, it will provide stability in demand and thus making recycling materials continuously profitable.

In the context of ship recycling, by-products such as steel, copper, and aluminum have their worth and can be sold to different industries to earn more revenue. However, the market price of these by-products can fluctuate which poses some problems in the aspect of economic efficiency in collection and recycling of wastes. It is thus important to invent new ways of growing the utility of waste products and by-products so as to enhance their value in the CE and in addition to that enhance the financial fare of the circular economy.

Key Takeaway 4. Incentives, both Economic and Legal

The role of policy and the market on the economic aspects of circular economy is to a large extent shaped and directed by governments and intergovernmental organizations. These frameworks can either promote or hinder the adoption of circular practices:

Financial aid in form of subsidies, grants and tax exemptions offered by many governments and international organizations has been offered to companies to embrace circular economy. For instance, incentives can be given for making an investment in new recycling technologies or

modifying older vessels in a bid to enhance their energy efficiency. These incentives can contribute to the covering of the initial investments and, therefore, make circular economy more financially viable.

EPR policies impose a financial liability on the producers for properly disposing products at their end of life and encourage the circular economy. In the maritime industry, shipbuilders and owners may have to pay for the recycling costs or may be forced to come up with better ship designs that will make it easier to recycle in order to meet the regulations. On the downside, EPR policies can impose certain economic impacts in the short run; however, they promote cost-saving and optimization of resources in the long run.

The maritime industry is under pressure to decrease the emission of greenhouse gases. Therefore, carbon pricing will receive more acceptance with either the carbon taxes or the cap-and-trade systems. The circular economy principles, which are associated with the use of less energy and lower emissions, can enable companies to escape high carbon costs, thus making it lucrative for organizations to embrace circular economy models.

On the other hand circular economy practices can also result in higher compliance costs as far as regulation is concerned. For instance, achieving high levels of recycling standards or acquiring certification on sustainability may be expensive and may take a lot of time. There are however other costs that companies have to consider in relation to the potential economic benefits or incentives that may arise from compliance.

Key Takeaway 5. Innovation and business model innovation investment

Transitioning to a circular economy requires companies to rethink their traditional business models, which involves both opportunities and economic challenges. A change to a circular economy means that big and sometimes systemic shifts are needed in how companies design value propositions, a process that has its inherent opportunities and economic implications: New business models that better reflect circular economy concepts are, for instance, leasing rather than owning ships, the ‘ship as a service’, or takeback of vessels at their EOL.

These models can be used to create new sources of income, increase customer retention and minimize the expenses incurred by ownership. However, such models are costly and time-consuming to build and amplify and require organizations to be prepared to accept risk and

change.

As circular economy practices, these strategies involve integrating shipowners, shipyards, recyclers, suppliers and regulators hence making the concept a multi-stakeholder endeavor. Jointly owned and used waste management assets, such as recycling plants or material recovery facilities, can alleviate the burden of costs and risks and make the circular economy more viable. Nevertheless, establishing trust and ensuring that the stakeholders' objectives are compatible may be difficult and may demand the adoption of new forms of financing, including partnerships between the public and the private sectors or business combinations.

This study also recognizes that the economic viability of circular practices may be exposed to risks such as commodity price volatility, geopolitics, or changes in the regulatory environment. To address these risks, organizations may have to spend capital on financial risk mitigation tools, such as futures contracts in recycled materials or insurance for legal issues. Although these strategies can reduce economic risks, they also increase the decision-making process's complexity and expenses.

Key Takeaway 6. Return on Investment (ROI) and Payback Period of a Long Duration

The last is the economic implications of investing in circular economy, including the rate of profitability as well as the time it takes to gain back the investment. Unlike traditional linear models, where returns are often immediate and predictable, circular economy investments may require a longer time horizon to realize benefits.

It has been established that circular economy practices can result in long-term financial benefits through cost efficiency, improved resource utilization, and revenue diversification. For instance, firms that innovate in designing ships for disassembly can minimize the decommissioning expenditures and create revenue streams from the sales of recycled parts. However, these advances could only be reaped in the next one or two decades at most, based on market environment, technological innovation, and policy shifts.

Thus, the payback period for circular economy investments might be longer than that of a conventional investment, because of high initial capital investment; and the time required to grab a share of the market and achieve breakeven. Thus, when addressing the payback period, the conditions have to be taken into account including references to the overall financial targets of

the company, its aptitude to risks, and the amount of resources available. We should also recall, however, that there can be cases when an individual has to invest money in something, while expecting donations or government subsidies in future to cover the costs of investment and wait for gains.

Key Takeaway 7. Prospective Consequences for a Macroeconomic Environment and General Concerns for the Sector

Finally, implementing circular economy practices in maritime logistics can have broader macroeconomic impacts on the industry and beyond.

Creating jobs therefore growth of the economy. This is because circular economy practices lead to job creation in new industries, which include recycling, remanufacturing, and refurbishing. These jobs may be beneficial in creating employment, especially in areas that rely on marine activities, including the coastal areas and the port cities. Additionally, circular practices can help the economy to grow through the creation of new business models, improvement of efficiency and development of sustainable commerce.

In the circular economy, strategies like reusing and recycling ensure that supply chains are less vulnerable to disruptions from natural disasters, geophysical conflicts, or even the current pandemic. For instance, focusing on the element of raw material dependency.

5.2 Future Research Suggestions

More and more plants are following circular economy concept with the intention of maximizing the material that can be retrieved out of the waste stream. For instance, Damen Shiprepair have engaged with other firms in recycling metals and parts for use in other ship constructions.

There are more and more green recycling, including bio-based solvents for cleaning and non-toxic materials for maintenance are applied.

Technological advancements in robotics, digital twin, and AI application for waste management and dismantling efficiency are being developed. For instance, the Norwegian facilities are among the first organizations that apply the use of drones in the assessment of site

conditions and safety.

More research should be conducted towards assessing the degree of effects on the environment and the society resulting from the employed ship recycling practices in the two areas. This could include assessing the levels of air and water pollution, emission of greenhouse gases or efficiency in handling of hazardous products. Other potential areas include labor conditions, occupational health and safety issues as well as community impacts in order to appreciate the secondary effects of the ship recycling operations.

One of the interesting topics for further research is to explore the relation between using technologies in a sustainable way during ship recycling. This may include analysing the implementation and performance of technologies including automatic dismantling systems, innovative waste management mechanisms and environment friendly decontamination technologies. The research could also identify and evaluate the factors that hinders the adoption of technology in Turkey and Western Europe and recommend ways of overcoming them.

Quantitative future studies should possibly undertake an evaluation of cost implications of sustainable practices to distinguish costs of differential practices. It should take into the account the formative expenses and cost like the labor, equipment, and legal issues while at the same time, looking at the incidental gains that include environmental conservation, resource recapture, and employment creation. It could also contrast the feasibility of sustainable approaches between Turkey and Western Europe and therefore shed light on the subject of how financial drivers and sustainability models can be applied to achieve circular economy.

Research based on a survey of stakeholders' perceptions and effective involvement methods that have not been explored before can give proper understanding of concerns, expectations and incentives of the actors in the sector namely shipowners, recycling yards, authorities, and non-governmental organizations. These insights may be useful in formulating policies and programs that are more resonant with stakeholders' idea and can promote higher levels of engagement toward sustainable development.

The creation of case studies focusing on emerging circular economy projects in ship recycling industry can provide examples of real life engagements that can be used by other regions.

Research could find out outstanding CE practices, including closed-loop recycling, novel material recovery technologies, or CE-based business models already in operation in Western Europe or Turkey. These case studies may reveal the success factors, issues, and trends that can be used to promote the scaling up of similar programs in other parts of the world.

Further research could analyse the impacts of international trade relations including shipping networks, trade policies and the political situation on ship recycling industry Turkey and the Western Europe. This research could explore how these dynamics influence the end-of-life vessel flows to various recycling centres, the competitive structure of the ship recycling industry and sustainable and circular economies.

With regards to future research, long-term investigations, which would illustrate dynamics of the changes in practices, regulations, and actors' behaviour in the sector in the long run would be valuable to assess the impacts of the current and future activities to improve sustainability in the sector. Such studies could establish how such policies, new technologies as well as marketforces have influenced the development of the industry in Turkey and Western Europe, and the trends that may be established from them for future reference.

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