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Developing a sustainable ship recycling facility to diversify coal port operations

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Abstract

The current ship recycling industry is environmentally, economically and socially unsustainable and not compliant with the International Maritime Organisation's Hong Kong Convention for the safe and environmentally sound recycling of ships. More global recycling capacity is required due to the anticipated influx of end-of-life ships and other offshore structures, like oil rigs, in the coming decade. At the same time, for single-commodity bulk ports, such as coal ports, diversification away from overspecialisation is more crucial than ever. Establishing a ship recycling industry in a coal port, like the Port of Newcastle, has the potential to secure its future and establish Australia as a global leader in this aspect of the circular economy.

1. Introduction

The ship dismantling industry used to be situated in ports in the 1950s. However, this is no longer the case as ship recycling facilities shifted to be closer to lower-cost workforces (Tola et al. 2023). Now, the ship recycling industry is primarily concentrated in South Asia; 90% of end-of-life ships (in gross tonnage) are recycled in Bangladesh, India and Pakistan (UNCTAD 2021). In these countries, labour costs are low, conditions for workers are often unsafe and ocean pollution is tolerated (Hiremath et al. 2016), lowering the cost of recycling (Gourdon 2019). Over the past two decades, there have been attempts to regulate the industry through agreements such as the Basel Convention of 2004, the Hong Kong Convention for the Safe and Environmentally Sound Recycling of Ships of 2009 (hereafter referred to as the Hong Kong Convention), and the European Union (EU) Ship Recycling Regulation (Gourdon 2019). As environmental concerns continue to drive the shift towards the circular economy paradigm, there is increasing pressure to recycle ships at facilities that adhere to these regulations.

To address this issue, this paper explores the potential for developing automated Hong Kong-compliant ship recycling facilities within Australian coal ports. Doing so could serve to future-proof coal ports should coal demand continue to decline, accelerate net zero decarbonization strategies, establish Australia as a major circular economy powerhouse, and facilitate a more sustainable ship recycling industry.

2. Literature review

2.1 Current ship recycling methods

Beaching, dry docking, pier breaking, and landing are currently the four methods used to recycle ships (Gourdon 2019). Beaching is the most common recycling method in South Asia. Ships are sailed onto beaches at high tide to give access to workers who gradually cut off pieces of steel from the ship (Gourdon 2019). This process is highly unsafe for workers and causes pollution to the surrounding environment (Adekola & Rizvi 2020). The dry-docking method involves breaking down the ship using cranes. It is seldom done due to the higher cost of doing so (Gourdon 2019). Pier breaking involves securing ships in calm waters, using cranes to remove pieces, and moving them to dry docks once the remaining ship is small enough (Gourdon 2019). Similarly, with the landing method, ships are sailed partly on the shores and are broken down using cranes (Gourdon, 2019). While both the pier breaking and landing methods reduce the requirements for labour, environmental pollution is still high. Overall, dry docking is considered the safest method that also minimises the possibility of toxic waste escaping into the environment. However, the disadvantage of this method of ship recycling is the relatively higher cost.

2.2 Ship recycling regulations

Efforts have been made to regulate the ship recycling industry, including the 2009 Hong Kong Convention to reduce the human and environmental impact caused by the recycling of ships (International Maritime Organisation 2022). However, the convention is still not yet in force more than a decade later. In the meantime, the European Union (EU) Ship Recycling Regulation was introduced. This applies to ships flying EU flags and stipulates that said ships must be recycled at an approved list of facilities (Directorate-General 2022). Facilities from any country can join the list provided certain human safety and environmental conditions are met. Unfortunately, there are anecdotal reports that suggest some ship owners switch away from EU flags before recycling to circumvent the EU regulation (Gourdon 2019).

The increasingly tight regulation of ship recycling coincides with an anticipated influx of ships for recycling, either due to becoming surplus to requirements as supply chains regain their pre-pandemic tempo or becoming substandard with respect to IMO environmental regulations starting in 2023 (Ford 2022). From 2023, ships above a certain size engaged in international trade will need to meet a new efficiency standard as measured the Energy Efficiency Existing Ship Index (EEXI) and a carbon intensity standard as rated by a Carbon Intensity Indicator (CII). Ships with an unacceptable rating will not be allowed to operate in states that have ratified the latest incarnation of the MARPOL convention (International Maritime Organisation 2022).

2.3 Automated ship recycling

If labour costs and the environmental impact of ship recycling can be lowered, an opportunity may be created for an Australian ship recycling industry. Technological advancements have recently been made in automating the ship dismantling process, which could facilitate health, safety, and environmental benefits. A startup (Circular Marine Technologies) is developing one automated process that can price-match facilities in South Asia by fully 'circularising' the process (Maritime Executive 2022). This process works by slicing and cutting the ship into small sections using hydro cutters (Maritime Executive 2022). In addition to the high volume of steel that can be recovered from recycling ships, organic waste can be recovered and converted into hydrogen or methane to power the recycling facility (Maritime Executive 2022). As automation technologies continue to develop, the potential for automated ship recycling grows.

3. Methodology

While many studies have been published on current and past ship recycling trends using system dynamics, there is little research on the potential for automated ship recycling facilities at port precincts. A preliminary system dynamics model was built to simulate the different relationships impacting the development of an automated ship recycling facility at the Port of Newcastle in Australia, currently the world's largest coal port. Several stock, flow, and variable elements build the foundations of the model; these are shown in Table 1.

Table 1: List of all elements in the system dynamics model

Elements	Description	Type
End-of-life ships	Number of ships that are at the end of its life	Flow
Automated ship recycling facility	Number of ships recycled at the automated recycling facility	Stock
Recovered ship resources	Resources (e.g. scrap steel, organic waste) recovered from the automated ship recycling process	Flow
Ship recycling efficiency	The efficiency at which resources are recovered	Variable
Registered ships	Number of registered ships globally	Flow
Ship recycling rate	The rate that ships are recycled	Variable
Trade patterns	The probability that trade patterns (e.g. trends in ship size, COVID-19 and sustainability factors) lead to the decision to recycle	Variable
Vessel age	The probability that a higher vessel age leads to the decision to recycle	Variable
Resale value	The probability that a lower resale value leads to the decision to recycle rather than sell	Variable
Cost to repair	The probability that a higher cost to repair the vessel leads to the decision to recycle rather than repair	Variable
Market price for scrap steel	The probability that a higher current market price for scrap steel will lead to the decision to recycle a ship	Variable
Facility capacity	Capacity at automated ship recycling facility	Variable
Costs	The cost difference between the automated and regular recycling methods	Variable
Automated ship recycling cost	Cost to recycle at the automated facility	Variable
Current ship recycling cost	Cost to recycle at the regular (beaching) ship recycling facility	Variable
Market price for ACCU	The market price for one Australian Carbon Credit Unit to be received	Variable
ESG evaluation	The difference in environmental, social and governance policies between the automated and regular recycling method	Variable
ESG for current ship recycling method	Evaluation of the beaching recycling method's ESG indicators	Variable
ESG for automated ship recycling method	Evaluation of the automated recycling method's ESG indicators	Variable

The preliminary system dynamics model is shown in Figure 1. As data has not been collected and validated yet, dummy data has been used as a placeholder to illustrate how the model functions. Overall, the model shows the total amount of scrap steel that can be recovered, dependent on certain elements and variables.

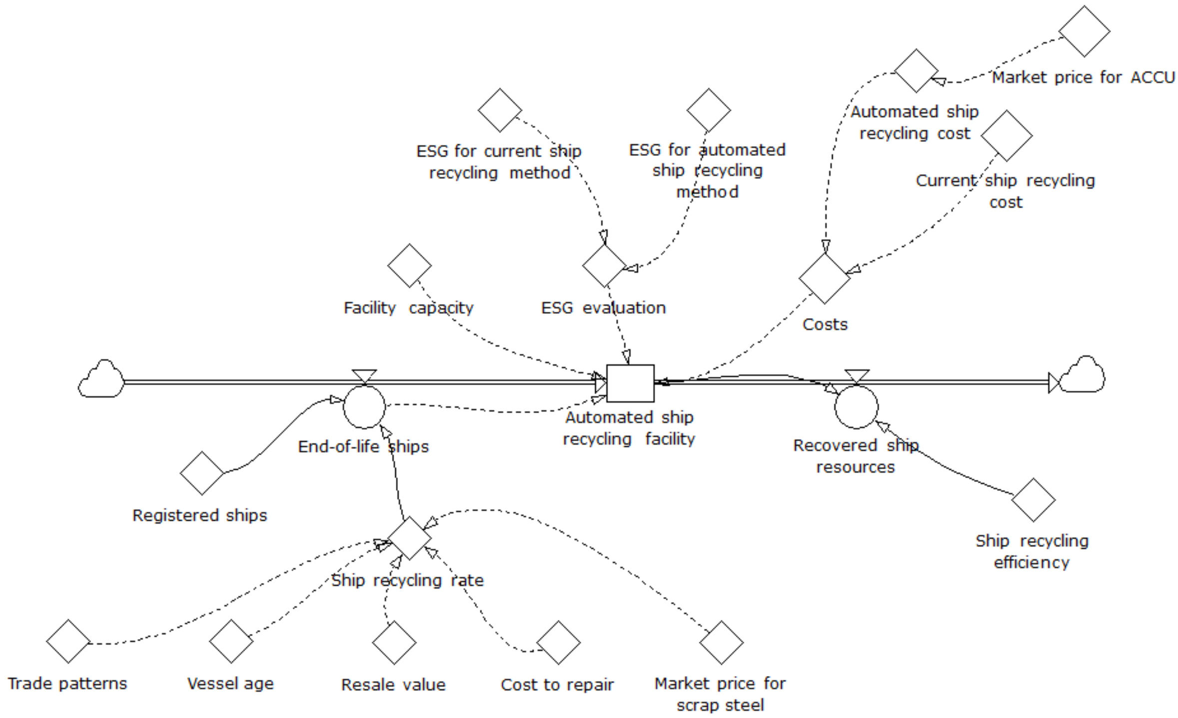

Figure 1: Preliminary system dynamics model

4. Discussion

The main stock in the system dynamics model is the 'Automated ship recycling facility', which is the sum of all ships that are recycled at the facility on the port. The inward flow into this stock is 'End-of-life ships'. The number of ships at the end of their life recycled globally is dependent primarily on two factors: The total number of 'Registered ships' in the world combined with the 'Ship recycling rate' which represents the rate by which registered ships are recycled annually. Additionally, the 'Ship recycling rate' is dependent on five variables: 'Trade patterns', 'Vessel age', 'Resale value', 'Cost to repair', and 'Market price for scrap steel'. The 'Trade patterns' variable represents the impact that changing ship size or type preferences has on ship recycling patterns, the impact that COVID-19 had on shipping patterns (i.e. many cruise ships were scrapped), and the impact of sustainability regulations for ships (i.e. EEXI and CII).

As ships have on average a 25–35-year lifespan, the probability that ship owners will decide to scrap the ship increases with the 'Vessel age'. The 'Resale value' variable signifies the notion that a higher 'Resale value' of a vessel compared to its scrap value will deter ship owners from deciding to recycle. The 'Cost to repair' variable denotes the probability that if a vessel is damaged, a higher repair cost may tip the balance in favour of scrapping. Lastly, the 'Market price for scrap steel' has a major impact on the decision to scrap and the ship recycling rate. In general, if the market price for the ship as scrap steel exceeds the value of the ship based on the charter rate and operating costs, there is a higher probability that the ship will be recycled.

The decision to recycle a ship at the automated ship recycling facility rather than the beaching method is determined by three factors: The capacity at the automated facility, the cost difference with respect to beaching, and the Environmental, Social, and Governance (ESG) policies of ship owning companies. Limited recycling capacity would cap the number of ships that can be recycled at the automated ship recycling facility, lowering the probability that a ship owner will decide to recycle their ship there. In general, the facility's recycling capacity depends on the amount of land available for the facility at the Port of Newcastle.

There is a reduced probability that the end-of-life ship is recycled at the automated ship recycling facility, if the cost of so doing does not at least match that in South Asia. However, restrictions on recycling in South Asia combined with ESG policies favour automated ship recycling. The automated ship recycling method has the potential to attract customers by providing carbon credits in Australia or elsewhere. The current carbon credit system in Australia is heavily flawed as the system is voluntary for companies emitting carbon. This reduces uptake of the system, leading to a low and volatile price for an Australian Carbon Credit Unit (ACCU). Additionally, some companies abuse the system by claiming ACCUs for processes that do not represent genuine carbon abatements. Nevertheless, while the Australian carbon credit system is heavily flawed, it could be repaired with legislative changes, and could be the key to profitable ship recycling facilities. For every ton of carbon emissions avoided or removed from the atmosphere, one ACCU could potentially be claimed and further sold for profit.

The outward flow from the automated ship recycling process is ‘Recovered ship resources’ which comprises various resources including scrap steel, organic waste, furniture, navigation equipment, etc., and are represented using a vector-valued variable as are ‘End-of-life ships’. Overall, the amount of resources that can be recovered is dependent on the number and type of end-of-life ships recycled using the automated process combined with the recycling efficiency of the facility.

For the Port of Newcastle’s case, producing green steel may also drive the transformation of Newcastle back to the prestigious ‘Steel City’ that it used to be. The recent developments for a ‘Clean Energy Hub’, producing green hydrogen on the Port of Newcastle precinct presents the opportunity to situate Australia as a green steel manufacturing leader. Developments in Australian research outputs show extreme potential for green steel manufacturing with the help of green hydrogen as opposed to steel manufactured using ‘coking coal’. Contributing more sustainable steel, in the form of both recycled steel and green steel, to the market would drive a more circular Australian economy.

5. Conclusion

The ship recycling industry is currently unsustainable, but this is changing with the help of three main sets of regulations (Basel Convention, Hong Kong Convention, and EU Ship Recycling Regulation). The transition to a more sustainable ship recycling industry combined with the need to diversify coal ports away from fossil fuel dependency, present the opportunity for the development of an automated ship recycling facility at the Port of Newcastle alongside green steel manufacturing. This paper has presented a preliminary system dynamics model demonstrating the variables impacting the development of such a facility. The next steps for this research are to collect data to predict the demand for ship recycling at the Port of Newcastle and demonstrate the potential associated costs.

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