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Rejuvenation of State Ships to Drive Decarbonization of the Shipping Sector

Danawiryya Silaksanti[1*], Tri Cahyadi[2], Mutiara Adella[3], Winarno[4]

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Abstract**—** In line with the 2023 IMO GHG Strategy, adopted at the 80th Marine Environment Protection Committee (MEPC 80) on the Reduction of GHG Emissions from Ships, Indonesia has been implementing climate action that aligns with its national policy to combat climate change. The Government of Indonesia has been making efforts to rejuvenate state ships, specifically navigation and patrol ships, by building new ships and scrapping old ones. This study assessed the potential for reducing greenhouse gas emissions from state ship construction activities using modern technology. It analyzed operational data for each ship's specifications, such as fuel type, power, and gross tonnage. The study showed that the GHG emission reduction from this activity in 2023 is 128.564,39 tons of CO2, resulting from the 22 new ships built between 2019 and 2023. The construction of these new ships demonstrates the government's commitment to reducing emissions from the operation of state ships by eliminating older ships. It is hoped that if commercial ships are also scrapped and replaced with new ones built using more modern technology that saves fuel, this will enhance efforts to reduce emissions from the shipping sector and encourage maritime decarbonization.

*Keywords***—** *climate action; GHG emissions reduction from ships; maritime decarbonization; scrap and built; ship rejuvenation.*

**Corresponding Author: danawiryya@gmail.com*

I. Introduction

According to the Enhanced Nationally Determined Contribution (ENDC) document submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in 2022, The Government of Indonesia has committed to reducing Greenhouse Gas (GHG) emissions by 31.89% compared to business as usual by 2030, and up to 43.2% with foreign financial [1]. The transport sector, which is part of the energy sector of the ENDC, plays a key role in achieving the ENDC targets, including the maritime sub-sector. Therefore, the Ministry of Transportation issued Minister of Transportation Decree number KM 8 of 2023 concerning the Determination of Climate Change Mitigation Actions in the Transportation Sector to Achieve Nationally Determined Contribution Targets [2]. The regulation lists 10 measures to mitigate climate change in the maritime sub-sector, one of which is ship rejuvenation.

The shipping sector is essential to international commerce, enabling the distribution of products worldwide. Nonetheless, it is notably carbon-intensive, contributing around 3% of global greenhouse gas emissions, similar to the aviation industry (European Federation for Transport and Environment, 2024). As most of these emissions are generated in international waters, regional and global efforts must be undertaken to promote sustainability within the industry.

Based on the Fourth IMO GHG Study, the amount of GHG emissions including carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), expressed in CO2e releases by all types of shipping (including international, domestic, and fishing) have increased from 977 million tons in 2012 to 1.076 million tons in 2018, which is an increase of 9.6%. In 2012, there were 962 million tons of CO2 emissions. By 2018, this increased by 9.3% to 1.056 million tons of CO2. Shipping emissions accounted for 2.89% of global anthropogenic emissions in 2018, increased from 2.76% in 2012. Meanwhile, shipping emissions are projected to rise from approximately 90% of the 2008 levels in 2018 to between 90% and 130% of the 2008 emissions by the year 2050, based on various feasible long-term economic and energy projections. So, at the current growth rates, it is projected that shipping may account for approximately 10% of global GHG emissions by the year 2050 [3].

According to the 2023 IMO GHG Strategy, to combat climate change and its impacts, the IMO contributes to the global effort to combat climate change. IMO adopted an Initial Strategy for reducing GHG emissions from ships in 2018, establishing a vision that confirms its commitment to reducing GHG emissions and phasing them out as soon as possible. Afterward, IMO adopted the 2023 IMO Strategy on Reducing GHG Emissions from Ships in July 2023 (MEPC 80). The 2023 IMO GHG Strategy has a vision that IMO remains committed to decreasing GHG emissions from international shipping, and aims to urgently eliminate these emissions at the earliest feasible time while promoting a just and equitable transition in the context of this Strategy. The first level of ambition of this strategy is for the carbon intensity of the ship to decline through further improvement of the energy efficiency for new ships. In particular, the 2023 IMO GHG Strategy aims to reduce CO2 emissions per transport work (reduce the carbon intensity) by 40%, on average, across international shipping by 2030, compared to 2008. By 2030, the 2023 IMO GHG Strategy includes a new level of ambition on

Danawiryya Silaksanti. Kementerian Perhubungan. Email: danawiryya@gmail.com
Tri Cahyadi. Sekolah Tinggi Ilmu Pelayaran. Email: tritricahyadi2@gmail.com
Mutiara Adella. Kementerian Perhubungan. Email: muthatibie@gmail.com
Winarno. Sekolah Tinggi Ilmu Pelayaran. Email: winarnowhien@gmail.com

using zero or near-zero GHG emission technologies, fuels, and/or energy sources for international shipping that represent at least 5%, aiming for 10%, of its energy consumption. It is imperative to reach the peak of GHG emissions from international shipping as soon as feasible and to achieve net-zero emissions by around 2050 considering the diverse national contexts. Concurrently, efforts should be made to phase out these emissions, following the Vision that aligns with the long-term temperature goals outlined in Article 2 of the Paris Agreement [4].

Ship rejuvenation is carried out to rejuvenate ships or replace old ships in terms of technical age to ensure shipping safety, security, and service. Ship rejuvenation can be done by replacing ship engines with modern and efficient technology or scrapping and constructing new ships. For example, one of Indonesia's shipping companies, PT Pelayaran Nasional Indonesia (Pelni), continues striving to rejuvenate its passenger ships over 30 years old. Of the 101 ships operated by Pelni, 26 passenger ships have been assigned by the government through the Public Service Obligation. Of these, 12 ships are over 30 years old and the remaining 14 are between 15 and 30. For safety reasons, it should be noted that ships over 30 years old are prone to damage that could lead to accidents. Furthermore, these older ships have a higher total load on Continuing Repairs (RR) and Floating Repair Docks (FRD) than the average Pelni vessel, which creates inefficiencies [5].

This program was also implemented by Pertamina International Shipping (PIS), a leading energy distribution company in Indonesia, including LNG. To meet the high needs, PIS is trying to adopt the latest technology that is more environmentally friendly in terms of efficiency and consumption. The world's LNG demand will increase to 666 million tons per annum in 2033, and to meet this demand, it is projected that PIS will need 100 new ships in the next nine years [6].

Another example, based on the final report of The Study on Domestic Shipping Development Plan in the Philippines (DSDP) prepared by the Japan International Cooperation Agency (JICA) and Maritime Industry Authority (MARINA), is that the domestic shipping sector must consistently acquire vessels to meet growing demand and replace aging ones. The DSDP proposed a fleet procurement. The following planning criteria were included in the fleet procurement and modernization plan that the DSDP suggested: to gradually create a younger fleet profile, vessels that are over 30 years old will be scrapped; a policy will be implemented to restrict the importation of vessels with a gross tonnage of less than 500 GT; and any larger vessels that are procured will have an average age of 15 years or younger, with an expected breakdown of 70% falling within the 10 to 15-year range and 30% within the 5 to 10-year range[7].

Modernizing ships is regarded as one of the best strategies to improve the fleet and lengthen the life of the ships. Under specific technical circumstances, modernizing the hull, engines, machinery, and electrical systems can extend a ship's service life for the duration that the shipowner has specified [8].

In recent years, there has been a growing demand to enhance the efficiency and sustainability of modern inland waterway transport. Consequently, recent research by CORDIS–EU has created and examined retrofit solutions and strategies, providing onboard insights and best practices for vessels operating on the Rhine and other major rivers in Europe. The project aimed to examine and establish practical retrofit strategies for existing inland vessels to improve their environmental and economic performance. With the average age of inland vessels exceeding 40 years, the process of modernizing the fleet through new builds will require many years. The examination of various retrofit alternatives indicates that ship owners have shown minimal interest in power-related retrofits. This lack of interest can be attributed to the fact that emission reduction methods, including filters and catalysts, offer very limited fuel savings, which may occasionally lead to higher fuel consumption. Additionally, these methods offer minimal economic incentives, making them less appealing for business considerations. Likewise, options like LNG, CNG, fuel cells, and both diesel-electric and all-electric propulsion require extensive alterations to the engine room and considerable capital investment, which further diminishes their attractiveness. Additionally, the preferences exhibited by ship owners suggest that there is no single universal retrofit solution that is effective for all inland vessels.

The urgency to enhance both environmental and economic outcomes highlights the significance of upgrading current inland ships, making retrofit solutions particularly relevant. According to the findings in the CORDIS - EU research, the retrofit strategies identified as the most effective by ship owners and specialists are as follows [9]:

1. Advancing propulsion efficiency by utilizing a pre-swirl stator, which features multiple blades situated before the propeller to enhance inflow;
2. Optimizing the stern shape, particularly the tunnels, to optimize the flow directed to the propeller;
3. Minimizing drag on gondolas and rudders by refining their shapes, as well as eliminating flanking rudders and struts from the propeller nozzles;
4. Replacing the main engines;
5. Enhancing power management through the adoption of waste heat recovery systems;
6. Employing Selective Catalytic Reduction (SCR) alongside particle filters as a means to achieve reductions in nitrogen oxides (NOx) and particulate matter (PM);
7. Extending the length of a vessel;
8. Utilizing trapezoidal bodies positioned between the ship's bow and the barge pushed by the ship to improve flow characteristics and decrease hydrodynamic resistance.

Another research conducted in Europe by the Interreg-Danube Transnational Programme is the EU Strategy for the Danube Region (EUSDR), Strategy on Fleet Modernization, which focuses on ships sailing in the

Danube region. Located in central and southeastern Europe, the Danube region comprises the Danube River and the various countries it passes through. The EUSDR oversees this area, focusing on the advancement of its economy, environmental sustainability, and transportation infrastructure. The EUSDR encompasses primarily the basin of the Danube River, which extends for 2.857 kilometers. This area also includes the mountainous regions where the river's tributaries originate, such as the Alps and the Carpathians. The area spans from the Black Forest in Germany to the Black Sea, touching upon Romania, Moldova, and Ukraine, and is inhabited by approximately 115 million people.

Comprising 14 countries, it represents the largest and most diverse macro-regional strategy, including nine EU Member States (Austria, Bulgaria, Croatia, Czechia, parts of Germany, Hungary, Romania, Slovakia, and Slovenia), three Accession Countries (Bosnia and Herzegovina, Montenegro, Serbia), as well as Ukraine and Moldova [10]. The Danube region is illustrated in Figure 1 below.

Figure 1. The Danube Region

The Danube fleet comprises a significant number of vessels constructed between 1960 and 1990, with 62 percent of these vessels built during the period from 1971 to 1990. As of 2018, the average age of all cargo units in the fleet was 41 years. Typically, a ship's engine is replaced after approximately 15 years or more of service. In contrast, truck engines generally have an average service life of five to ten years. This disparity highlights that meeting stricter emission standards in inland navigation will inherently require a longer timeframe than in the road transport sector. In other words, this illustrates the low level of modernization of ships operating on the Danube River [11].

Given the numerous factors that contribute to the slow modernization of the Danube inland fleet, any effective strategy aimed at accelerating this process must encompass a combination of measures. It is essential to recognize that the strategy will not succeed if it relies solely on individual measures, as this will not sufficiently tackle all the causes of the slow modernization. The following outline illustrates the critical issues related to the sluggish pace of fleet modernization alongside a range of measures and their expected outcomes [11]:

1. Initiatives to overcome the challenges posed by insufficient business cases and limited investment funding.
   a. Internalization of external costs of transport.
   b. Expanding financing options, including investment funding and grants, to facilitate fleet modernization and promote green initiatives.
   c. Assess the potential of public guarantee instruments in improving the financial viability of investment initiatives for small and medium-sized enterprises.
   d. Endorse price reductions for ships that adhere to environmental regulations in specified zones.
2. A niche and specialized market for inland vessels and their engines.
   a. Contribute to the progressive enhancement of the research agenda focused on Inland Waterway Transport.
   b. Initiate voluntary collaborations between public and private entities towards environmental sustainability goals.
3. Emission regulations do not affect the current fleet of legacy ships.
   a. Play a role in the creation of more efficient type approval protocols for innovative technologies.
   b. Promote the adoption of enhanced emission limits applicable to existing ships.

Hereinafter, The Chinese government has introduced a subsidy initiative aimed at incentivizing shipowners to recycle their older Chinese-flagged vessels within China, encouraging them to replace these ships with newly constructed ones. The Scrap and Build Policy has been established to promote the swift modernization of China's commercial shipping fleet. This policy reflects the subsidy initiative established during the 2008 financial crisis, which provided crucial support to Chinese shipyards amid a significant economic decline [12].

As mentioned in [13], The Scrap and Build Policy outlines the governmental regulations and guidelines concerning the scrapping and purchasing age of domestic vessels. Its primary objective is to modernize the fleet by reducing the average age of vessels. The mechanisms for implementing this policy are diverse, including (a) stringent mandatory age requirement legislation, (b) fiscal incentives such as accelerated depreciation for vessels, (c) rigorous maintenance requirements for vessels, (d) financial incentives, including low interest rates for new vessel acquisitions, (e) enhancements in operating conditions for new vessels, such as improved port efficiency, and (f) additional measures. Nevertheless, persuading shipowners remains a challenge, as the current business environment is conducive to the acquisition and operation of older second-hand vessels.

The Scrap and Build Program, also implemented by the Indonesian Ministry of Transportation, focuses on state-owned ships, including navigation ships, patrol ships for sea and coastal guard, and pioneer passenger ships intended for routes in remote, frontier, and outermost areas. During the period from 2019 to 2023, a total of 18 ships were scrapped, while 22 new ships were constructed.

With the growth of the global economy, the demand for maritime transport is becoming increasingly significant, particularly in constricted regions such as straits and canals, as well as in high-traffic areas like ports and intersections of shipping routes. This surge in maritime activity presents a considerable risk of shipping incidents, including collisions between vessels and other navigational dangers such as shipwrecks or grounding in shallow waters. Given these circumstances, regular hydrographic surveys are essential for maintaining and monitoring shipping lanes and navigational markers, thereby ensuring the safety and efficiency of maritime operations. Shipping lanes are established to provide a secure and efficient passage for vessels entering port areas. The design of these lanes must consider various factors, including the dimensions of the vessels to be served (length, width, weight, and speed), as well as the number of traffic lanes required. To effectively fulfill these responsibilities, constructing a navigation vessel in the form of a survey boat is necessary. This survey boat also plays a crucial role in enhancing the operational efficiency of the Navigation District, facilitating swift movement, personnel deployment, fuel supply to lighthouses, and rapid, straightforward repairs.

Concurrently, the patrol vessels constructed by the Directorate of Sea and Coast Guard serve as a supportive element in fulfilling duties associated with monitoring maritime safety and security. Designed for this purpose, patrol vessels serve within the Work Area and Area of Interest under the operational Technical Implementation Units (TIU) of the Directorate General of Sea Transportation. Their deployment is intended to improve the overall performance of the TIU.

This study aims to determine the reduction of GHG emissions from government policies for the rejuvenation of state ships as one of the climate actions in sea transportation.

II. METHOD

The Ministry of Transportation's ship rejuvenation activity is an implementation of the climate change mitigation actions listed in KM 8 of 2023. Specifically, this mitigation action is implemented on a project scale, and the Ministry of Transportation calculated ship GHG emissions that occur after the implementation of the ship rejuvenation action and compared them with ship emissions if no such action is implemented. Referring to the DKI Jakarta Province, Greenhouse Gas Emission Reduction Reporting document, GHG emission reduction is generally the difference between baseline emissions and mitigation emissions, where baseline emissions are emissions that arise in the baseline scenario at the same time as the implementation of mitigation, which is a condition/scenario that logically describes the projection of GHG emissions that arise if there are no planned mitigation measures. Mitigation emissions are the level of GHG emissions after the implementation of planned mitigation activities (Jakarta Provincial Environmental Agency, 2019)[14].

This study employs a quantitative methodology to analyze and compare the GHG emissions produced by the scrapped vessels during their operational period with those generated by newly constructed and operated vessels. The authors analyzed shipping data categorized by fuel type, gross tonnage, engine power, and operational days, encompassing both scrapped and newly constructed vessels, by utilizing the national emission factors published by the Ministry of Energy and Mineral Resources.

The general formula for counting the GHG emission reduction for this study is as follows:

$$ER = BE - ME \quad (1)$$

BE : Baseline Emission
ME : Mitigation Emission
ER : Emission Reduction

Baseline emissions in the ship rejuvenation project refers to GHG emissions produced by state ships that are scrapped while still in operation, whilst mitigation emissions are GHG emissions generated from newly built vessels.

Meanwhile, to calculate ship emissions, the formula is used from the IPCC Guidelines as follows (IPCC, 2006):

$$\text{Emission} = FC \times MF \quad (2)$$

Then the authors used the fuel consumption formula at full power as a function of gross tonnage (GRT), and the state ships are categorized as other ships, so the formula is as follows (IPCC, 2006):

$$FC\ daily = 9{,}7126 + (0{,}00091 \times GRT) \quad (3)$$

FC : Fuel Consumption (ton/day)
GRT : Gross Tonnage

TABLE 1.
SCRAPPED SHIPS DATA

Ship Name	Construction Year	Gross Tonnage	Ship Power
KN B-118	1961	127	255
KN Suar - 006	1973	65.34	150
KN AE-025	1969	82.65	245
KN Suar - 004	1971	158	200
KN B-134	1964	34.68	240

CONTINUED TABLE 1.
SCRAPPED SHIPS DATA

Ship Name	Construction Year	Gross Tonnage	Ship Power
KN MUCI	1975	606	1200
KN Suar - 011	1979	115.37	350
KN Damara	1952	72.98	0
KN Pradawana	1979	762.78	850
KN Bitanggor	1967	133.08	100
KN.P. 470	2004	40	1000
KN.P 50020	2002	6	400
KN.P 50021	2006	6	400
KN.P 545	1980	6	400
KN.P.5103	2011	6	400
KN.P 542	1980	6	400
KN.P 556	1982	6	400
KN.P 5122	2012	6	400

Meanwhile, the newly built ship's data can be shown in Table 2 below.

TABLE 2.
NEWLY BUILT SHIPS DATA

Ship Name	Construction Year	Gross Tonnage	Ship Power
Boat Survey Takong	2019	9	180
Boat Survey Jabung	2019	9	180
Boat Survey Dumai	2019	9	180
Boat Survey Cilacap	2019	9	180
Boat Survey Sebatik	2020	9	180
Boat Survey Setinjan	2020	9	180
Boat Survey Bunta	2021	9	180
Boat Survey P. Panjang	2021	9	180
Boat Survey Karsik	2021	9	180
Boat Survey Samosir	2021	9	180
Boat Survey Breueh	2022	9	180
Boat Survey Tanjung Matoa	2022	9	180
Boat Survey Bawean	2023	10	200
Boat Survey Rinca	2023	10	200
Cape William	2023	6	150
KN.P 381	2023	11	3000
KN.P 382	2023	11	3000
KN.P 4006	2023	40	1000
KN.P 4007	2023	40	1000
KN.P 4008	2023	40	1000
KN.P 4009	2023	40	1000
KN.P 4010	2023	40	1000

All the scrapped state ships use High-Speed Diesel (HSD) as their fuel, this fuel's density is 837,5 kg/m3, and the Net Calorific Value (NCV) is 42,66 TJ/Gg. The authors also use the national Emission Factor which is published by the Ministry of Energy and Mineral Resources. The Emission Factor of this fuel is 72.986 Kg/TJ.

Meanwhile, 15 units of the newly built state ships use gasoline with octane number 92 (RON92), and the other 7 units use HSD. Meanwhile, the density of RON92 is 748,4 kg/m3, and its NCV is 44,61 TJ/Gg.

III. RESULTS AND DISCUSSION

The findings of this research indicate that implementing the Scrap and Build program can lead to a reduction of 128.564,39 tons of CO_2 emissions. This figure is derived from a baseline emission level of 168.336,55 tons of CO_2, which accounts for emissions from scrapped state vessels as the baseline emission, alongside mitigation emissions of 39.772,16 tons of CO_2 resulting from the operation of newly constructed ships.

TABLE 3.
THE BASELINE EMISSIONS FROM THE SCRAPPED STATE VESSELS CAN BE SEEN IN.

Ship Name	GT	Fuel Consumption (TJ/year)	Emission (ton CO_2)
KN B-118	127	128,167	9.354
KN Suar - 006	65,34	127,43	9.301
KN AE-025	82,65	127,64	9.316
KN Suar - 004	158	128,53	9.381
KN B-134	34,68	127,07	9.274
KN MUCI	606	133,85	9.769
KN Suar - 011	115,37	128,03	9.344
KN Damara	72,98	127,52	9.307
KN Pradawana	762,78	135,71	9.905
KN Bitanggor	133,08	128,24	9.360
KN.P. 470	40	127,13	9.279
KN.P 50020	6	126,73	9.249
KN.P 50021	6	126,73	9.249
KN.P 545	6	126,73	9.249
KN.P.5103	6	126,73	9.249
KN.P 542	6	126,73	9.249
KN.P 556	6	126,73	9.249
KN.P 5122	6	126,73	9.249
		Total	**168.336,55**

TABLE 4.
MITIGATION EMISSIONS FROM THE NEWLY BUILT STATE SHIPS

Ship Name	GT	Fuel Consumption (TJ/year)	Emissions (Ton CO_2)
Boat Survey Takong	9	24.116	1,664.98
Boat Survey Jabung	9	24.116	1,664.98
Boat Survey Dumai	9	24.116	1,664.98
Boat Survey Cilacap	9	24.116	1,664.98
Boat Survey Sebatik	9	24.116	1,664.98
Boat Survey Setinjan	9	24.116	1,664.98
Boat Survey Bunta	9	24.116	1,664.98
Boat Survey P. Panjang	9	24.116	1,664.98
Boat Survey Karsik	9	24.116	1,664.98
Boat Survey Samosir	9	24.116	1,664.98
Boat Survey Breueh	9	24.116	1,664.98
Boat Survey Tanjung Matoa	9	24.116	1,664.98
Boat Survey Bawean	10	24.171	1,668.75
Boat Survey Rinca	10	24.171	1,668.75
Cape William	6	23.952	1,653.68
KN.P 381	121	37.069	2,361.16
KN.P 382	121	37.069	2,361.16
KN.P 4006	40	31.647	2,015.77
KN.P 4007	40	31.647	2,015.77
KN.P 4008	40	31.647	2,015.77
KN.P 4009	40	31.647	2,015.77
KN.P 4010	40	31.647	2,015.77
		Total	39.772,16

Emission Reduction = 168.336,55 – 39.772,16 = 128.564,39 ton CO2.

Alongside its role in decreasing greenhouse gas emissions, the Scrap and Build program is also expected to achieve energy savings of 40.726,74 tons of oil equivalent (TOE), which can be seen in Table 5.

TABLE 5.
ENERGY EFFICIENCY OF THE SCARP AND BUILT PROGRAM

Energy Efficiency	TJ	TOE
Fuel Consumption Baseline	2.306,43	53.924,38
Fuel Consumption Mitigation	564,48	13.197,64
Total Energy Efficiency		**40.726,74**

Consequently, this program has played a significant part in advancing maritime decarbonization efforts.

TABLE 6.
GNSS RECEIVER TEST

No	Sensor Value		Google Maps		Error (M)
	Latitude	Longitude	Latitude	Longitude	
1	-6,301259	106,781136	-6,301226	106,781056	9,57
2	-6,301263	106,781136	-6,301226	106,781056	9,53
3	-6,301267	106,781136	-6,301226	106,781056	9,49
4	-6,301271	106,781136	-6,301226	106,781056	9,44
5	-6,301276	106,781136	-6,301226	106,781056	9,40
6	-6,30128	106,781136	-6,301226	106,781056	9,36
7	-6,301284	106,781136	-6,301226	106,781056	9,31
8	-6,301289	106,781136	-6,301226	106,781056	9,27
9	-6,301293	106,781136	-6,301226	106,781056	9,23
10	-6,301297	106,781136	-6,301226	106,781056	9,18
11	-6,301301	106,781136	-6,301226	106,781056	9,14
12	-6,301306	106,781136	-6,301226	106,781056	9,10
13	-6,30131	106,781136	-6,301226	106,781056	9,05
14	-6,301314	106,781136	-6,301226	106,781056	9,01
15	-6,301319	106,781136	-6,301226	106,781056	8,97
16	-6,301323	106,781136	-6,301226	106,781056	8,92
17	-6,301327	106,781136	-6,301226	106,781056	8,88
18	-6,301332	106,781136	-6,301226	106,781056	8,84
19	-6,301336	106,781136	-6,301226	106,781056	8,80
20	-6,30134	106,781136	-6,301226	106,781056	8,75
21	-6,301344	106,781136	-6,301226	106,781056	8,71
22	-6,301349	106,781136	-6,301226	106,781056	8,67
23	-6,301353	106,781136	-6,301226	106,781056	8,62
24	-6,301357	106,781136	-6,301226	106,781056	8,58
25	-6,301362	106,781136	-6,301226	106,781056	8,54
26	-6,301366	106,781136	-6,301226	106,781056	8,49
27	-6,30137	106,781136	-6,301226	106,781056	8,45
28	-6,301374	106,781136	-6,301226	106,781056	8,41
29	-6,301379	106,781136	-6,301226	106,781056	8,36
30	-6,301383	106,781136	-6,301226	106,781056	8,32
Error Average					**8,28**

IV. CONCLUSION

Through the Scrap and Build program, the Government is modernizing its fleet by scrapping ships over 30 years old, as they are no longer efficient in their operations. To replace these aging vessels, the Government is investing in the construction of new state ships to ensure the continuation of vital functions and improve shipping safety, while also reinforcing efforts to protect Indonesian waters. Furthermore, this initiative has a beneficial environmental impact, reducing GHG emissions by 128.564,39 tons of CO2 and an energy savings of 40.726,74 TOE. To maximize its impact, policymakers should consider scaling the Scrap and Build initiative to include commercial fleets and incentivizing private sector participation. The transition to sustainable maritime transport could be accelerated by strengthening regulatory frameworks, providing financial support for fleet rejuvenation, and cultivating a business climate that encourages investment in the green shipping sector, particularly through adopting advanced technologies for ship modernization. This study highlights the critical role of government-led initiatives in shaping a greener, more efficient shipping industry, ultimately contributing to global efforts in maritime decarbonization

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