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Initial Engineering Studies of Battery Capacity Prediction Power of "Electric Ship of FTK UNSADA" Container Concept from Jakarta to Ibu Kota Nusantara

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Addressing global issues like climate change requires transformative solutions, and the shipping industry is no exception. Moving towards emission-free ship design has become a critical need, offering a chance to significantly reduce greenhouse gas emissions from maritime transport. In 2018, the International Maritime Organization (IMO) adopted a bold strategy to cut these emissions by at least 50% by 2050. Embracing renewable energy sources like batteries, wind, solar, and hydrogen fuel cells is key to achieving this ambitious goal. While electric ships powered by batteries are pioneering the way, meeting the IMO's target will necessitate radical changes in future ship design. Here, Indonesia holds a unique advantage, the legacy of the Sriwijaya Empire renowned for its mastery of wind-powered ships, resonates with this emerging era of green shipping. Abundant sunshine, strong wind potential, and growing expertise in maritime engineering position Indonesia to become a leader in the development and deployment of sustainable ship designs. Harnessing these historical and contemporary strengths, Indonesia can play a pivotal role in revolutionizing the shipping industry. By fostering collaboration between policy makers, researchers, and shipbuilders, Indonesia can spearhead the transition to a future where cargo ships navigate the oceans propelled by the clean power of renewable energy, leaving behind a legacy of environmental stewardship and economic prosperity. This paper estimates the energy consumption and power needs of Container ships on short inter-island routes in Indonesia, with a particular focus on the potential application of batteries in such scenarios. The initial design utilizes similar vessel data collected from various locations around the world. Our findings indicate that a container ship operating on the Jakarta-Semarang route would require batteries with a capacity of 15.25 MWh, Semarang to Surabaya route would require 12.20 MWh batteries, from Surabaya-Tanjung Benoa Bali route required 15.25 MWh, from Tanjung Benoa Bali to Ujung Pandang route require 21.35 MWh batteries, all with a capacity of 1.5 MWh each and from Ujung pandang – Ibu Kota Nusantara require 18.3 MWh. These calculations assume normal sea and weather conditions and a design speed of 10 knots. Implementing battery-powered Containers on these routes reduces the CO2 emission into the air as long as the ship route operates.

1. Introduction

The maritime transportation industry, a major source of greenhouse gases responsible for nearly 2.51% of global emissions [1] aims to achieve a 50% reduction in emissions released since 2008 by 2050 [2]. However, beyond greenhouse gases, ships also emit several toxic gases, including NOx and sulfur, throughout their journeys, contributing to respiratory problems, acid rain, and other health concerns [3] [4], and to protect our planet and our health, continued efforts are necessary to ensure cleaner shipping practices and a more sustainable future. Emissions from the shipping industry, including greenhouse gases like CO2 and gaseous pollutants like NOx, contribute significantly to climate change, air pollution, and ocean acidification [5], Beyond air pollution and health impacts, studies show that the shipping industry's greenhouse gas emissions, contributing to an average global temperature increase of 1°C since the pre-industrial era and accounting for roughly 2.5% of global CO2 emissions, demand urgent action towards cleaner practices to mitigate climate change [2] Therefore, without a robust prevention program in the marine transportation industry, CO2 emissions could double by 2050, further jeopardizing our planet's future. As the latest data from the International Maritime Organization shows, nearly all intercontinental ships still rely on fossil fuels like HFO and HSD, spewing approximately 896 million tons of CO2 into the atmosphere annually. It's imperative for the industry and policymakers to work together to implement stricter regulations and invest in cleaner technologies, like renewable energy sources and carbon capture systems, to chart a sustainable course for maritime transport before it's too late [1].

Emission control technologies play a crucial role in reducing harmful emissions from ship propulsion systems. Widely used solutions include exhaust gas filters like wet scrubbers and dry scrubbers, which can remove up to 98% of particulate matter. Exhaust gas recirculation (EGR) systems can improve fuel efficiency while lowering NOx emissions by 20%. Selective catalytic reduction (SCR) technology, using liquid urea, effectively reduces NOx emissions by up to 90%. These technologies not only mitigate environmental damage but also enhance operational efficiency and contribute to fulfilling the IMO's ambitious emission reduction targets. Continued research and development in even more advanced emission control technologies are essential for a cleaner and more sustainable future for the maritime industry [6] [7] [8].

Global concerns about climate change, amplified by the near-universal ratification of the Paris Agreement in 2015, have compelled the shipping world to take concrete steps toward curbing emissions. The industry is now actively investing in cleaner technologies, adopting stricter regulations, and implementing operational changes to reduce its environmental footprint and contribute to a sustainable future for maritime transport [9] [10]. Several countries in the world, including Indonesia, have also ratified and followed up on rules and regulations [11] [12]. In a global effort to combat climate change, nearly all countries, aligned with the International Maritime Organization's (IMO) roadmap, have established short-medium- and long-term targets to significantly reduce greenhouse gas (GHG) emissions from maritime transport. This ambitious roadmap mandates at least a 40% reduction in GHG emissions by 2030 compared to 2008 levels, even as the maritime sector continues to experience significant growth. Achieving these targets is crucial for mitigating the industry's impact on the environment and securing a sustainable future for global shipping [13] [14]. According to 2023 data, China, Japan, and Greece collectively contribute the largest share of CO2 emissions from maritime transport, largely due to their sizeable fleets and shipping activity. These countries are followed by the United States, Hong Kong, and Germany. Recognizing the significant impact of these leading emitters, targeted efforts within these nations and across the entire industry are crucial to achieving global emission reduction goals for the maritime sector [15] [16]. While land transportation has implemented various regulations like emission standards and fuel efficiency requirements to curb pollution, the maritime sector is embracing innovative solutions like shore connection. This technology allows ships to connect their onboard electrical systems to land-based power sources, such as the electricity grid or renewable energy sources like solar or wind. Shore connection not only significantly reduces air pollution and greenhouse gas emissions, but also minimizes noise pollution, lowers operating costs for ships, and improves air quality at ports. With several major ports worldwide adopting this technology and shipping companies like X and Y actively implementing it, shore connection holds immense potential as a game-changer in the fight against maritime pollution and paving the way for a cleaner and greener future for this crucial industry [17] [18] [19].

Indonesia, boasting over 3.2 million square kilometers of the world's largest sea area and a staggering 78,798 kilometers of coastline, holds unrivaled maritime potential. Its waters brim with rich fishing grounds, abundant fossil fuel and marine geothermal energy reserves, and stunning landscapes ripe for marine tourism. Additionally, with its strategic shipping lanes, connecting vital trade routes across the globe, made position of Indonesia to become a maritime hub and a key player in international trade. To fully harness this potential, Indonesia can leverage its strategic location, invest in port infrastructure and technological advancements, and prioritize sustainable practices in fishing, energy exploration, and tourism. By doing so, Indonesia can not only strengthen its geopolitical and economic standing but also establish itself as a leader in sustainable maritime development, setting a path for a thriving future [20]. To fully unlock the potential of its vast maritime territory, Indonesia urgently needs a series of strategic breakthroughs. Implementing the Sea Toll concept with optimized routes, larger vessels, and targeted subsidies can dramatically improve inter-island connectivity, reduce transportation costs, and boost regional economies. Revitalizing traditional and small-scale shipping along these routes can empower local communities and foster sustainable development. Furthermore, by fostering regional industries based on local commodities, like processing seafood or building boat parts, Indonesia can create jobs, add value to its resources, and further strengthen its national economic fabric. These bold initiatives hold the key to transforming Indonesia's maritime potential into a driving force for inclusive growth and prosperity. Learning from the successful implementation of similar models in countries like Norway or the Philippines can further guide Indonesia's path towards becoming a true maritime powerhouse [20] [21].

Indonesian ports experienced a surge in activity in 2021, with ship visits reaching 753,330, a 5.26 % increase compared to 2020. This trend represents the highest annual increase in recent years and showcases the growing importance of Indonesia's maritime trade. The average cargo capacity of visiting ships also rose by 1.64 %, reaching 2.28 thousand gross tonnage (GT), a measure of a ship's cargo-carrying capacity. This increase in both the number and size of ships highlights the vital role Indonesian ports play in facilitating international trade and suggests potential for further economic growth. However, it also raises questions about the need for further investments in port infrastructure and operational efficiency to handle this growing volume of activity sustainably [21]. As a maritime nation nestled in Southeast Asia, Indonesia sits at the crossroads of the Indian and Pacific Oceans, a strategic position that places its waters among the most critical maritime spaces for global trade. Recognized by the ASEAN Outlook on the Indo-Pacific, Indonesia's role extends beyond merely connecting major shipping routes. Its vast coastline boasts bustling ports like Tanjung Priok, known as a gateway for regional trade, while its abundant marine resources fuel thriving fisheries and tourism industries. Recognizing this strategic maritime potential, Indonesia is poised to play a leading role in shaping the future of the Indo-Pacific region [22], Indonesia, the world's largest archipelago, straddles the Malacca and Sunda Straits, two of the busiest shipping lanes for international trade. This strategic location, combined with its over 17,000 islands, makes the maritime industry the lifeblood of the nation. It directly employs millions of Indonesians, making it the third-largest supplier of seafarers globally. Beyond manpower, the $27 billion USD fisheries sector, a major exporter of tuna and shrimp, further underscores the maritime economy's importance. In essence, Indonesia's national identity, society, and economy are inextricably linked to its seas, shaping its politics, culture, and future prosperity. However, navigating issues like infrastructure development, environmental protection, and sustainable resource management will be crucial for this maritime giant to realize its full potential [23] [24].

With an annual fossil fuel energy demand of 114,732 GWh, Indonesia's maritime industry ranks among the world's biggest consumers. This reliance on fossil fuels not only poses environmental risks but also exposes the country to potential fluctuations in global energy prices. Accelerating the adoption of renewable energy sources and energy-efficient technologies can strengthen Indonesia's maritime competitiveness and safeguard its environmental future [23]. Faced with high fuel consumption and ambitious targets to reduce carbon emissions by 40 % by 2030, Indonesia's maritime sector stands at a crucial crossroads. Transitioning away from fossil fuels, which currently account for X million tons of annual consumption and Y % of national CO2 emissions, is no longer optional but an urgent necessity. Electric ships, already gaining traction in several countries, offer a promising solution. With potential applications for ferries, coastal cargo vessels, and even short-range tourism boats, electric ships can significantly reduce emissions while boosting energy efficiency. While challenges like battery range and infrastructure need to be addressed, Indonesia can leverage its abundant renewable energy resources and strategic location to become a regional leader in developing and deploying these clean technologies. By investing in local battery production, establishing charging stations at key ports, and fostering collaboration between the government, private sector, and research institutions, Indonesia can seize this opportunity to secure a cleaner and more sustainable future for its maritime industry and contribute to a healthier planet for all [25] [26].

The future of maritime transportation appears increasingly autonomous. Driven by advancements in artificial intelligence and sensor technology, unmanned or autonomous ships, capable of navigating and operating without human crew, are no longer science fiction. These vessels promise significant gains in safety, efficiency, and cost reduction, revolutionizing everything from cargo shipping to offshore operations. While challenges like regulatory frameworks and cybersecurity need to be addressed, the potential benefits are undeniable. For Indonesia, embracing this technological shift could bring a wave of opportunities. New jobs could emerge in sectors like AI development and remote vessel management, and Indonesia's strategic location could be further leveraged to become a hub for autonomous shipping technology and services. However, ensuring equitable access to these benefits and navigating potential socio-economic impacts will require proactive planning and collaboration. By actively investing in research, infrastructure, and workforce training, Indonesia can position itself at the fore front of this ground breaking maritime paradigm, securing a competitive edge and shaping a sustainable future for its maritime industry [27].

While claims of it being the first are debated, the People's Republic of China (PRC) made waves in 2017 when it launched the "Tianjin Sunhe," an electric container barge with a maximum range of 80 kilometers on a single charge. This pioneering vessel, primarily suitable for short-distance domestic routes, showcases the potential of electric technology in maritime transportation. However, further advancements in battery capacity and charging infrastructure are crucial for electric cargo ships to truly compete with larger, fossil-fueled vessels on longer routes [28] [29]. Following China's pioneering efforts, Japan took a bold step towards cleaner maritime transportation by forming a consortium to develop the "e5", the world's first fully electric oil tanker. This ambitious project aims to replace traditional, fuel-guzzling tankers with zero-emission vessels, significantly reducing air and water pollution. With a planned capacity of [mention cargo capacity] and a target launch date of [mention year], the "e5" represents a leap forward in tackling maritime emissions and showcases Japan's commitment to innovation and sustainability within its crucial oil import sector [30]. Packing a punch for its size, the e5 boasts a 3.5 MWh (3500 kWh) battery, powering two 300 kW electric engines and two 68 kW bow thrusters, propelling it at a cruising speed of 11 knots (20 km/h). This translates into a 150 km range on a single charge, roughly the distance between Nagasaki and Fukuoka in Japan. This capacity, even without intermediate charging, holds potential for short-distance routes, while with charging infrastructure like that envisioned for the Nagasaki-Busan route, the e5 could even tackle international cargo transport. This pioneering vessel not only contributes to regional emission reduction goals but also paves the way for cleaner maritime transportation globally. However, further advancements in battery technology and widespread charging infrastructure will be crucial for widespread adoption. Nonetheless, the e5 serves as a beacon of hope for a greener future of maritime shipping, inspiring similar projects and ongoing research efforts around the world [30].

Marking a major milestone in sustainable shipping, Norwegian company Yara International is poised to unleash the world's first zero-emission autonomous cargo ship, the Yara Birkeland. Conceived in 2017 and soon ready for its maiden voyage, this electric vessel will silently transport fertilizer between Norwegian ports, paving the way for cleaner and more efficient shipping. Its autonomous navigation capabilities hold immense potential, offering cost reductions and heightened safety. While navigating regulatory hurdles and refining technology remain challenges, the Yara Birkeland serves as a beacon for a future where autonomous, emission-free ships dominate the seas, revolutionizing the maritime industry and safeguarding our planet [31]. The tide is turning towards electric ships: As of 2023, 439 are already navigating the seas, with another 167 under construction. By 2027, this number is predicted to surge by 188, bringing the total to a staggering 794, a 180% increase in just four years. This rapid growth signifies a major shift in the maritime industry, promising significant environmental benefits like reduced emissions and air pollution. While electric ships currently represent a small fraction of the global fleet, their increasing diversity, from cargo vessels to ferries and fishing boats, demonstrates their expanding potential. Continued investments in battery technology and charging infrastructure will be crucial to propel this momentum and unlock the full potential of electric shipping for a cleaner and more sustainable maritime future (Figure 1), 45 MWH on board ship will be build [32] and 797 vessel totally registered [33].

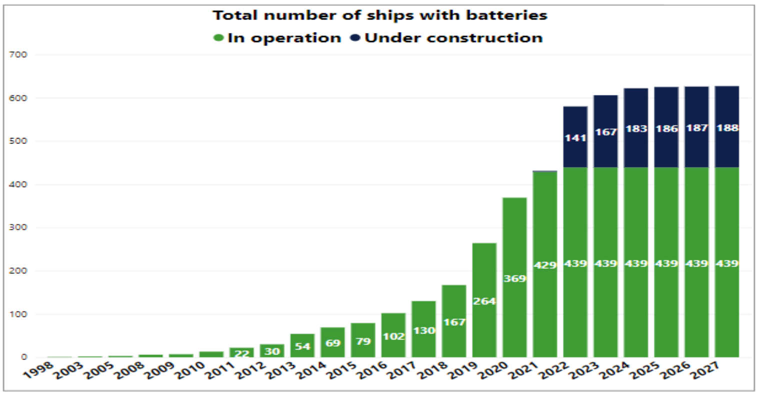

Figure 1. Total Number of ships with batteries (installed and on order).
(Maritime Battery Forum 2023)

While the concept of electric vessels may seem cutting-edge, it actually boasts a surprisingly long history. As early as 1886, electric ferries took to the waters of the river Spree in Germany, marking a bold experiment in clean maritime transportation. Though hampered by the limitations of undeveloped batteries at the time, this pioneering effort offered valuable insights and paved the way for modern advancements. Today, thanks to breakthroughs in battery technology, electric ships are experiencing a global renaissance, promising a cleaner and more sustainable future for the maritime industry. Looking back, the early German project serves as a reminder of the cyclical nature of innovation and the enduring human aspiration for cleaner transportation solutions [34] [35]. The first battery-operated submarine, the "Peral", was built in Spain in 1887 [36], Most submarines since then have always used electric motors with batteries. The global power vessel market is projected to grow from $3.83 billion in 2023 to $12.87 billion in 2030, at a CAGR (compound annual growth rate) of 18.9% over the period for which forecasts have been made in recent years [37] [38]. The rising need for the reduction of carbon footprints as well as lower fuel wastage has led to the need for an electrically operated marine vessel [39]. Electric ships or those designed to operate unmanned have been designed and built, there are several such projects around the world for example the project built by Rolls-Royce in Finland (Rolls-Royce n.d.), but still, there are three leaders in the construction of these unmanned electric vessels namely; MUNIN, DNV GL ReVolt and YARA Birkeland, based in Norwa [40] y. Electric ships offer several compelling advantages over their traditional counterparts. Firstly, electric motors require less space than combustion engines, freeing up valuable cargo capacity on board. Secondly, their flexible and precise control enables improved maneuverability and easier docking, particularly in tight waterways. Thirdly, by optimizing generator use based on load, electric ships can operate more efficiently and potentially reduce fuel consumption. And finally, the absence of large cooling systems further reduces overall weight and minimizes noise pollution. While challenges like battery range and charging infrastructure remain, the clear advantages of electric ships pave the way for a cleaner and more efficient future for maritime transportation [41]. Consideration of environmental impacts in the maritime transportation sector, especially regarding CO2 emissions released into the air and the impact of global warming [1] [9], has moved all stakeholders in the maritime transportation sector in the world to start using environmentally friendly energy in the application of ship propulsion energy technology and the use of batteries in zero-emission ship designs has started the use of all-electric propulsion.

This paper explores the potential of electric ships by comparing their emission reduction value with traditional ships on a specific route (e.g., between major ports in Southeast Asia). It then delves into port operations, identifying opportunities for improvements and additional infrastructure like shore power stations or battery swapping facilities to further optimize electric ship performance and maximize emission reduction benefits. By analyzing this specific case study, the paper can provide valuable insights for policymakers, maritime stakeholders, and researchers, contributing to the advancement of sustainable shipping practices in the region and beyond. The paper takes a deep dive into the potential of electric ships by analyzing their emission reduction and operational efficiency on a crucial route: from Jakarta to the new capital city (Ibu Kota Nusantara) in Kalimantan. This journey, encompassing diverse waters and port sizes like Semarang, Surabaya, Tanjung Benoa, and Makassar, offers a real-world test bed for the study. By examining electric ship performance and infrastructure needs at each location, the research can generate valuable insights for optimizing operations, developing appropriate infrastructure, and informing policy decisions related to sustainable maritime transportation in Indonesia and other regions facing similar challenges. This paper takes a quantitative approach, employing descriptive statistics and regression analysis to assess the potential of electric ships. Recognizing the need for greater transparency in this evolving field, the research leverages data from authoritative sources like peer-reviewed journals and industry reports, meticulously documented alongside the underlying assumptions. This transparent data collection, readily accessible for future research, significantly boosts the reliability and reproducibility of findings, fostering cumulative knowledge and paving the way for further advancements in electric ship technology. By analyzing data from electric ships operating in various countries, this research aims to fill critical gaps in our understanding and contribute to sustainable shipping initiatives through informed policy decisions. The analysis assumes a hypothetical route with four intermediate ports before reaching the destination, reflecting various real-world scenarios with multiple stops. To provide a concrete reference point, the authors chose the MS Ampere, the world's first operational electric ferry, as the basis for their design analysis. This selection aligns well with the assumed route characteristics regarding size, range, and passenger capacity [42] [35]. This study focuses on the environmental and economic impact of using electric ships on this route, specifically analyzing the battery power capacity required during sailing at each port until reaching the destination. By comparing energy consumption with potential charging opportunities at each stop, the research aims to quantify potential emissions reductions, fuel cost savings, and improvements in operational efficiency.

2. Methods

2.1. The basic theory of electrical power/engine to calculate resistance and Kilowatt.

To get the cost of the quantity of electric electricity for the electrical motor so that it will be hooked up in an idea of an electric deliver layout, this will be completed by means of first calculating the whole ship resistance when cruising at a precise speed. From the effects of the full resistance calculation, the number of losses that occur inside the predominant drive gadget could be calculated where the losses will be introduced so they emerge as the total accumulation of the electrical motor energy necessities. Calculating the amount of deliver resistance while sailing entails several complicated factors, and the manner commonly involves numerous steps and engineering calculations. here's a well-known assessment of how this technique may be carried out. ship resistance while sailing is commonly divided into numerous kinds, including friction resistance that occurs due to friction between the surface of the ship's hull and water, second form Resistance produced by the shape of the ship which causes turbulence and disruption of water go with the flow, the third is wave resistance that happens because of the formation of waves while the deliver moves via water. The fourth is Wave Resistance due to the formation of waves and whirlpools in the back of the ship, and the last is Turbulent waft Resistance Produced by means of the float of water that isn't always clean around the ship. Wave resistance is extra complex and is frequently calculated using empirical records or computer models. one of the usually used models is the "Holtrop-Mennen" [43] method or other tactics that remember the shape of the deliver and the characteristics of the waves, next is the size or Calculation of Wave Resistance, This often includes calculating the waves generated through the ship. Empirical or numerical fashions are generally used to calculate rain resistance by considering the rate and form of the deliver. The total resistance of a ship has been subdivided into :

$$R_{total} = R_f\,(1 + k_1) + R_{app} + R_w + R_B + R_{TR} + R_A \tag{1}$$

Where R_{total} is frictional resistance according to the ITTC-1957 friction formula, $1 + k_1$ is a form factor describing the viscous resistance of the hull form is relation to R_f, R_{APP} is resistance of appendage, R_W is wave-making and wave-breaking resistance, R_B is additional pressure resistance of bulbous bow near the water survace, R_{TR} is additional pressure resistance of immersed transomm stern, and R_A is model ship correlation resistance. integrate All Resistance is called the total resistance of the ship whilst crusing is the sum of all sorts of resistance, This calculation regularly includes the usage of unique software and realistic enjoy in deliver design and engineering. every ship may also have precise wishes and conditions that have an effect on the calculation of resistance. these methode is also using of Maxsurf software and will use for this paper to calculate the electric Kilowatt of main electric propulsion system of this case ship design. Maxsurf is a suite of software program tools evolved by Bentley systems used normally for the design and analysis of marine vessel. Is is famous inside the naval calculation and marine engineering field for its strong abilities in modelling, hydrodynamic analysis, and structural analysis of ship and other marine structures.

2.2. Ship route design and initial development of ship

Battery-electric propulsion is energi longer confined to small container ship. While technical advancements allow journeys of up to 15,000 km, economic factors like infrastructure costs and operational efficiency currently limit widespread adoption for routes exceeding 10,000 km. However, this still represents a significant leap compared to earlier constraints, opening up possibilities for electric ship to navigate longer distances. With ongoing research and development addressing these economic hurdles, the future of battery-powered ferries appears remarkably bright, promising even farther voyages and a cleaner maritime future. With rapid advancements in battery technology, container ships exceeding a capacity of, for instance, 5,000 TEUs, may soon benefit from increasingly lightweight, high-capacity batteries. While fully electric operation for vessels of this size might still require additional energi sources like gas turbine generators for peak demand or extended voyages, it would still represent a significant leap towards reduced emissions compared to traditional oil-powered ships. To fully unlock the potential of electric container ships, overcoming infrastructure challenges like long-distance charging and exploring clean and sustainable gas fuel sources remain crucial. However, with continuous progress in battery development and alternative fuels, the dream of zero-emission container giants navigating the oceans may soon become a reality. This research breaks new ground with a container ship as a sketch design (see Figure 2) that features both batteries and micro turbines as its main propulsion system. The initial engineering studies of the concept of container ship of these, we call " Electric Ship of FTK UNSADA" .

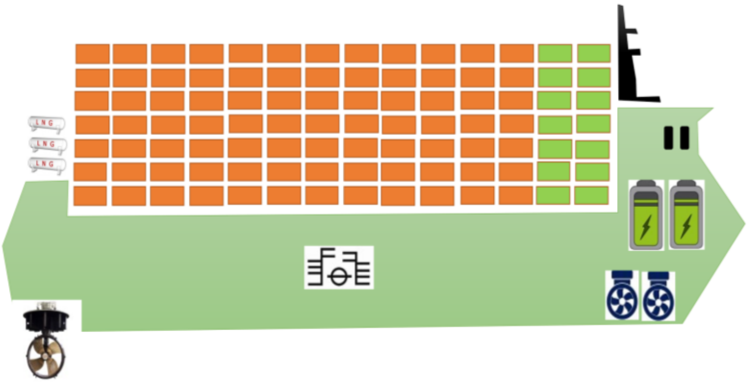

Figure 2. Case ship route distance (Nautical Mile)

While batteries power the ship under normal conditions, the micro turbines seamlessly step in as backup when energi demand exceeds battery capacity due to factors like extended voyages or increased cargo load. This innovative hybrid approach promises significant emission reductions compared to traditional ships, paving the way for a cleaner and more sustainable future for maritime transportation. This container ship embarks on a dynamic journey from Energi to IKN (Ibu kota Nusantara), making stops at four key ports as illustrated in (Figure 3).

Figure 3. Case ship route distance (Nautical Mile)

Equipped with both batteries and 2 (Two) 1 MW gas turbines, it adapts its propulsion system for optimal efficiency. While the battery-powered primary engine ensures smooth sailing, the gas turbines seamlessly kick in when needed, supporting durations ranging from 25 hours for shorter stretches to 33 hours for longer legs with heavier cargo or specific port combinations. This innovative hybrid approach not only offers flexibility and speed but also paves the way for cleaner maritime transportation by potentially reducing emissions compared to traditional ships (Figure 4). Tables 2 & 3 present the specifications for cargo container ships for inter-island shipping with the assumption that the design ship speed is 10 knots. This cruising speed limit was created for the reason that in the general graphic standard, the ship resistance curve and the power required for the ship to reach higher speeds will form a function graph-power of X^3

Table 1. Typical Electric container ship specification for case study

Specification	Nominal
Design ship speed	10 Knots
Design of Distance	350 nM
Gas micro turbine	2 x 580
Battery Storage Capacity	Ekw
	22 MWH

Table 2. Electric container Ship Concept Hull Specification

Dimension	Notation	Value (M)
Length Over All	LoA	131.58
Length Between Perpendicular	Lbp	120.48
Length of Waterlines	LwL	125.42
Breadth	B	24.20
Heigh	H	9.80
Draft	T	5.40

Table 3. Displacement and Ship Coefficient Specification

Dimension And Coefficient	Notation	Value
Ton Displacement (Ton)	Δ	10,423
Coefficient Block	Cb	0.620
Coefficient of Prismatic	Cp	0.625
Coefficient of Waterlines	Cw	0.798
Coefficient of Midship Section	Cm	0.992

In general, the higher the speed a ship wants to achieve, the greater the thrust required from its propellers. This is due to several factors including; water resistance, the faster a ship moves the greater water resistance it encounters. This resistance force is directly proportional to the square of the ship’ s speed. This means that if the speed of the ship is doubled, the water resistance will increase fourfold. Ship mass is a ship with a larger mass requires more power to reach the same speed compared to a smaller ship, this is because the larger inertia of the ship requires more energy to overcome. Ship design is the shape and design of the ship also affects the power requirements for the propellers, a ship with a more slender and aerodynamic design will require less power compared to a ship with a less optimal design. So that the decisions taken are in accordance with considerations of saving battery usage. The design of electric and hybrid ships necessitates meticulous consideration of technical aspects that minimize power consumption. This paper explores several strategies employed to achieve this objective, fostering the development of more sustainable marine transportation solutions. Using Azimuth Thrusters, Enhancing Maneuverability and Efficiency. Conventional rudders, while crucial for steering, are known to be energy-intensive components. The adoption of azimuth thrusters, capable of 360-degree rotation, eliminates the need for rudders. This innovative technology not only enhances maneuverability but also contributes to a reduction in overall power consumption. The second is using Bow Thrusters: Optimizing Low-Speed Maneuvering, bow thrusters play a vital role in facilitating precise maneuvering during low-speed operations, particularly when entering or leaving harbors. Their utilization reduces reliance on tugboats, which are external sources of energy consumption. This translates to lower operational costs and improved overall efficiency for electric and hybrid vessels. The third option is Hydrodynamic Optimization through Minimizing Hull Resistance, The underwater shape of the hull significantly impacts a ship's hydrodynamic performance. By optimizing the hull design, engineers can minimize frictional resistance between the hull and the water. This optimization process leads to improved overall efficiency and a consequent reduction in the power required for propulsion. Wind Resistance Mitigation like Streamlining the Superstructure, the windage area, which refers to the exposed surface area of the superstructure above the waterline has a direct correlation with wind resistance. By minimizing the windage area through strategic design choices, the impact of wind resistance on propulsion energy requirements is reduced. Route Planning and Optimization, Embracing Dynamic Factors traditional route planning often overlooks dynamic environmental factors such as wind speed, tidal wave, and wave patterns. Integrating these factors into the route planning process allows for the optimization of voyage efficiency. In some scenarios, this may even lead to shorter travel distances from the shoreline, further reducing power consumption. Digital Monitoring and Optimization, Leveraging Real-Time Data the integration of real-time data from satellite signals into route planning and propulsion strategies offers further potential for optimization.

Table 4. The distance of the shipping route; Jakarta to IKN Nusantara

Distance (Nautical Mile)	Departure	Arrival
243.55	Jakarta	Semarang
194.50	Semarang	Surabaya
246.74	Surabaya	Benoa-Bali
331.62	Denpasar	Makasar
289.85	Makasar	Nusantara

With a distance of the first route of approximately; 250 nM, 200 nM, 250 nM, 330 nM, and 280 nM, then the sailing time for each stage of sailing takes as shown in Table 4. For simplicity, it is assumed that the designed ship speed and sailing distance will be rounded off. Power requirements for electric ferry propulsion are based on a series of variables, including the correlation between speed and power which can be shown in the form of a curve that shows an exponential increase, as can be seen from the curve in Figure 4 [44] [35].

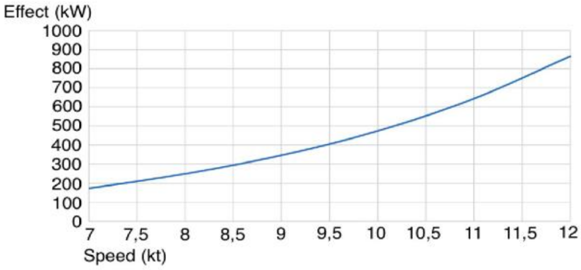

Figure 4. Effect speed curve for a typical ship with a capacity of 120 car

This research aims to design the underwater hull of electric or hybrid ships using Maxsurf software. Initial design data is obtained from a literature review of existing electric or hybrid ship designs. Key data points include the ship’s main dimensions (length, breadth, draft), block coefficient, and other standard technical data (Tabel 2, Tabel 3), this data is then incorporated into the Maxsurf software. Through several design iterations, the actual values of the final main dimensions and the shape of the ship’s hull are determined. The amount of power required (Figure 6) at the planned ship speed can also be determined. The calculation process is performed automatically by the Maxsurf software. These results are used as critical data for determining the battery capacity needed for the ship to navigate according to the planned route. The resulting hull shape from the design process is presented in (Figure 5).

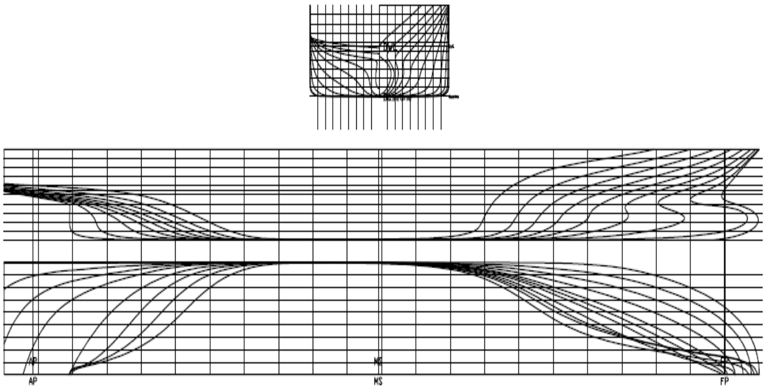

Figure 5. Initial design of ship body plan

The presented hull form is solely intended for estimating the propulsion power requirements of the prototype vessel for the purpose of this paper and is not intended for actual use. When designing ships, particularly those primarily relying on electric propulsion, numerous factors must be considered, with a primary focus on minimizing total resistance to prevent unnecessary energy consumption. The resistance and power data presented in this paper were obtained using Maxsurf software for the purpose of further calculations. A comparison was conducted between the power requirement predictions obtained from the referenced literature (Figure 4) and the results generated through calculations within Maxsurf software (Figure 6).

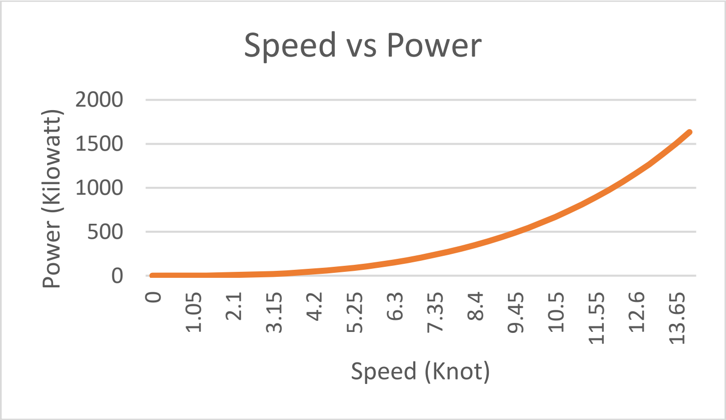

Figure 6. Initial design of ship body plan

The findings revealed a close alignment between the two values. References suggested a power requirement range of 480 kW to 500 kW, while the author’s calculations using Maxsurf yielded a range of 500 kW to 580 kW (see Table 1). Consequently, based on this convergence, a power requirement of 580 kW was established to propel the ship at a designated speed (V). For a more granular understanding of the technical aspects, Table 5 presents the actual values of critical parameters like ship speed (V), hull resistance (Rt), and power requirement (P). These values form the foundation for determining the battery capacity and backup power requirements, which may include a gas-powered generator set as a supplementary energy source. The text emphasizes the critical role of hybrid power systems in achieving sustainable marine propulsion for electric and hybrid ships. These systems combine the strengths of battery and gas turbine technology, offering a synergistic approach to reduce environmental impact.

Table 5. The power requirements of ship concept

Power (Kilowatt)	Resistance (KN)	Speed (Knot)
0,000	0,00	0,00
0,859	1,60	1,05

6,316	5,80	2.10
14,484	10,10	2,80
36,343	18,30	3,85
72,992	29,00	4,90
128,009	41,80	5,95
235,985	62,40	7,35
391,319	86,90	8,75
544,785	108,10	9,80
556,650	110,02	10,00
604,015	115,70	10,15
667,690	123,60	10,50

2.3. Energy storage

Batteries play a pivotal role in electric ship propulsion systems, serving as energy storage devices that power the vessel's engines and other electrical components. Ideally, these batteries should possess high storage capacity with minimal weight to maximize the ship's efficiency and range. Selecting the appropriate battery for an electric ship requires careful consideration of various factors, including; Capacity, the ability to store sufficient energy to meet the ship's power requirements throughout its voyage. Efficiency is the ability to minimize energy losses during both charging and discharging cycles. Power is the ability to deliver the necessary power surge for tasks like acceleration and maneuvering. Weight, and minimizing battery weight is crucial for improving overall ship efficiency and reducing fuel consumption. Cost, balancing the upfront cost of batteries with their long-term performance and reliability. Safety, ensuring the batteries meet stringent safety standards to prevent potential hazards. Types of Batteries for Electric Ships that are Several battery types are available for electric ship applications, each with its own advantages and limitations. Supercapacitors, offer high power density, enabling rapid power delivery for acceleration, but have lower energy density and efficiency compared to other options. Lithium-Ion Batteries, provide a balance between energy and power density, making them suitable for electric ship propulsion. However, they may experience performance degradation over time due to internal insulator degradation. Lead-Acid Batteries, have lower energy and power density than other types but are more affordable and easier to recycle. The sailing distance and total electrical energy requirement of an electric ship are influenced by the chosen route and prevailing weather conditions. Backup power is essential to anticipate unforeseen external circumstances that could increase energy demand. For electric ships with extended sailing ranges, a combination of batteries and additional propulsion engines might be necessary to provide sufficient recharging capabilities. Emission and safety considerations encourage the use of low-carbon energy sources as alternatives. The following table illustrates examples of lithium-ion battery capacities used in some constructed electric ships: MS Maid 320 kWh, Yara Birkeland 4.3 MWh, Ellen 4.7 MWh. The development of efficient and reliable batteries is crucial for the advancement of electric ship propulsion. As battery technology continues to evolve, we can expect to see more electric ships navigating the seas, contributing to a cleaner and more sustainable maritime industry.

The maritime industry is increasingly embracing sustainable solutions to reduce its environmental impact. Electric ships, powered by batteries and other renewable energy sources, offer a promising alternative to conventional diesel-powered vessels. However, battery technology alone may not be sufficient for long-range voyages or sudden power demands. To address these limitations, a hybrid power supply system incorporating batteries and a backup energy source, such as microturbines powered by liquefied natural gas (LNG), can provide a reliable and efficient solution. The proposed hybrid power supply system for electric ships consists of the following key components using a primary Power Source: Lithium-Ion Batteries with 16 units (Predictions) of standard 20-foot containerized lithium-ion batteries with a total capacity of 24 MWh, these batteries provide the primary source of energy for the ship's propulsion and other electrical systems (by micro gas turbine). The next step is to provide the auxiliary Power Source as a unit of microturbines and LNG Tanks. Microturbines powered by LNG serve as the backup energy source. The next component of the propulsion system uses azimuth Propellers, two azimuth propellers serve as the primary propulsion units, these propellers receive electrical power from the batteries or microturbines (if emergency situation), depending on the power requirements if the system Operates under normal operating conditions. The batteries provide the primary source of energy for the ship's propulsion and other electrical systems using gas, and the microturbines remain in standby mode. During periods of high power demand or in case of battery depletion, the microturbines automatically start up and provide additional power to the propulsion system, and the LNG tanks supply fuel for the microturbines. This hybrid power supply system offers several advantages any like; extended Range, the combination of batteries, and LNG-powered microturbines extends the ship's range beyond the limitations of battery power alone. Efficient Operation, the system utilizes batteries for efficient operation during normal conditions and switches to microturbines only when necessary, minimizing fuel consumption. Reliability, the backup energy source ensures continuous operation even in case of battery failure or extended power demands. Environmental Friendliness, the use of LNG as a fuel reduces emissions compared to conventional diesel-powered ships, provided in Figure 7, and as an alternative using hydrogen gas fuel cells as shown in Figure 8.

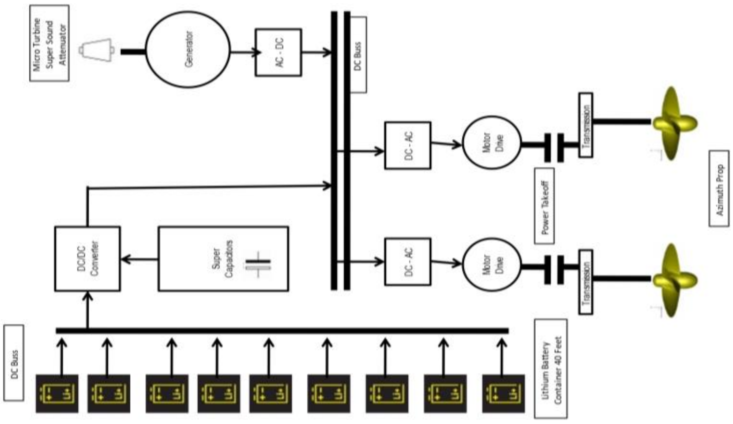

Figure 7. Initial design of power system schematic

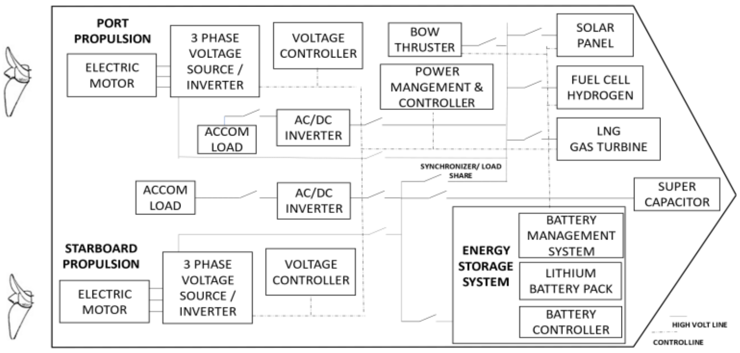

Figure 8. Initial design of power system schematic of electric ship

3. Results and Discussion

In this paper, we do not discuss whether the destination city, namely the " Ibu Kota Nusantara" already has an adequate port for container ships to dock or not, because this is a prediction of the energy needs of electric ships in a concept which first ignores the existence of ports. All stakeholders need to be aware that maritime transportation has started to move towards an environmentally friendly concept or what is known as zero emissions. For this reason, the author can predict the need for a maritime transportation system that will definitely lead to that direction (zero emissions). And what is more important for a new capital city whose development will continue in the future, will require 3 dimensions of the transportation system, namely we call; land transportation system, sea transportation system, and air transport system. That's all the limitations of this preliminary technical study carried out in the hope of inspiring all parties who are thinking about this matter.

3.1. Environmental potency & sea form characteristic

In the discussion section which discusses environmental conditions on this shipping route, the focus is on data on wind speed and wave height, because in this technical study, the biggest problem is the ship resistance that occurs when sailing with the wind in the opposite direction to the destination and second is the aspect of additional resistance. due to the high sea waves that occur, the data for these two things was taken when this article was written around May and Juni, using data Satellite from the web [45] was used for this article. The sailing route that will be traversed by this concept electric ship starts from Jakarta to Semarang. Based on the data that can be seen in [45], the wind speed that may occur between these two ports is between the lowest limit of 8 knots to the highest 10 Knots [45] wind speed The highest occurs at the departure port location, and during the voyage, the average is around 8 Knots [45]. The sea wave height level on this route is between 0.5 meters to 1 meter. For shipping from Semarang to Surabaya, the wind speed level is around 6.5 Knots to 10 Knots, for the wind direction from the port of departure to Surabaya is in the opposite position to the direction of shipping, where the wind blows from the northeast to the southwest, so it will increase resistance in the windward area when sailing opposite the port of destination. For shipping from Surabaya to Tanjung Benoa Harbor on the island of Bali, the lowest and highest wind speed data is at 6 Knots to 10 Knots, and the possibility of quite strong winds is when crossing the Bali Strait where the wind direction will increase by around 12 Knots and the current The sea is quite strong in the Bali Strait location. There is an important note regarding the character of these ocean currents, where naturally the movement of sea water will become stronger with the difference in deep sea temperature so that electrical energy is expected to increase to maintain ship speed. Regarding the wave height for this route, it will increase quite high when the ship passes at the southern tip of the island of Bali and finds height data of 2 meters. The longest route will be taken from Tanjung Benoa Harbor to the following destination port, namely Makasar Harbor, where the lowest wind speed is 6 Knots and the highest wind speed reaches 25 Knots around the coast of the southern part of Sulawesi Island. The wind direction for this route when this data was taken in May and June is from southeast to northwest and technically this will reduce the use of electrical power on the ship because the wind direction tends to be in the same direction as the shipping destination of the electric ship to Makasar Port. The highest wave height on this route is around the Java Sea in the southern part of Sulawesi Island, reaching a height of 1.5 meters, so this aspect is a consideration for using alternative power reserves on ships using gas turbines. The final route in the electric ship shipping concept is from the Port of Makassar to the Port of the capital of the archipelago (for the case in this paper), where the wind blows in the same direction as the shipping route, namely from Southeast to Northwest which is the final destination port. The lowest wind speed when this data was taken was 10 Knots and the highest was 20 Knots [45]. Sea wave data on this route is between 1 meter and 1.5 meters. From the data discussed regarding the condition of the water environment and sea characteristics, the author will increase the battery capacity required for this route and the ship route from Tanjung Benoa to Makasar Port. Additional electricity reserves are required to meet the needs on this route (See Figure 9).

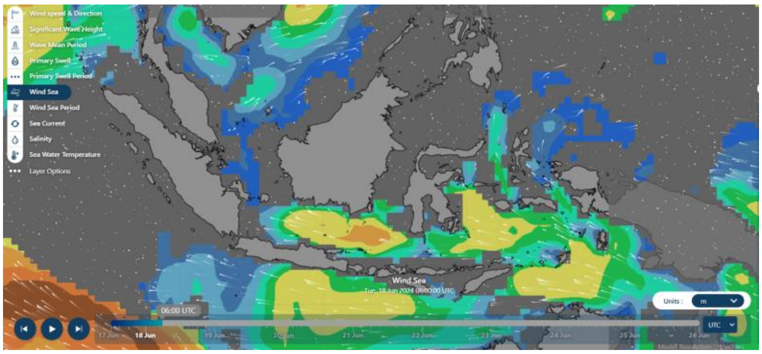

Figure 9. Wind speed and significant wave height on the ship route [45]

3.2. Ship type and design

This article is the beginning of a technical study regarding an Electric ship design concept which in several countries has been completed and is operating well. I will explain here that the type of ship will be more general if starting with the type of short-distance ferry ship, but in my next thought is that if this study has been completed in several countries, the author will direct it to the container ship type with the consideration that this type of ship carries large-sized cargo. the same and easier to place in the goods room. Second is consideration of the type of goods transported for the operational route from Jakarta to the capital of the archipelago with transit at 3 ports, namely Semarang, Surabaya, Tanjung Benoa, and Makassar, where the cargo that can be transported from various types of goods is very flexible and will really support development. the economy in the capital of the archipelago in the future will really consider environmentally friendly aspects in future concepts. The size determined by the author is based on the type of unmanned ship in one of the countries that have developed the design of this type of container ship. Some literature can be found freely in the world of search engines.

For this reason, the author uses initial design data and takes all the main size comparisons needed as a reference for designing the main size of the ship with the help of Maxsurf software. From the design made, the main dimensions of the ship are determined which are also equipped with calculation results for calculating the value of the ship's resistance, the required power, and predictions of other technical data; such as block coefficient, prismatic coefficient, midship coefficient, and other important data. From the results of important calculations in the field of initial design, it was found that the maximum power value required to achieve a cruising speed of 10 Knots was 580 KW. The consideration for using a speed of 10 Knots is to look at it from the perspective of efficient use of energy, where the natural characteristics of a ship body operating in sea water will provide a moderate resistance value when the ship operates between speeds of 6 Knots to 11 Knots. And the author set 10 Knots because of that consideration. For propulsion system losses, the author plans to use an azimuth-type propeller that can rotate 360 degrees, so that it is deemed that no other electrical power is needed for the steering system on conventional ships. This article does not discuss energy requirements for other accommodations because the design is for an unmanned ship or autonomous ship.

3.3. Ship Route

The Shipping routes are chosen to take into account distance and for some routes passing through the open sea but not more than 400 Nautical miles due to limited space capacity for lithium-ion batteries which will be installed in the ship's hold as an integrated part of the construction and strength of the ship's design. The initial route is planned to be around 250 nautical miles, the second distance is 200 nautical miles, the third distance is 250 nautical miles, the fourth distance is 330 nautical miles and the final distance is 290 nautical miles. For the furthest sailing distance, the author will use it as a guide for the electrical energy needs that must be stored on board the ship, and if we look at weather, wave, and wind losses, the author will add 15 percent of the electrical power reserves when experiencing extreme weather conditions. Technically, even though this ship is designed to be fully electric, there are no regulations regarding this type of ship yet and the author refers to standard guidelines that have been issued in several countries ( ), ( ), ( ). To reserve energy sources, the author plans to use a micro turbine with a capacity according to needs, in this case using a reserve of 1.5 MWh to later be able to fill the battery reserves which are starting to decrease in electricity storage levels. To anticipate energy needs outside the battery, LNG gas is used as an energy source to drive the micro turbine. The installation is designed to be integrated and considered so that it can be refilled at the port of call. For a sketch of the charging infrastructure design, (see Figure 10).

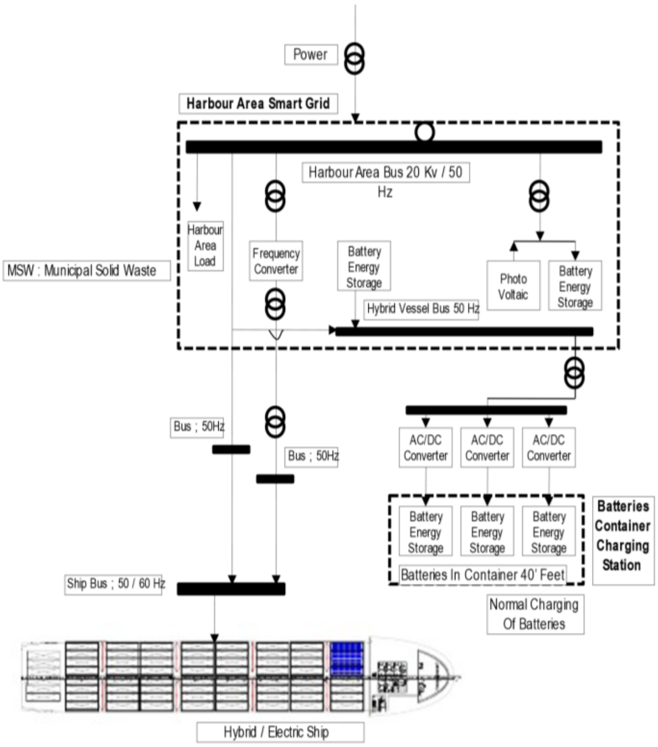

Figure 10. Schematic concept of energy filler dispenser at the port with variable source renewable energy.

3.4. Energy requirement

This article only discusses the energy requirements for this concept ship to sail according to its cruising speed of 10 Knots. From the calculations presented in the previous sentence, it is shown that it is 580 KWh in the propulsion component, namely the ship's propeller. If the losses for using azimuth-type propellers are 5%, then each propeller will require 305 KWh of power (excluding the bow power requirements thruster at the front of the ship). The total energy needed to propel the ship at cruising speed is 610 kWh. From data on sailing distance and sailing time with the additional safety factor of sailing time (plus 10%), if the ship operates on a route that passes through 4 ports (Semarang, Surabaya, Tanjung Benoa, and Makassar), then the furthest distance obtained is 331.62 Nautical miles. (Table 4), will be rounded to a value of 350 Nautical miles. From the data on the cruising speed of 10 Knots and the sailing distance, the longest route requires battery energy for 35 hours of sailing operations, so the energy required is 21.35 MWh. This is a guideline for planning the longest voyage and to be able to determine the energy requirements for each route, it can be seen in Table 6 below.

Table 6. Energy Requirements of the ship from Jakarta to IKN Nusantara

Energi (MWh)	Departure	Arrival
15.25	Jakarta	Semarang
12.20	Semarang	Surabaya
15.25	Surabaya	Benoa-Bali
21.35	Tj Benoa	Makasar
18.30	Makasar	Nusantara

Several countries have built ships that use 100% batteries, one of which is known to be made by a battery maker specifically used in ship applications, namely "Corvus Battery"[45]. This type of battery has a capacity of 1492 KWh (1.5 MWh) and is in the form of a standard 20 Feet container so it is very flexible to use according to needs. Indeed, if you calculate the amount of energy for the farthest voyage it will be 14 battery container units. And with the weight of each unit being 7.1 tons [45] 15 batteries are needed with a total weight of 106.5 tons. This is a fairly large weight prediction and when compared with the total ship displacement value of 10,243 Tons displacement, it will use up the total weight of the battery compared to the entire ship displacement by around 1% to 1.5%. This amount is outside the micro-turbine-based electricity supply system used for accommodation and lighting. Battery capacity for electric ships is growing, currently, some have been built with battery capacities of up to 45 MWh [32].

3.5. Future ship power option in Indonesia

Maritime transportation in Indonesia in the future will likely be served by several short-distance electric ship routes, one of which is a type of medium-capacity container ship that can operate on batteries or hybrids and will develop more efficiently with the concept of unmanned ships. This has been studied in several countries and may be applied with several important notes as expressed in an article on this matter.[40] Judging from the amount of emissions that can be reduced with the electric container ship concept, it can be calculated using several empirical formulas which have a correlation between engine power requirements, ship speed, and consumption of fossil fuels that burn and cause emissions into the air

[45]. The international maritime organization has also prepared a road map regarding strategies for reducing greenhouse gases until 2050 which has been written in full in the journal "International Maritime Safety, Environmental Affairs, and Shipping" and will gradually improve the target for reducing emissions from sea transportation on a regular basis. [13], where the activities carried out from 2018 to 2023 have been arranged well.

3.6. Ports infrastructures

Indonesia has quite large geothermal reserves and according to data it is 29,544 MWh from the existing reserves, if seen from the locations that have quite large potential, they are on the islands of Java and Sumatra. From the route written in this study, the ports passed are Jakarta-Semarang-Surabaya-Bali-Makasar-Nusantara, of the 6 port locations that may be supplied by geothermal energy are those on the island of Java. Other sources of clean energy for locations that pass through this electric ship route can use other alternative energy such as wind, solar, and biomass generators. Translated in simple language, infrastructure can be built at these 6 ports to facilitate clean energy sources directly to the port, so that they can accommodate the energy needs for charging batteries on these electric ships. For the characteristics of large cities visited, there is also the potential for energy that can be processed from city waste. You can also use this type of generator to convert city waste into electrical energy to charge ship batteries, by building a waste energy generator (MSW) with floating facilities so that it does not reduce existing facilities.

4. Conclusion

Ships with electric propulsion that use battery energy as electrical energy storage have been widely discussed and evaluated from various points of view, such as fuel savings, reducing the noise value of ship operations for the crew and all passengers, significant space savings from the loss of use of the main machine and this has implications for increasing space for goods, as well as a reduction in costs and energy for the maintenance process. Currently, sea transportation towards the era of clean energy is all moving towards the 0 emissions target to avoid the impact of climate change in the future. Electrically powered ships are starting to be developed for this reason and based on studies that have been carried out, several electric ship concepts have operated more economically and slightly reduced initial investment costs (with special notes), where the supporting port infrastructure must be carefully prepared. Apart from the advantages produced above, the aspect of reducing vibrations due to the use of electric motors has an impact on ship construction costs as well as the advantage of having a very low noise level because there is no longer the boom of combustion results from piston and valve movements and the exhaust gas flow of conventional combustion motors. Currently, navigation technology has also developed with the help of satellites for land transportation systems and this is very possible to be applied in sea transportation systems which are also covered by digital satellite signals. This is very applicable and several countries have completed making regulations regarding the regulation of ships without crew or what is called an "autonomous ship".

In-depth studies and analyzes regarding the use of electric motors as the main component besides batteries in the design of world electric ships have been carried out and there are many research journals and scientific articles discussing this. It is true that the direction is towards the use of electric motors, either AC or DC. Several studies on this matter have emerged, such as how to recycle lithium-ion batteries and several safety risks related to operating electric ships in open waters or intercontinental crossings. Technical considerations are important in using this electric motor and the energy savings that can be achieved, where the main drive of the propulsion system uses a pusher axle or if the propulsion system uses a 360 deg drive system there will be calculations of losses that occur and have an impact on the efficiency of the electric ship propulsion system. In general, electric ship propulsion systems can be grouped into electric propulsion systems using electric motors with fossil energy sources still used to produce electricity, and the second is using an applied combination of lithium batteries as the main energy source with a hybrid concept where the batteries are supported by a charging system. backup using gas fuel. And the last one is purely using batteries as the main propulsion energy for electric ships. Hybrid energy can also be combined with the installation of a fuel cell energy system in the form of hydrogen gas as a complement.

Technically, the electric ship propulsion system uses alternating current (AC system) power and there is a converter media to change from DC current in the battery system. For loads such as accommodation needs, you can use a single-phase current system which can be powered by a battery. For a main propulsion system using an electric motor to load a ship's propeller as the main propulsion, inverter, rectifier, and transformer components are needed, and several important components to reduce the total harmonic distortion factor or in technical language are components that function to measure the quality of the electrical load, equipment industry standards Electricity defines as the ratio of harmonic components to basic components and the measuring tool to determine this is to use a power analyzer. For components such as converter panels that require sufficient space, it is necessary to consider installing them in the main engine room so that they can be more effective and safe. The use of several electrical control components must be evaluated before implementation because it will involve energy losses when implemented in the actual system. In several technical studies, it can be said that losses or reductions in electrical power cannot be avoided when there is a flow of energy from the main storage source such as a battery to the electric propulsion system because there are several "energy conversion" processes from the battery supply to the propeller shaft driving the electric ship on the side. use of transformers, inverters, converters, and shafts. From the aspect of using an induction electric motor in the main drive system, each main motor has dissipated energy to a certain extent (depending on variations in propeller load), this is a common occurrence and is the basic characteristic of induction electric motors.

When a ship moves normally at the planned speed at Vs, the load factor will also be better than when the ship has not yet reached its cruising speed, of course this will make the main support system for electric motor components such as windings or transformers work harder and release heat. which is significant when operating and needs to be calculated properly on how to cool the supporting components. Several conclusions from this article can be conveyed, such as;

1. Container-type electric ships can be considered to start with designs that are more suitable for short and medium-distance shipping routes with complete supporting infrastructure at ports of call.

2. Indonesia has a source of "Earth Batteries" in the form of reserves of renewable energy sources in the form of geothermal heat, wind, sun, and municipal waste which can be used to recharge electric ship batteries in the future. From now on, port infrastructure must be set aside to allocate land for building "Electric dispensers" and large-capacity battery recharging equipment to power short and medium-distance national electric ships.
3. In accordance with the title of the study of this paper, regarding the initial technical analysis of the estimated battery requirements for FTK Unsada's electric ship propulsion requirements, it is concluded:
   a. The Jakarta to Semarang route requires 15.25 MWh of electrical energy with a shipping distance of 243.55 Nautical Mile with a total of 10 standard 1.5 MWH size batteries.
   b. The Semarang to Surabaya route requires 12.20 MWh of electrical energy over a distance of 194.50 Nautical Mile with 8 standard units of 1.5 MWH battery containers.
   c. For the Surabaya to Benoa-Bali route, 15.25 MWh of electrical energy is required over a distance of 246.74 Nautical Mile with 10 standard units of 1.5 MWH battery containers.
   d. The Tanjung Benoa to Makassar route requires 21.35 MWh of electrical energy over a distance of 331.62 Nautical Mile with 14 standard units of 1.5 MWH battery containers.
   e. For the Makasar route to the capital city of the Nusantara (IKN), 18.3 MWh of electrical energy is required over a distance of 289.85 Nautical Mile with 12 standard units of 1.5 MWH battery containers.

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