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Research paper

Development of A Novel Marine Propulsion System Using Renewable Energy Sources

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Abstract

The shipping industry contributes greatly to international greenhouse gas emissions. While more people recognize the destructive influence of climate change, the marine sector has a critical need to switch to green operations using such renewable energies as a means to mitigate its footprints on the environment. One alternative is the deployment of renewable energy sources on ships, which might help the shipping industry achieve its sustainability goals and drastically cut emissions. Each energy source's benefits and drawbacks are also covered. The most recent developments in ship renewable energy, including fuel cells and hybrid propulsion systems, are also covered in the article. This paper offers insightful recommendations for ship operators and owners and provides crucial tips on how to manage contemporary marine propulsion plant systems effectively.

Keywords: *Sustainable Practices; Hybrid Propulsion Systems; Innovations; Development; Energy.*

1. Introduction

Marine engineering is the branch that deals with the designing of maritime propulsion systems. Marine propulsion has progressed from human-powered paddles and oars to sail-powered ships [2][14]. But smaller ships still use the conventional means, i.e., paddles and sails [2]. Rowed galleys, frequently fitted with sails, were used in early maritime warfare and exploration. The 1950s saw the construction of the first nuclear reactors in the sea. The steam generated by these reactors powers icebreakers and warships. Late in the decade, a commercial application was attempted but failed. Battery-operated electric motors have been proposed for energy-efficient propulsion and have been utilized for propulsion on electric boats and submarines [15]. [1]

Nowadays, fossil fuels provide almost 85% of all energy, including the majority of electrical energy [12]. Sea transportation is one of the industries that uses fossil fuels. Diesel engines power over 95 percent of civil ships [3]. Sea transportation contributes to 2.5% of global warming and emits about 1,000 million tons of CO2 annually. As a result, research into energy conservation, alternative fuels, environmental protection technology, and alternative energy is growing in popularity [4]. Natural resources including sunshine, wind, tides, and geothermal energy are the source of renewable energy and are naturally replenished. The environmental impact of the marine industry is far greater than earlier estimated, with pollutants believed to be at twice the previously estimated levels [6]. .Sea transportation is one of the industries that uses fossil fuels. Diesel engines power over 95 percent of civil ships. Sea transportation contributes to 2.5% of global warming and emits about 1,000 million tons of CO2 annually. As a result, research into energy conservation, alternative fuels, environmental protection technology, and alternative energy is growing in popularity [4]. Natural resources including sunshine, wind, tides, and geothermal energy are the source of renewable energy and are naturally replenished. This paper first explores existing propulsion technologies and their evolution (Section 2), followed by an assessment of energy efficiency measures (Section 3), before evaluating current renewable options in detail (Section 4). Section 5 discusses the technological and regulatory challenges faced in implementation

2. Literature review

Nabae et al. demonstrated the use of a heartbeat breadth modulation program to set up an NPC inverter in 1980. Flying capacitor (FC) MLI is actually launched in 1990s. Current literature has thoroughly discussed the merits and demerits of cascaded H-bridge topologies, diode-clamped capacitors, and flying capacitors, collectively known as "classical topologies." A new voltage balancing management method has been introduced for diode-clamped multilevel systems [11]. The main equations are derived, and the circuit structure of the proposed converter is specified [8]. Recent research from DNV (2023) outlines maritime decarbonization pathways, highlighting hybrid-electric systems and ammonia-fueled ships as feasible near-future solutions. Lindstad et al. (2021) also provided insights on the cost-benefit analysis of alternative fuels in commercial vessels [16].

3. Ship energy efficiency management

The working environment, the time spent at work, and the experiments conducted by sailors on vessels could all lead to errors in the functioning of maritime devices. One of these marine propulsion plant issues might easily cause the ship to be damaged. As a result, the impact on the regular operation of the ships' authorized equipment is extremely substantial. In addition, there will be significant environmental issues, such as diesel oil spills and seawater contamination from nautical mishaps. Hence, the marine propulsion plant has a crucial role in marine safety and marine engineering. Individual methods, as described in Fig., have incorporated the specifics of these solutions.

Fig. 1: The Scheme of Ship Energy Efficiency Management.

Because it has been the primary conduit for trade between nations for a long time, maritime transportation is one of the factors that contribute to countries' economic growth. More precisely, maritime transportation accounts for 80–90% of world trade . One important reason for shipping's widespread use is that it uses less energy than air and road transportation. International shipping is the largest consumer of fuel in the transportation sector because of its widespread use [10]. LNG's position in the market was hampered by drawbacks including methane leak and challenges with onboard storage, even if it performs better than HFO and MDO in terms of energy efficiency and GHG emissions. For example, research that contrasted LNG and HFO discovered that LNG could cut CO2, NOx, and SOx emissions by 11%, 86%, and 98%, respectively.

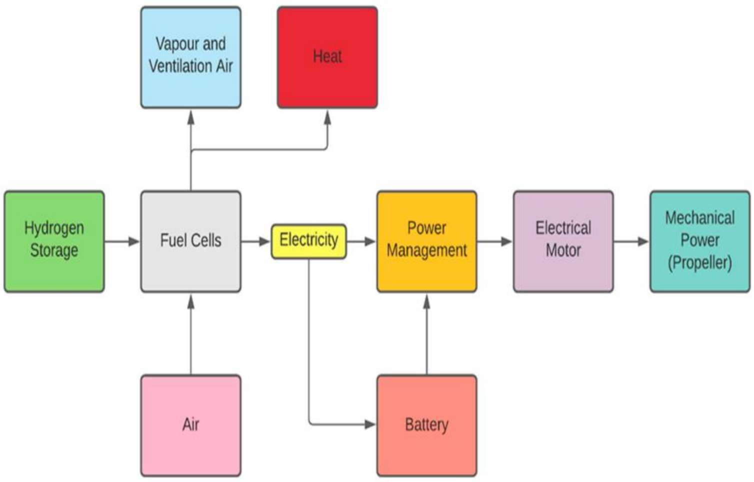

Fig. 2: Hydrogen Fuel Cell-Powered Ships.

4. Overall method for announcing renewable energy in the shipping industry

This is in sync with the possible incorporation of renewable energy in shipping. Major elements of the strategy include building alternative low- or zero-carbon fuels, using innovation and technology to advance zero-emission ships, and the role of research and development in meeting emission reduction goals. The IMO's focus on biofuels, alternative fuels, and advanced technologies underscores the potential for renewable energy in shipping. Recent achievements in lowering the shipping industry's greenhouse gas (GHG) emission levels are directly connected to renewable energy in the sector. The EU Emissions Trading System (ETS) has been extended to include CO2 emissions from large vessels calling at EU ports, encouraging cleaner fuels.

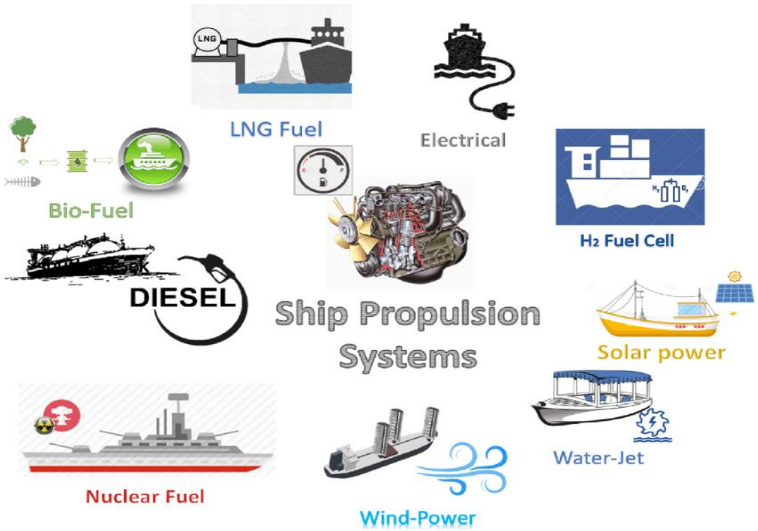

Fig. 3: Ship Propulsion System.

4.1. Energy from the sun

Wind, solar, and nuclear propulsion systems are the most widely employed RE propulsion systems on ships. These renewable energy sources emit no carbon dioxide and are clean [9]. These renewable technologies are now viable clean energy sources as alternatives to fossil fuels since their efficiency has increased over time and their costs have drastically decreased.

Propulsion by Wind

The first circumnavigation of the world was made possible by Magellan's journey 500 years ago, which was made possible by the Egyptians' use of wind energy since 3500 BC. With the increasing focus on climate change and global warming, naval engineers and marine engineers have looked to the past in trying to adopt the old method of sail propulsion as a solution to the problem of greenhouse emissions from vessels.

4.2. Propulsion by the sun

Solar energy is the most plentiful and environmentally friendly source of electricity. On the surface of the earth in tropical to subtropical climates, an estimated 150-250 W/m2 of solar power is received. To utilize this power, solar technologies like solar photovoltaic (PV) panels can be used to capture sunlight and produce electrical power. Solar power is a promising method for decarbonization, since commercial solar PV panels have efficiencies of 15-20% and are cost-effective, at $2.60-$3.20 per watt [5]. In an effort to cut CO2 and other greenhouse gas emissions, solar panels have been installed on shipping ships' decks. However, solar integration faces technical challenges such as corrosion from seawater, limited space on deck for PV arrays, and performance drops due to motion-induced shading. Typically, PV yield ranges between 100–160 W/m² at sea, with operational efficiency affected by weather and tilt angles. For example, the *Eco Marine Power* project demonstrated that solar panels contributed ~5% of onboard energy during peak conditions

4.3. Alternative fuels

In order to decarbonize the maritime sector, alternative fuels may be utilized as a substitute for fossil fuels. These fuels are more efficient than the RE fuel source and emit less CO2 and GHG gas than the traditional HFO or marine diesel fuel used for ship power. We discuss the five most widely utilized AF: methanol, LNG, hydrogen, ammonia, and biofuel.

4.4. Fuel cell propulsion

An emerging technology known as fuel cell propulsion uses hydrogen to generate electricity through a chemical reaction rather than combustion. This system is very effective and good for the environment.

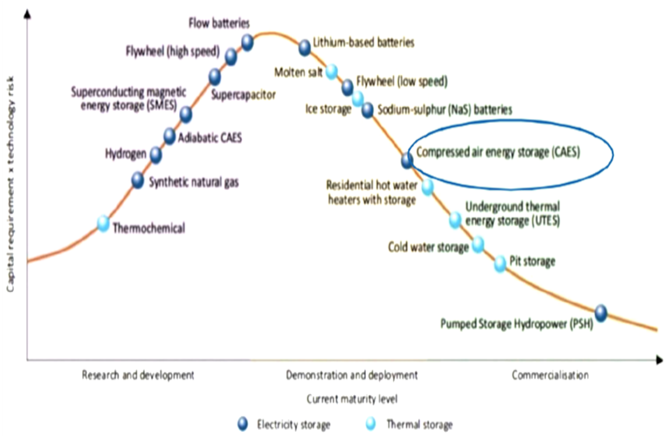

Fig. 4: Harley Chart of Technology Maturity of Various Energy Storage Technologies.

As shown in Fig. 4, fuel cells and ammonia combustion technologies are still in the demonstration phase, whereas solar and wind-assisted propulsion have reached pilot or early commercial stages, indicating their higher feasibility for near-term adoption.
A comparative analysis of major renewable propulsion technologies is provided in Table 1.

Table 1: Comparative Analysis of Renewable Propulsion Technologies for Marine Applications

Technology	Efficiency (%)	Cost ($/kWh)	Scalability	Key Challenge
Solar PV	15–20	2.8–3.2	Moderate	Space limitation on decks
Wind (Kites/Sails)	20–30	1.5–2.0	High	Dependence on wind direction
Hydrogen Fuel Cell	40–55	>5.0	Low–Medium	Storage & infrastructure
Ammonia Combustion	~30	3.5–4.2	Medium	Toxicity, engine adaptation

5. Discussion

Figure 5 illustrates the projected reduction in greenhouse gas concentrations achievable through the adoption of renewable energy technologies in marine operations. The graph shows a consistent decline in GHG levels corresponding to increased use of clean propulsion systems, emphasizing the potential impact of decarbonization strategies in maritime transport.. Additionally, one of the primary causes of greenhouse gas (GHG) emissions is the marine sector. Penalties for environmental pollution should therefore be enforced. In fact, the marine industry has not adopted the new technological systems and is regarded as a conservative industry sector [13-14].

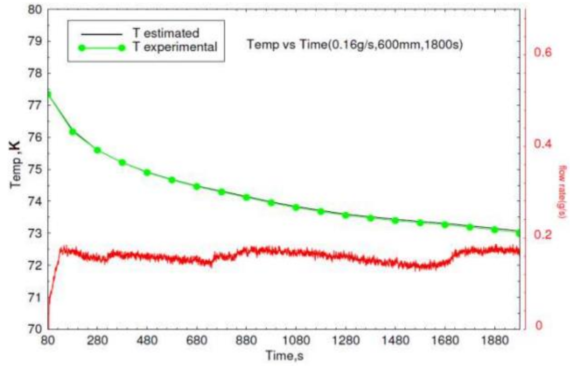

Fig. 5: Temperature Fall in Greenhouse Gas.

In order to drastically lower emissions and expenses, shipowners are encouraged by international marine policy to install state-of-the-art technology projects aboard their boats. Additionally, the shipping sector is confronted by minimizing ship fuel consumption by virtue of global warming emissions by international shipping and unstable fuel prices.

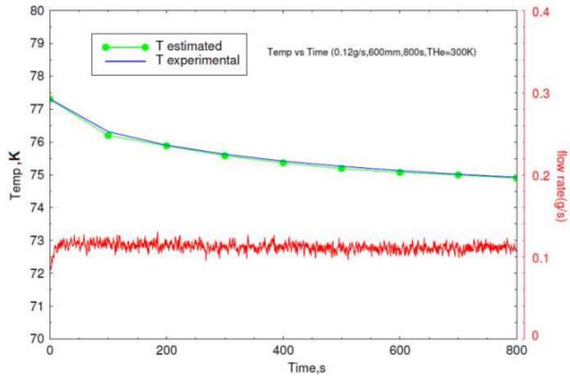

Fig. 6: Temperature Fall in Operational Energy Efficiency.

By increasing the technical and operational energy efficiency, new construction, in addition to existing ships, has the ability to reduce fuel consumption. Figure 6 provides a graphical view of the temperature decline trend associated with improvements in ship operational energy efficiency. This visual emphasizes how optimization of propulsion systems and fuel usage can lead to significant thermal savings and reduced emissions, supporting compliance with IMO efficiency mandates.

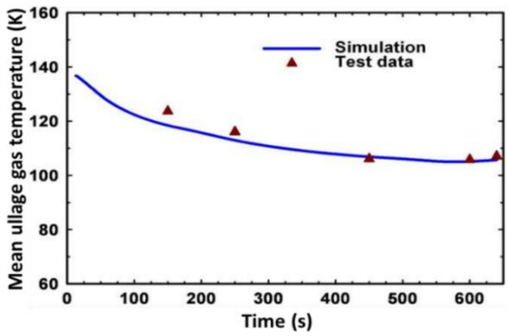

Fig. 7: Mean Ullage Gas Temperature.

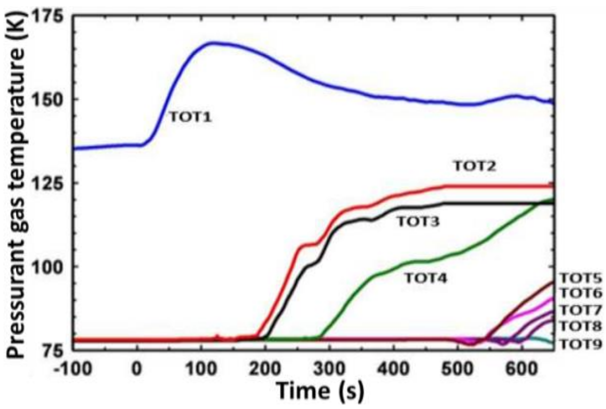

Fig. 8: High-Efficiency Electric Propulsion System.

Figure 8 illustrates the configuration of a high-efficiency electric propulsion system, which combines battery storage with smart inverters and electric drive trains. Such systems are vital in transitioning toward zero-emission vessels, offering superior control, lower maintenance, and integration capability with renewable sources like solar or wind.Additionally, ship owners and operators had to develop expert energy solutions and rationalize their energy usage. Although hydrogen fuel cells are emission-free at point-of-use, they pose significant challenges such as onboard storage in cryogenic conditions and lack of port refueling infrastructure. Balcombe et al. (2021) suggest that widespread adoption will depend heavily on government support and logistics investments As shown in Figure 7, monitoring of mean ullage gas temperature serves as a performance indicator for energy efficiency in fuel storage systems. Reduced ullage temperatures reflect improved thermal insulation and better energy conservation, critical for liquid fuel and hydrogen storage in maritime settings

6. Conclusion

With the shipping industry making efforts to lower its carbon footprint and shift away from fossil fuels, renewable energy sources are becoming more and more prominent. This article explored the evolution and implementation of renewable energy principles in the maritime industry from multiple viewpoints. The solution suggested has wide-ranging implications for mobile applications since the total system cost will reduce with the projected quick improvements in the renewable energy field. Nevertheless, for renewable energy to gain wide-spread use in the maritime industry, further innovation, new technology investment, and combined efforts to counter current economic and regulatory obstacles will be necessary.

References

[1] International Maritime Organization. (1973). The International Convention for the Prevention of Pollution from Ships adopted on 2 November; 1973.

[2] Fan, W., Osman, S., Zainudin, N., & Yao, P. (2024). How Content Attributes of Short Video Influence Online Purchase Intention: The Mediating Role of Perceived Value. *Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications, 15*(3), 445-458. https://doi.org/10.58346/JOWUA.2024.I3.029.

[3] Sakthivelu, U., & Vinoth Kumar, C.N.S. (2024). Defence Mechanism against Advanced Persistent Threat Attack Using Significant Features based Deep Learning Model. *Journal of Internet Services and Information Security, 14*(4), 263-277. https://doi.org/10.58346/JISIS.2024.I4.016.

[4] Guevara, K. G., Guevara, L. A. R., Gonzales, T. V. P., Neyra-Panta, M. J., Gálvez, J. F. E., & Saavedra, N. L. C. (2024). Review of Scientific Literature on Social Networks in Organizations. *Indian Journal of Information Sources and Services, 14*(4), 125–130. https://doi.org/10.51983/ijiss-2024.14.4.19.

[5] Umayalakshmi, R. (2014). Difference Identification in Synthetic Aperature Radar Images based on Image Fusion and Fuzzy Clustering Algorithm. *International Academic Journal of Science and Engineering, 1*(2), 161–167.

[6] Obetta, C., Mbata, F. U., & Akinniyi, O. J. (2024). Embryonic development of Atya gabonesis (Giebel, 1875) from River Niger, Jebba, Jebba, Kwara State, Nigeria. *International Journal of Aquatic Research and Environmental Studies, 4*(1), 49-62. https://doi.org/10.70102/IJARES/V4I1/5.

[7] Monson, A. K., & Matharine, L. (2023). Unlocking wireless potential: The four-element MIMO antenna. National Journal of Antennas and Propagation, 5(1), 26–32. https://doi.org/10.31838/NJAP/05.01.05.

[8] Ali, W., Ashour, H., & Murshid, N. (2025). Photonic integrated circuits: Key concepts and applications. Progress in Electronics and Communication Engineering, 2(2), 1–9.

[9] Ewanchuk, J., Salmon, J., & Vafakhah, B. (2011). A five-/nine-level twelve-switch neutral-point-clamped inverter for high-speed electric drives. *IEEE Transactions on Industry Applications*, *47*(5), 2145-2153. https://doi.org/10.1109/TIA.2011.2161857.

[10] Attaianese, C., Di Monaco, M., & Tomasso, G. (2010, June). Three-Phase Three-Level active NPC converters for high power systems. In *SPEEDAM 2010* (pp. 204-209). IEEE. https://doi.org/10.1109/SPEEDAM.2010.5542195.

[11] Vincentelli, B., & Schaumont, K. R. (2025). A review of security protocols for embedded systems in critical infrastructure. SCCTS Journal of Embedded Systems Design and Applications, 2(1), 1–11.

[12] Weiwei, L., Xiu, W., & Yifan, J. Z. (2025). Wireless sensor network energy harvesting for IoT applications: Emerging trends. Journal of Wireless Sensor Networks and IoT, 2(1), 50-61.

[13] Vishnupriya, T. (2025). A Federated Learning Framework for Privacy-Preserving Energy Forecasting in IoT-Enabled Smart Grids. National Journal of Intelligent Power Systems and Technology, 1(1), 38-47.

[14] DNV (2023). *Maritime Forecast to 2050*. DNV Publications

[15] Balcombe, P., Speirs, J., & Hawkes, A. (2021). *Challenges of Hydrogen in Maritime Decarbonization*. Renewable and Sustainable Energy Reviews.

[16] Lindstad, E., et al. (2021). *Cost-Effective Decarbonization Pathways for Maritime Transport*. Marine Policy Journal.