Salt, Sea, and Sustainability: Rethinking Power for Malaysia's Small Fishing Vessels

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Abstract: In many coastal communities across Malaysia, small to medium-sized fishing vessels rely on repurposed motorcycle batteries as their primary source of electrical power. These batteries are used to operate essential equipment such as lamps and to charge mobile devices, which are vital for navigation, safety, and communication. However, this practice raises significant sustainability concerns, including improper battery disposal, safety risks, and recurring costs for low-income fishermen. This study addresses the pressing need for a more sustainable, low-maintenance alternative by analysing the thematic concerns surrounding energy use aboard fishing vessels and laying the groundwork for the design of a saltwater-based electricity generator. The research employs a qualitative thematic analysis, drawing insights from interviews with local fishermen, field observations at fishing docks, and a review of existing literature on off-grid renewable energy technologies in marine settings. The analysis explores key themes such as energy accessibility, safety, environmental impact, cost burden, and technological awareness among fishermen. These themes are used to inform the conceptual development of an alternative energy solution that is both practical and environmentally friendly. Insights from the analysis reinforce the relevance of pursuing a saltwater-based electrochemical generator as a viable solution. While the project is in its initial stages, the thematic analysis offers a crucial foundation for user-centred design and aligns with broader goals of sustainable marine development.

Keywords: *sustainable energy, fishing vessels, salt water generator, electricity generation, thematic analysis, off-grid electricity*

1.0 INTRODUCTION

In many Malaysian coastal communities, small-scale fishing boats often use makeshift power setups—primarily refurbished motorcycle batteries—to operate lighting, radios, and mobile devices. These batteries power critical onboard systems such as navigation lights, radios, and mobile devices, ensuring not just operational efficiency but also the safety of the fishermen at sea. However, while these setups ensure operational continuity and safety at sea, they come with several drawbacks, including frequent replacements, improper disposal, safety hazards, and financial pressure on low-income users. In light of growing global focus on climate resilience and sustainability, this study investigates renewable and low-maintenance energy options. It lays the groundwork for a saltwater-based electrochemical generator designed to meet the unique energy needs of local fishing communities.

2.0 LITERATURE REVIEW

Studies have shown that small fishing communities often rely on informal or improvised energy sources, resulting in various environmental and operational issues (Sharma et al., 2021). Battery waste, particularly from lead-acid batteries, poses a significant environmental threat due to leakage of toxic materials into marine ecosystems (Gaines et al., 2014). Additionally, energy poverty in coastal communities contributes to reduced safety standards and operational inefficiencies (Modi et al., 2005). In Malaysia and similar maritime economies, small fishing vessels rely heavily on second-hand or repurposed lead-acid motorcycle batteries, which are not only inefficient but also hazardous to health and the environment (Sharma et al., 2021; Tan & Mohd Yusof, 2022).

2.1 Battery waste and environmental risks

Lead-acid battery usage can have some environmental concerns. Studies in coastal Southeast Asia, especially Thailand and Indonesia, have reported that makeshift battery use in fishing communities can cause both environmental harm and operational inefficiencies (Sharma et al., 2021). Lead-acid batteries, which are commonly used, pose serious environmental risks due to their toxic components, especially when they are improperly disposed of by being dumped into the sea, as well as inappropriately recycled (Gaines et al., 2014). This can lead to heavy metal contamination, threatening marine biodiversity and human health (Saputro et al., 2020; Pham et al., 2023).

2.2 Energy access inequality

Modi et al. (2005) and Nor et al. (2020) emphasize the impact of energy poverty on coastal communities. Limited access to reliable energy sources diminishes safety and productivity, particularly in Malaysia's east coast regions. In India, Singh and Khatri (2021) have noted that 67% of small fishing boat operators lacked consistent access to charged batteries, affecting navigation and communication during emergencies.

2.3 Off-grid renewable alternatives

Solar and wind-powered systems have shown moderate success in remote island communities across Indonesia and the Philippines. However, their broader application remains limited due to high initial costs, complex maintenance requirements, and vulnerability to extreme weather conditions (Rahman et al., 2019; Yuliana & Siregar, 2021). While these off-grid renewable solutions have been implemented in numerous contexts, widespread application is often limited by financial barriers, technical complexity, and inadequate local expertise (Lutzenhiser, 2014). Additionally, socio-cultural misalignment frequently renders such technologies impractical or unacceptable within the target communities. Saltwater electrochemical cells, while less efficient than lithium-ion technologies, offer promise due to their simplicity, low cost, and availability of materials (Kim et al., 2013). These factors make them a viable candidate for small-scale, user-friendly marine applications.

Kim et al. (2013) demonstrated the feasibility of aluminum-copper saltwater batteries in low-load applications. More recent research by Ahmad et al. (2023) from Universiti Teknologi MARA showed early-stage prototypes achieving operational stability over short durations, positioning them as sustainable stopgaps for energy-poor maritime zones.

Table 1 compares various energy storage and generation technologies—Lead-acid batteries, Lithium-ion batteries, Solar Panels with Batteries, and Saltwater Electrochemical systems—in terms of cost, environmental impact, maintenance level, and suitability for boat use. It also references relevant case studies from Asian countries, highlighting regional research and adoption. The data suggests that while lead-acid batteries are initially affordable, they have higher environmental and maintenance costs. In contrast, saltwater electrochemical systems offer the lowest environmental impact and maintenance needs, making them highly suitable for sustainable marine applications.

Table 1
Comparison of Battery and Energy Technologies for Boat Applications in Asia

Technology	Cost	Environmental Impact	Maintenance Level	Suitability for Boats	Asian Case Study
Lead-acid Batteries	Low initial	High	High	Moderate	Malaysia, India (Tan & Yusof, 2022)
Lithium-ion Batteries	High	Moderate	Moderate	High	Thailand (Pham et al., 2023)
Solar Panels + Batteries	High	Low	Moderate	Moderate	Indonesia (Rahman et al., 2019)
Saltwater Electrochemical	Very Low	Very Low	Low	High	Malaysia (Ahmad et al., 2023)

2.4 Adoption barriers and knowledge gaps on renewable energy

Although there is a growing interest in sustainable energy alternatives among coastal communities, a significant gap remains in both technological awareness and access to formal training. A 2022 survey conducted by the Institute of Oceanography and Environment (INOS) found that only 18% of boat operators in Malaysia's rural fishing districts were familiar with renewable energy systems. These findings are consistent with the results of our fieldwork in Kuala Kedah, where many fishermen expressed curiosity about alternative energy solutions but lacked practical knowledge or exposure to such technologies. This knowledge gap presents a critical barrier to the effective adoption and long-term viability of renewable off-grid systems in the maritime sector.

3.0 METHODOLOGY

This research employed a qualitative thematic analysis methodology. Data were collected through:

i. Semi-structured interviews with 12 local fishermen in the Kuala Kedah area.
ii. Field observations conducted over two weeks at the fishing docks in Kuala Kedah.
iii. A desk review of existing studies on off-grid and marine-based energy systems.

The interviews were audio- and video-recorded, transcribed, and coded manually. Observations focused on equipment used, typical energy demands, and safety practices. Literature was analysed to contextualise the empirical findings within broader sustainability discourses.

4.0 DATA ANALYSIS AND FINDINGS

The thematic analysis of the data uncovered five key themes reflecting the challenges and perceptions of fishermen regarding energy use in their daily operations:

i. **Energy Accessibility**
Fishermen frequently reported inconsistent battery performance and challenges in sourcing reliable replacements. A significant number rely on second-hand or refurbished batteries, which often lack durability and reliability.

ii. **Safety Risks**
Safety concerns were prominent, with several participants recounting incidents of battery leakage or overheating. These issues were typically linked to battery overuse or exposure to seawater, highlighting the need for more robust and marine-suitable energy solutions.

iii. **Environmental Concerns**
Improper battery disposal emerged as a critical issue. Many batteries were discarded into the sea or abandoned at docks, leading to environmental contamination and long-term ecological damage.

iv. **Cost Burden**.
Fishermen reported spending up to RM300 per month on battery replacement or repairs, which can affect a significant portion of their limited income, especially during rainy seasons.

v. **Technological Awareness**
Despite an expressed interest in more sustainable energy alternatives, most fishermen had limited exposure to renewable technologies. The lack of formal training and accessible information contributes to low adoption rates of environmentally friendly solutions.

These findings underscore the urgency of developing a low-cost, easy-to-maintain alternative. The saltwater electrochemical generator was positively received as a concept, especially due to its potential use of locally available materials and reduced environmental footprint.

5.0 DISCUSSION AND CONCLUSIONS

This research identifies a pressing gap in sustainable energy use among Malaysia's small-scale fisheries. Although current solutions meet basic needs, they come at high environmental and safety costs. The proposed saltwater generator represents a promising, low-impact alternative that supports national efforts toward green and inclusive development. For this solution to succeed, local participation, hands-on training, and ongoing policy support are essential. The study serves as a stepping stone toward developing practical, community-driven innovations in off-grid marine energy systems.

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