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Functional reliability assessment of marine electrical systems and energy efficiency opportunities: A case study of KMP Sebuku

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ABSTRAK

Penelitian ini mengevaluasi keandalan fungsional sistem kelistrikan, pemantauan main switchboard (MSB), dan peluang efisiensi energi pada KMP Sebuku, kapal Ro-Ro yang melayani Merak–Bakauheni. Studi kasus kualitatif deskriptif ini menganalisis satu catatan observasi teknis tanggal 26 Agustus 2026, tanpa pengukuran tambahan melalui klasifikasi kondisi peralatan, interpretasi risiko, dan penyusunan prioritas perbaikan. Riwayat operasi yang dilaporkan tidak mencatat blackout, tetapi layar power meter digital MSB tidak menampilkan informasi, sementara meter analog masih berfungsi. Temuan lain mencakup catu daya tambahan, pengendali wiper yang tidak berfungsi, pengaturan penerangan manual, dan penggunaan lampu fluoresen. Simulasi penggantian lampu 36 W menjadi 16 W menunjukkan pengurangan daya 20 W per titik atau 55,6% pada beban lampu tersebut; penghematan aktual kapal belum terukur. Penelitian merekomendasikan diagnosis bertahap, verifikasi fungsi keselamatan, penataan instalasi, pemeliharaan berbasis kondisi, dan audit energi sebelum retrofit.

Kata Kunci: efisiensi energi, keandalan kelistrikan, kapal penyeberangan, main switchboard, pemeliharaan.

ABSTRACT

This study evaluates the functional reliability of marine electrical systems, main switchboard (MSB) monitoring, and energy-efficiency opportunities aboard KMP Sebuku, a Ro-Ro ferry operating on the Merak–Bakauheni route. A descriptive qualitative case-study design was applied to a single technical observation record dated 26 August 2026, without additional measurements. Evidence was classified by equipment condition, functional consequence, verification needs, and corrective-action priority. The reported operating history contained no blackout incidents; nevertheless, the MSB digital power-meter display was blank while analog instruments remained functional. Other findings included supplementary power supplies, a nonfunctional digital wiper controller, manual lighting selection, and extensive fluorescent lighting. An illustrative conversion from 36 W fluorescent lamps to 16 W LEDs yields a nominal reduction of 20 W per lamp (55.6% of the original lamp load), but vessel-wide savings were not measured. The study recommends sequential fault diagnosis, verification of safety-related auxiliary functions, installation inspection, condition-based maintenance, and an instrumented energy baseline before retrofit decisions. Findings distinguish documented observations from hypotheses requiring further tests.

Keywords: *electrical reliability, energy efficiency, ferry, main switchboard, maintenance.*

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INTRODUCTION

Reliable electrical power is essential to ferry navigation, communications, safety equipment, machinery auxiliaries, and passenger services. Reliability therefore involves not only continuity of generation but also distribution integrity, instrumentation, protection, and the availability of critical auxiliary functions. On a frequently operating Ro-Ro ferry, variations between sailing, manoeuvring, and port conditions place different demands on generators and connected loads. Prior research emphasizes shipboard power quality and monitoring as contributors to operational resilience [1], [2], [3].

The International Convention for the Safety of Life at Sea (SOLAS) provides the broader safety framework for electrical and emergency power arrangements [4]. The International Safety Management (ISM) Code further emphasizes maintenance procedures, reporting, and corrective action [5]. IEC 60092 provides relevant principles for shipboard electrical installations (International Electrotechnical Commission [IEC], n.d.). These instruments frame the analysis; the available observation record is insufficient for a formal compliance determination. Reviews of shipboard system architecture emphasize distinct requirements for stability, protection, and reliability [6], [7].

KMP Sebuku is a 5,553 GT Ro-Ro ferry operating between Merak and Bakauheni. Its technical observation record identifies four 438 kW main diesel generators, an 85 kVA harbour generator, and a 194 kW emergency generator. Although the main supply was reported to remain operational, a blank digital power-meter display at the MSB raised concerns about the visibility of electrical parameters. Supplementary DC supplies, an inoperative wiper controller, manually selected lighting circuits, and fluorescent luminaires were also documented [8]. This article addresses four questions: what can be concluded about functional continuity of the main electrical system; which monitoring and auxiliary faults warrant verification; what lighting-energy savings are technically plausible; and how should corrective maintenance be prioritized? The contribution is an evidence-graded diagnostic framework that avoids treating a single inspection as a statistically validated reliability or energy audit.

RESEARCH METHODOLOGY

A descriptive qualitative, applied case-study approach was used. The unit of analysis was KMP Sebuku's electrical installation as documented in a two-page technical observation record prepared on 26 August 2026 in the operating environment of PT ASDP Indonesia Ferry (Persero), Merak Branch. The subsequent research report provided technical interpretation and scenario calculations. No additional shipboard testing, interviews, measurements, or site visits are claimed. Data extraction covered vessel specifications, observed equipment states, reported operating history, potential functional consequences, and proposed follow-up actions.

Evidence was classified into four categories: directly observed condition, reported history, technically plausible but unverified causal hypothesis, and proposed intervention. Findings were grouped into generation and distribution, MSB instrumentation, DC/control supply, auxiliary and safety-related equipment, and lighting efficiency. The analysis used descriptive equipment mapping and a qualitative prioritization matrix. High-priority items were those potentially affecting monitoring or safety-related operational functions; medium-priority items involved installation quality and supporting instruments; programmatic items required inventory or baseline data before investment. No failure-frequency, mean-time-between-failures, insulation-resistance, harmonic, fuel-consumption, or generator load-test results were available.

Priority reflects the potential consequence of an observed condition rather than its probability of failure. The evidence source for each item is the observation record unless explicitly identified as reported history or an illustrative calculation. Within each priority class, sequencing should follow the vessel safety management system and authorization for electrical work. No calibrated risk matrix was applied. For a hypothetical lighting replacement, nominal power reduction was calculated as $\Delta P = N(P_{old} - P_{new})/1000$ (kW), and annual energy saving as $\Delta E = \Delta P \times h \times d$ (kWh), where N is lamp count, h is daily operating hours, and d is annual operating days. The scenario assumes 36 W versus 16 W per lamp, eight hours daily, and 300 days annually; these are assumptions rather than measured operating values.

RESULTS AND DISCUSSION

Vessel electrical configuration and reported continuity

The vessel record lists four main generator sets rated at 438 kW each, giving a summed nameplate capacity of 1,752 kW. It also lists an 85 kVA harbour generator and a 194 kW emergency generator. The propulsion plant comprises two 3,500 HP main engines, and a 600 kW bow thruster is among the principal loads. Summed installed generator capacity must not be interpreted as continuously available output or actual load, because dispatch, redundancy, power factor and operating mode were not documented.

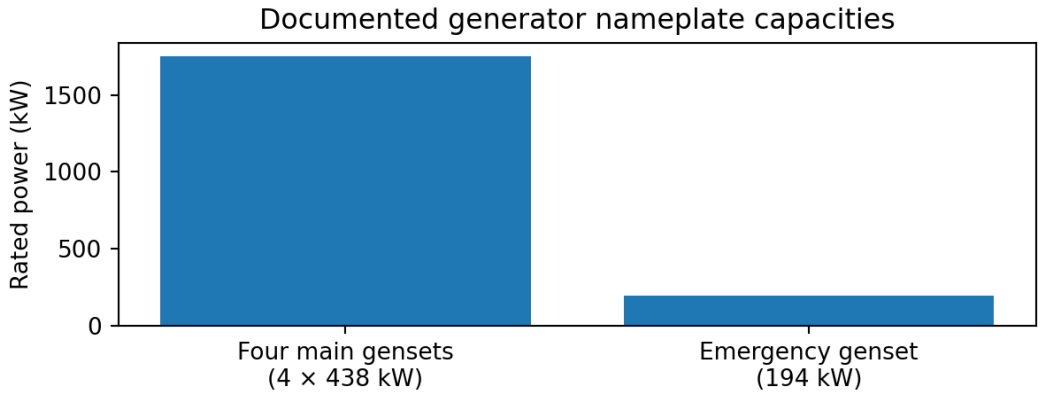

Figure 1. Documented generator nameplate capacity (not measured output).

The observation record reports no blackout incidents in the vessel's operating history. This is a reported historical claim rather than an independently audited incident count. The analog MSB instruments were functional during observation, and basic readings therefore remained accessible at that time. No longitudinal operating logs or failure statistics were supplied to quantify system reliability.

Monitoring and auxiliary equipment findings

Table 1 summarizes the documented condition and the verification required before any root cause can be confirmed.

Table 1. Observed electrical conditions and diagnostic implications

Equipment	Documented condition	Recommended verification
MSB digital power meter	Display blank/black	Check supply, fuse, connectors, display and communication
MSB analog meters	Functional	Check calibration and log readings
24 V DC charger	Active; reported 24–28 V DC, 300 A	Measure loaded output, ripple and battery condition
Supplementary supply/UPS	DDAKAI AP-60AD and APC UPS; exposed wiring	Trace supply paths and inspect wiring protection
Digital wiper controller	Display inoperative	Test controller supply, manual control and wiper motor
Fire damper, drencher, WTD panels	Standby indications	Perform authorized functional tests
Lighting panels 1 and 6	Manual operating instructions	Review circuit labels, essential loads and procedures
Fluorescent lighting	T8/T12 lamps prevalent	Inventory fittings, wattage and operating hours

A failed digital display is not equivalent to loss of MSB busbar voltage, and a working analog instrument does not demonstrate that all monitoring, alarms, or protection functions are healthy. Possible explanations for the blank display include loss of auxiliary supply, blown fuse, connector defect, failed display module, or internal converter fault. These are hypotheses, not confirmed failure mechanisms. Diagnosis should proceed from safe verification of external supplies toward component-level examination. Recent diagnostic reviews support staged fault isolation rather than attributing an unresponsive display to a particular component without testing [9].

The operating DC charger likewise does not prove adequate voltage at every downstream control load. The supplementary supply and UPS installations require tracing against electrical drawings,

mechanical cable protection, and assessment of any undocumented dependency. Standby indications on fire-damper, drencher, and watertight-door (WTD) panels indicate status only; successful actuation cannot be inferred without authorized testing. Maintenance and isolation should follow the vessel safety management system and applicable manufacturer/class requirements.

Illustrative lighting-efficiency scenarios

The observed fluorescent luminaires present an identifiable opportunity to improve energy efficiency. The proposed comparison uses a nominal 36 W fluorescent luminaire and a 16 W replacement. The difference in the rating of one lighting point is 20 W, equivalent to 55.6% of the original rating. Table 2 presents conditional savings under fixed operating-hour assumptions.

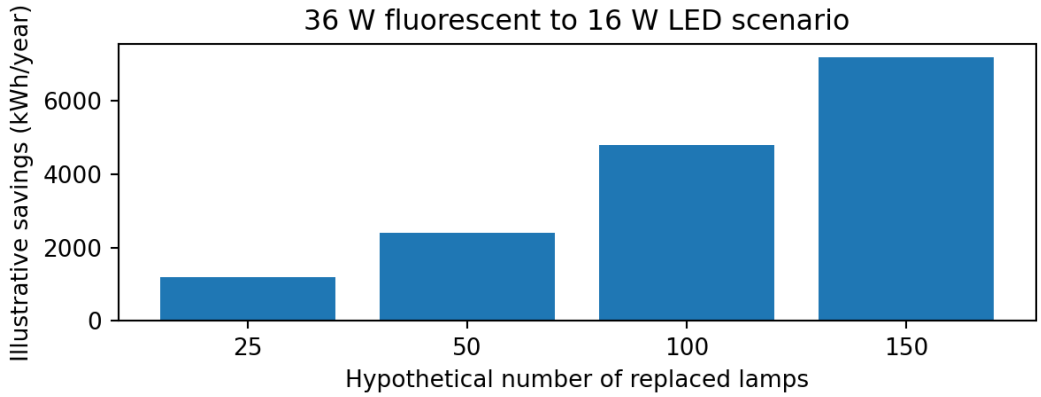

Figure 2. Illustrative LED energy savings (8 h/day, 300 days/year; not measured aboard).

Table 2. Illustrative LED conversion scenarios (8 h/day, 300 days/year)

Replaced lamps	Reduced connected load	Illustrative annual savings
50	1.0 kW	2,400 kWh
100	2.0 kW	4,800 kWh
200	4.0 kW	9,600 kWh
300	6.0 kW	14,400 kWh

These figures are scenario outputs, not measured vessel savings. They exclude ballast/driver differences, actual lamp inventory, illuminance requirements, duty cycles, and generator efficiency. A 55.6% lamp-level reduction must not be described as a 55.6% reduction in overall vessel electrical demand or fuel consumption. Any retrofit should preserve required lighting performance and emergency-circuit integrity. ISO 50001 principles support establishing comparable baselines and monitoring energy performance before and after interventions [10]. Other potentially consequential measures include generator dispatch matched to verified load profiles, control of nonessential hotel loads, maintenance of electrical connections, and assessment of variable-speed drives for suitable pumps or fans. These options were not quantitatively evaluated; their feasibility depends on measured demand, operational constraints, harmonics, and lifecycle cost. This broader approach is consistent with maritime energy-management literature [11], [12].

Corrective action and planned maintenance priorities

Table 3 converts the condition mapping into an actionable sequence. Priority is a qualitative management recommendation, not a numerical risk score.

Table 3. Proposed corrective-action priorities

Priority	Item	Action and closure evidence
High	MSB digital display	Supply-to-module diagnosis; restored readings and test record
High	Wiper controller	Authorized operational test; documented repair
High	Safety-related standby panels	Functional test records under ship procedures
Medium	Supplementary supplies	Protected wiring and updated as-built drawings
Medium	Analog instruments	Calibration/verification and log entries

Priority	Item	Action and closure evidence
Programmatic	Fluorescent lighting	Inventory, pilot retrofit and metered kWh comparison
Programmatic	Lighting control and pumps/fans	Review safe automation and load profiles before investment

A planned maintenance system should link inspection findings to work orders, responsible personnel, target dates, and closure evidence. Condition-based practices may include thermographic inspection, charger/battery checks, cleaning and tightening in accordance with manufacturer procedures, and insulation-resistance testing of suitable equipment. IEEE Std 43-2013 provides relevant guidance for rotating machinery insulation testing, but acceptance criteria and test voltages depend on equipment characteristics [13]. None of these tests was reported as completed in the present case. Condition-monitoring studies support evidence-based maintenance and documented verification [14], [15]. The main practical implication is that apparent power continuity can coexist with degraded observability and auxiliary functionality.

Restoration of monitoring and confirmation of safety-related functions should precede discretionary efficiency investments. For future quantitative evaluation, the operator should collect generator kW/kWh logs, running hours, alarm histories, load inventories, measured lighting consumption, and fuel data under comparable voyage and port conditions. Verification of blackout history requires dated alarm/event logs, generator trip records and operating hours over a defined period. Actual energy savings require pre- and post-retrofit circuit measurements under comparable duty cycles, including ballast or driver input and lighting performance. Applicable IEC 60092 parts and the edition and scope of IEEE 43 must be checked against the equipment and vessel requirements before specifying acceptance criteria. Shipboard electrical-system research addresses energy management, safety margins, network resilience, and fault diagnosis [16], [17], [18], [19], [20]. These studies provide a comparison framework; their settings and methods do not establish the validity or magnitude of the findings of the present study.

Shipboard electrical-system research addresses energy management, safety margins, network resilience, and fault diagnosis (Ahn J. 2021; Tsoumpris C. 2023; Xu L. 2022; Stevens B. 2015; Li Y. 2023; Lai K. 2018; Hester P. 2005; Lan H. 2010; Lan H. 2010). The research settings and study designs differ. These publications provide context for interpreting the topic. They do not independently validate the results of the present study. FMEA research addresses RPN models and alternative approaches that account for uncertainty or weighting [21], [22], [23], [24]. The research settings and study designs differ. These publications provide context for interpreting the topic. They do not independently validate the results of the present study.

CONCLUSION

KMP Sebuku's main electrical supply was reported to remain operational, and analog MSB instruments were observed to function; however, the available single-observation evidence cannot establish a statistical reliability index or independently confirm a blackout-free service history. A blank MSB digital meter, supplementary DC power arrangements, a nonfunctional wiper controller, and manually operated lighting circuits demonstrate the need to assess monitoring and auxiliary functions separately from generation continuity. The blank display's underlying cause remains unverified. An illustrative fluorescent-to-LED conversion offers 20 W of nominal reduction per lamp, but no ship-wide energy or fuel saving has yet been measured. Priority should therefore be given to safe sequential diagnosis, documented auxiliary functional tests, installation correction, and condition-based planned maintenance, followed by an instrumented energy audit and carefully evaluated retrofit pilots. Further longitudinal evidence is needed to determine performance improvement after corrective action.

DECLARATIONS AND ADDITIONAL INFORMATION

ORIGINALITY AND EXCLUSIVE SUBMISSION

The authors are requested to confirm that the manuscript is original, has not been published and is not under consideration elsewhere.

AUTHOR CONTRIBUTIONS

Proposed CRediT statement (for author approval): Syairi Anwar: conceptualization, methodology, formal analysis, writing – original draft. Heru Maryanto; Dedtri Anwar; Yollanda Octavitri;

DATA AVAILABILITY

The study draws on electrical inspection and operating records for the vessel. Access to underlying material should be requested from the corresponding author and is subject to confidentiality and applicable permissions.

USE OF ARTIFICIAL INTELLIGENCE

Abdurrohim Ilham Dalimunthe; Fifi Hijriani Azizah: investigation, validation and writing – review & editing.

CONFLICT OF INTEREST

No competing interests have been reported.

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ETHICAL APPROVAL

This study uses electrical inspection and operating records for the vessel. Ethics approval details are not reported.

INFORMED CONSENT

No participant recruitment is reported for this records-based or technical study.

ChatGPT (OpenAI) assisted with language editing, consistency checks, structure and formatting. The authors remain responsible for the data, interpretation and scientific content.

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EDITORIAL INDEPENDENCE

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REFERENCES

[1] Barros, J., & Diego, R. I. (2016). A review of measurement and analysis of electric power quality on shipboard power system networks. *Renewable and Sustainable Energy Reviews, 62*, 665–672. https://doi.org/10.1016/j.rser.2016.05.043

[2] Tarasiuk, T., Jayasinghe, S. G., Gorniak, M., Pilat, A., Shagar, V., Liu, W., & Guerrero, J. M. (2021). Review of power quality issues in maritime microgrids. *IEEE Access*. https://doi.org/10.1109/ACCESS.2021.3086000

[3] Mindykowski, J., Tarasiuk, T., & Gnaciński, P. (2021). Review of legal aspects of electrical power quality in ship systems in the wake of the novelisation and implementation of IACS rules and requirement. *Energies, 14*(11), 3151. https://doi.org/10.3390/en14113151

[4] International Maritime Organization. (1974, as amended). *International Convention for the safety of life at Sea (SOLAS), chapter II-1*. IMO.

[5] International Maritime Organization. (2018). *International Safety Management (ISM) Code and guidelines on implementation*. IMO.

[6] Zohrabi, N., Shi, J., & Abdelwahed, S. (2019). An overview of design specifications and requirements for the MVDC shipboard power system. *International Journal of Electrical Power & Energy Systems, 104*, 680–693. https://doi.org/10.1016/j.ijepes.2018.07.050

[7] van der Sande, R., Shekhar, A., & Bauer, P. (2025). Reliable DC shipboard power systems—Design, assessment, and improvement. *IEEE Open Journal of the Industrial Electronics Society, 6*, 235–264. https://doi.org/10.1109/OJIES.2025.3532095

[8] KMP Sebuku Research Team. (2026). Applied technical observation report on the electrical systems of KMP Sebuku (26 August 2026) [Unpublished internal technical record].

[9] Huang, K., Li, W., Cao, S., Gao, F., Li, R., Xu, W., & Lin, B. (2026). Recent advances in fault diagnosis of ship integrated power systems: A review. *Ocean Engineering*. https://doi.org/10.1016/j.oceaneng.2025.123141

[10] International Organization for Standardization. (2018). ISO 50001:2018 energy management systems—Requirements with guidance for use. *ISO*.

[11] Al-Falahi, M. D. A., Tarasiuk, T., Jayasinghe, S. G., Jin, Z., Enshaei, H., & Guerrero, J. M. (2018). AC ship microgrids: Control and power management optimization. *Energies, 11*(6), 1458. https://doi.org/10.3390/en11061458

[12] Hüffmeier, J., & Johanson, M. (2021). State-of-the-art methods to improve energy efficiency of ships. *Journal of Marine Science and Engineering, 9*(4), 447. https://doi.org/10.3390/jmse9040447

[13] Institute of Electrical and Electronics Engineers. (2013). IEEE Std 43-2013: IEEE recommended practice for testing insulation resistance of electric machinery. *IEEE*.

[14] Karatuğ, Ç., & Arslanoğlu, Y. (2022). Development of condition-based maintenance strategy for fault diagnosis for ship engine systems. *Ocean Engineering, 256*, 111515. https://doi.org/10.1016/j.oceaneng.2022.111515

[15] Ma, R., Zhao, Q., Wang, K., Cao, J., Yang, C., Hu, Z., & Huang, L. (2025). Energy efficiency improvement technologies for ship in operation: A comprehensive review. *Ocean Engineering, 331*, 121258. https://doi.org/10.1016/j.oceaneng.2025.121258

[16] Fang, S., & Xu, Y.. (2020). Multi-objective robust energy management for all-electric shipboard microgrid under uncertain wind and wave. *International Journal of Electrical Power & Energy Systems*. https://doi.org/10.1016/j.ijepes.2019.105600

[17] Jung, J., Jeon, H., & Kim, J.. (2026). Grid risk index-based safety margin assessment for hybrid electric shipboard power systems. *International Journal of Electrical Power & Energy Systems*. https://doi.org/10.1016/j.ijepes.2026.112229

[18] Billah Kushal, T. R., & Illindala, M. S.. (2020). Correlation-based feature selection for resilience analysis of MVDC shipboard power system. *International Journal of Electrical Power & Energy Systems*. https://doi.org/10.1016/j.ijepes.2019.105742

[19] Ding, Y., Ma, S., Liu, G., Sui, C., & Xiang, L.. (2025). Optimization of sizing and energy management in hybrid energy storage systems for transient suppression in ship power systems under adverse sea conditions. *International Journal of Electrical Power & Energy Systems*. https://doi.org/10.1016/j.ijepes.2025.110864

[20] Liu, S., Sun, Y., Zhang, L., & Su, P.. (2021). Fault diagnosis of shipboard medium-voltage DC power system based on machine learning. *International Journal of Electrical Power & Energy Systems*. https://doi.org/10.1016/j.ijepes.2020.106399

[21] Kim, K. O., & Zuo, M. J.. (2018). General model for the risk priority number in failure mode and effects analysis. *Reliability Engineering & System Safety*. https://doi.org/10.1016/j.ress.2017.09.010

[22] Zheng, H., & Tang, Y.. (2020). Deng entropy weighted risk priority number model for failure mode and effects analysis. *Entropy*. https://doi.org/10.3390/e22030280

[23] Bhattacharjee, P., Dey, V., & Mandal, U. K.. (2020). Risk assessment by failure mode and effects analysis (FMEA) using an interval number based logistic regression model. *Safety Science*. https://doi.org/10.1016/j.ssci.2020.104967

[24] Tang, Y., Zhou, D., & Chan, F. T. S.. (2018). AMWRPN: Ambiguity measure weighted risk priority number model for failure mode and effects analysis. *IEEE Access*. https://doi.org/10.1109/access.2018.2836139

[25] International Electrotechnical Commission. (n.d.). IEC 60092 series: Electrical installations in ships. IEC.

[26] Ahn, J., Lee, S., Jeong, J., & Choi, Y. (2021). Comparative feasibility study of combined cycles for marine power system in a large container ship considering energy efficiency design index (EEDI). *International Journal of Hydrogen Energy*. https://doi.org/10.1016/j.ijhydene.2021.07.068

[27] Tsoumpris, C., & Theotokatos, G. (2023). A decision-making approach for the health-aware energy management of ship hybrid power plants. *Reliability Engineering & System Safety*. https://doi.org/10.1016/j.ress.2023.109263

[28] Xu, L., Wen, Y., Luo, X., Lu, Z., & Guan, X. (2022). A modified power management algorithm with energy efficiency and GHG emissions limitation for hybrid power ship system. *Applied Energy*. https://doi.org/10.1016/j.apenergy.2022.119114

[29] Stevens, B., Dubey, A., & Santoso, S. (2015). On improving reliability of shipboard power system. *IEEE Transactions on Power Systems*. https://doi.org/10.1109/tpwrs.2014.2354638

[30] Li, Y., Ding, Z., Yu, Y., & Liu, Y. (2023). Hierarchical control of hybrid energy storage system in shipboard gas turbine power system with multiple pulsed power loads. *Energy Reports*. https://doi.org/10.1016/j.egyr.2023.05.144

[31] Lai, K., & Illindala, M. S. (2018). A distributed energy management strategy for resilient shipboard power system. *Applied Energy*. https://doi.org/10.1016/j.apenergy.2018.06.111

[32] Hester, P., Thomas, L., & Mahadevan, S. (2005). Reliability-Based shipboard facility optimization. *Journal of Ship Production*. https://doi.org/10.5957/jsp.2005.21.4.235

[33] Lan, H., Xiao, Y. Y., & Zhang, L. J. (2010). Multi-agent system optimized reconfiguration of shipboard power system. *Journal of Marine Science and Application*. https://doi.org/10.1007/s11804-010-1017-2

[34] Lan, H., Li, J. F., & Zhang, D. H. (2010). Power flow calculation method of large shipboard power system. *Journal of Marine Science and Application*. https://doi.org/10.1007/s11804-010-8088-y