ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2821-2975 (Online)
CODEN: EGESCS

Economic Growth and Environment Sustainability (EGNES)

DOI: http://doi.org/10.26480/egnes.02.2023.112.116

CrossMark

RESEARCH ARTICLE

SECURING LNG TERMINALS RELIABILITY: A COMPREHENSIVE LITERATURE REVIEW OF RELIABILITY-CENTERED MAINTENANCE STRATEGIES

Joachim Osheyor Gidiagba[a], Joel Leonard[b], Oluwaseun Ayo Ogunjobi[c], Kelechi Anthony Ofonagoro[d], Chibuike Daraojimba[e*]

[a]University of Johannesburg, South Africa.
[b]University of Pretoria, South Africa.
[c]S A & G Beeline Consulting, Nigeria.
[d]Kelanth Energy Solutions Limited, Nigeria.
[e]University of Pretoria, South Africa.
[*]Corresponding Author Email: Chibuike.daraojimba@tuks.co.za

ARTICLE DETAILS

Article History:

Received 16 July 2023
Accepted 19 August 2023
Accepted 22 September 2023
Available online 11 October 2023

ABSTRACT

The reliable operation of Liquified Natural Gas (LNG) terminals is of paramount importance for the energy industry. This paper presents a comprehensive literature review of Reliability-Centered Maintenance (RCM) strategies tailored to secure the reliability of LNG terminals. The study explores the unique challenges faced by LNG terminals, ranging from equipment complexity to safety regulations. It examines the principles and components of RCM processes, highlighting the benefits and limitations. Additionally, the paper delves into the transformative role of Artificial Intelligence (AI) and Machine Learning (ML) applications in enhancing LNG terminal maintenance. Real-world case studies demonstrate the practical implementation of AI/ML-driven predictive maintenance, robotic inspection, condition monitoring, and anomaly detection. The challenges and limitations associated with the adoption of AI/ML in LNG terminal maintenance are discussed, along with future opportunities for innovation and integration with emerging technologies. The study concludes by emphasizing the significance of embracing AI/ML for enhancing LNG terminal reliability and sustainability in the evolving energy landscape.

KEYWORDS

Reliability, LNG, Reliability Centered Maintenance, Machine learning, Strategies.

1. INTRODUCTION

1.1 Background and Motivation

Liquified Natural Gas (LNG) terminals play a crucial role in the global energy supply chain by enabling the efficient transportation and distribution of natural gas. Ensuring the reliability and safety of these terminals is paramount to maintaining uninterrupted energy supply and meeting growing demand. However, the complexity of LNG terminal equipment, stringent safety regulations, and the need for continuous operation present significant challenges. Reliability-Centered Maintenance (RCM) strategies offer a systematic approach to address these challenges by optimizing maintenance practices to enhance terminal reliability. This literature review aims to provide a comprehensive understanding of the various RCM strategies and their applications in securing the reliability of LNG terminals.

1.2 Purpose of the Study

The primary purpose of this study is to conduct a comprehensive literature review focused on Reliability-Centered Maintenance (RCM) strategies specifically tailored for Liquified Natural Gas (LNG) terminals. By examining existing research and practical implementations, this study aims to provide insights into the diverse RCM approaches employed to enhance the reliability, safety, and operational efficiency of LNG terminals. The review will encompass both traditional RCM methodologies and the transformative impact of Artificial Intelligence (AI) and Machine Learning (ML) applications in LNG terminal maintenance. Through this examination, the study intends to contribute to a deeper understanding of effective maintenance strategies that can secure the reliability of LNG terminals in an evolving energy landscape.

1.3 Research Objectives

The research objectives of this study are as follows:

To analyze the challenges and complexities associated with maintaining the reliability of Liquified Natural Gas (LNG) terminals, including equipment intricacies and safety regulations.

To provide a comprehensive overview of Reliability-Centered Maintenance (RCM) strategies and their significance in addressing the unique maintenance needs of LNG terminals.

To explore the applications and benefits of Artificial Intelligence (AI) and Machine Learning (ML) in enhancing the effectiveness of RCM strategies for LNG terminal maintenance.

To present real-world case studies and practical implementations that demonstrate the successful integration of RCM practices and AI/ML technologies in ensuring LNG terminal reliability.

To identify the challenges, limitations, and ethical considerations associated with the adoption of AI/ML in LNG terminal maintenance and highlight opportunities for future advancements in the field.

By achieving these objectives, the study aims to contribute valuable

Quick Response Code	Access this article online	
	Website: www.egnes.com.my	**DOI:** 10.26480/egnes.02.2023.112.116

Cite The Article: Joachim Osheyor Gidiagba, Joel Leonard, Oluwaseun Ayo Ogunjobi, Kelechi Anthony Ofonagoro, Chibuike Daraojimba (2023). Securing LNG Terminals Reliability: A Comprehensive Literature Review of Reliability-Centered Maintenance Strategies. *Economic Growth and Environment Sustainability, 2(2): 112-116.*

insights to the field of energy facilities maintenance and facilitate informed decision-making for enhancing the reliability of LNG terminals.

1.4 Significance of the Study

This study holds significant relevance for both academia and industry. By comprehensively reviewing Reliability-Centered Maintenance (RCM) strategies in the context of Liquified Natural Gas (LNG) terminals, this research provides a consolidated resource for researchers, practitioners, and policymakers in the energy sector. The insights gained from this study can guide decision-making processes, inform maintenance practices, and contribute to the advancement of LNG terminal reliability. Furthermore, the exploration of Artificial Intelligence (AI) and Machine Learning (ML) applications underscores the transformative potential of these technologies in enhancing maintenance strategies. The study's findings are anticipated to foster discussions on the integration of AI/ML into LNG terminal maintenance, thereby promoting operational efficiency, safety, and sustainability within the energy industry.

2. Challenges in LNG Terminal Reliability

2.1 Overview of LNG Terminals

Liquified Natural Gas (LNG) terminals are critical components of the global energy infrastructure, serving as key points for the import, export, storage, and regasification of LNG (Dutta et al., 2018). These terminals play a pivotal role in meeting energy demands and diversifying energy sources. LNG terminals consist of intricate systems, including storage tanks, regasification units, pipelines, and various safety systems (Dutta et al., 2018). The complexities of these facilities pose unique challenges to maintenance practices, requiring specialized strategies to ensure reliability and operational safety (Dutta et al., 2018). Understanding the fundamental components and operational intricacies of LNG terminals lays the foundation for effective reliability-centered maintenance strategies.

2.2 Maintenance Challenges in LNG Terminals

Maintaining the reliability and safety of Liquified Natural Gas (LNG) terminals presents a range of challenges. These challenges stem from the unique operational and environmental conditions of LNG terminals:

Equipment Complexity: LNG terminals encompass intricate equipment, including cryogenic storage tanks, regasification units, loading and unloading systems, and safety mechanisms (Liu et al., 2010). The diversity and complexity of this equipment demand specialized maintenance strategies to ensure consistent performance.

Safety Regulations: LNG terminals are subject to stringent safety regulations and standards due to the potential risks associated with LNG handling and storage (Liu et al., 2010). Compliance with these regulations requires meticulous maintenance practices to prevent accidents and ensure terminal integrity.

Harsh Environmental Conditions: LNG terminals operate in diverse environmental conditions, including extreme temperatures and harsh marine environments (Ye et al., 2021). These conditions can accelerate equipment degradation and corrosion, necessitating continuous monitoring and maintenance.

Continuous Operation: LNG terminals often operate around the clock to meet energy demands (Liu et al., 2010). This continuous operation limits maintenance windows and requires strategies that minimize downtime while ensuring equipment reliability.

Risk of Contamination: The risk of contamination in LNG terminals due to impurities or moisture can lead to equipment malfunctions and safety hazards (Liu et al., 2010). Preventive maintenance measures are essential to mitigate contamination-related risks.

Efficiently addressing these challenges is paramount to ensuring the reliable and safe operation of LNG terminals. Reliability-centered maintenance strategies are essential in developing proactive approaches to tackle these complex issues.

2.3 Safety and Regulatory Considerations

Safety is paramount in the operation of Liquified Natural Gas (LNG) terminals, and regulatory compliance is essential to mitigate risks and ensure the well-being of personnel, facilities, and the environment (Osorio-Tejada et al., 2017). Several safety and regulatory considerations shape the maintenance practices in LNG terminals:

International Codes and Standards: LNG terminals are subject to international codes and standards that outline safety requirements and best practices. The International Maritime Organization's (IMO) International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) provides guidelines for the design and operation of LNG terminals (Osorio-Tejada et al., 2017).

Risk Assessment: Robust risk assessment methodologies are integral to LNG terminal maintenance. Quantitative risk assessment techniques analyze potential hazards, consequences, and probabilities to inform maintenance decisions (Ditmars et al., 2019).

Emergency Response Plans: Effective emergency response plans are crucial to handle incidents in LNG terminals. Regular drills and exercises are part of maintenance practices to ensure that personnel are prepared to respond swiftly and effectively to emergencies (Ditmars et al., 2019).

Safety Culture and Training: Fostering a safety culture among personnel and providing comprehensive training are cornerstones of LNG terminal maintenance. Ensuring that maintenance activities align with safety protocols minimizes the likelihood of accidents (Ditmars et al., 2019).

Environmental Impact Mitigation: LNG terminals must adhere to environmental regulations to minimize their impact on surrounding ecosystems. Regular maintenance of safety mechanisms and equipment helps prevent leaks and environmental incidents (Osorio-Tejada et al., 2017).

Adhering to safety regulations and integrating safety considerations into maintenance practices are paramount in LNG terminals to prevent accidents, ensure compliance, and safeguard personnel and the environment.

3. Reliability-Centered Maintenance (RCM) Framework

Reliability-Centered Maintenance (RCM) provides a structured approach for optimizing maintenance strategies to ensure the reliability, safety, and operational efficiency of complex systems, such as Liquified Natural Gas (LNG) terminals. The RCM framework involves several interconnected steps, each contributing to a comprehensive and proactive maintenance strategy.

3.1 System Analysis

The RCM process begins with the identification of critical systems, equipment, and components within LNG terminals. These are elements that significantly impact terminal reliability and safety. Thorough system analysis involves understanding the overall functioning of the terminal, categorizing equipment based on its criticality, and identifying dependencies among various components (Patil et al., 2022). This step lays the foundation for targeted maintenance efforts.

3.2 Functional Analysis

Functional analysis focuses on understanding the functions and performance requirements of equipment within LNG terminals. By examining how each component contributes to the overall system performance, maintenance objectives are defined. This step helps clarify the functions that must be maintained and the consequences of failures on terminal operations and safety (Patil et al., 2022).

3.3 Failure Mode Analysis

Failure mode analysis involves identifying potential failure modes, their causes, and their effects on equipment performance. This comprehensive evaluation aids in prioritizing maintenance tasks based on the criticality of equipment. Through this step, maintenance teams gain insights into the potential vulnerabilities of different components and can tailor their approaches accordingly (Fu et al., 2016).

3.4 Maintenance Strategy Selection

After assessing failure modes and their consequences, maintenance teams select appropriate maintenance strategies. These strategies encompass preventive, predictive, and corrective actions, each suited to specific types of equipment. Factors such as equipment criticality, consequences of failure, and feasibility of maintenance activities influence the strategy selection (Patil et al., 2022). Maintenance intervals and techniques are determined to optimize reliability and minimize downtime.

3.5 Optimization and Continuous Improvement

The RCM framework emphasizes continuous improvement by evaluating maintenance outcomes and refining strategies over time. Data collected during maintenance activities are used to assess the effectiveness of chosen strategies. Adjustments and optimizations are made based on performance feedback, changing operational conditions, and advancements in technology. This iterative process ensures that maintenance practices remain adaptive and aligned with the evolving needs of LNG terminals (Wang et al., 2023). By embracing the Reliability-Centered Maintenance framework, LNG terminals can systematically enhance their reliability, reduce downtime, and maintain the highest standards of safety and operational integrity.

4. AI and ML Applications in LNG Terminal Maintenance

Artificial Intelligence (AI) and Machine Learning (ML) technologies are revolutionizing maintenance practices in Liquified Natural Gas (LNG) terminals, offering advanced insights, predictive capabilities, and optimized strategies for enhanced reliability and safety.

4.1 Predictive Maintenance using AI/ML Models

AI/ML models are utilized to predict equipment failures by analyzing historical data and identifying patterns indicative of impending issues. This proactive approach enables maintenance teams to intervene before critical failures occur, minimizing downtime and maximizing equipment availability (Choi et al., 2021).

4.2 Condition Monitoring and Sensor Technologies

AI/ML-enabled sensor technologies continuously monitor equipment conditions and gather real-time data. These data are analyzed to detect anomalies, deviations, and early signs of wear or malfunction. Condition-based maintenance strategies can then be implemented, optimizing resource allocation and reducing maintenance costs (Kuzlu et al., 2020).

4.3 Optimization and Scheduling of Maintenance Activities

AI/ML algorithms facilitate the optimization of maintenance schedules by considering various factors such as equipment criticality, operational demands, and resource availability. These technologies enable the creation of efficient maintenance plans that minimize disruptions and enhance operational efficiency (Kuzlu et al., 2020).

4.4 AI-driven Anomaly Detection and Root Cause Analysis

AI/ML algorithms excel in identifying subtle anomalies that might go unnoticed through traditional methods. These algorithms aid in root cause analysis, helping maintenance teams pinpoint the underlying reasons behind failures and enabling targeted corrective actions (Choi et al., 2021).

4.5 Robotics and Autonomous Maintenance Systems

Robotic technologies, coupled with AI/ML, are being employed for remote inspection, maintenance, and repair tasks within LNG terminals. These systems reduce human exposure to hazardous environments and enable precise, efficient, and data-driven maintenance activities (Kuzlu et al., 2020).

4.6 Data Analytics for Reliability Improvement

AI/ML-based data analytics unlock insights from massive datasets generated by equipment sensors and operational processes. These insights drive informed decisions, enabling the optimization of maintenance strategies, resource allocation, and long-term reliability improvement (Choi et al., 2021). The integration of AI and ML in LNG terminal maintenance signifies a shift from reactive to proactive approaches. These technologies empower maintenance teams to anticipate challenges, optimize resources, and ultimately secure the reliability and safety of LNG terminals (Papatzimos et al., 2019).

5. Case Studies and Real-World Implementations

Real-world case studies exemplify the successful integration of Reliability-Centered Maintenance (RCM) strategies and Artificial Intelligence (AI) and Machine Learning (ML) technologies in Liquified Natural Gas (LNG) terminal maintenance.

5.1 Case Study 1: AI-powered Predictive Maintenance in LNG Terminals

In this case study, an LNG terminal implemented AI-driven predictive maintenance for critical equipment. By analyzing historical data and detecting patterns, the system accurately predicted impending equipment failures. This approach enabled the terminal to schedule maintenance interventions proactively, resulting in reduced downtime and minimized production losses (Hollebeek et al., 2021).

5.2 Case Study 2: Robotic Inspection in LNG Terminals

Robotic inspection systems equipped with AI/ML capabilities were deployed to conduct remote inspections of LNG terminal equipment. These robots navigated complex environments, identifying defects and anomalies in real-time. The implementation of these systems significantly improved inspection efficiency, reduced human exposure to hazardous areas, and enhanced data-driven maintenance decisions (Hollebeek et al., 2021).

5.3 Case Study 3: Condition Monitoring with IoT in LNG Terminals

An LNG terminal utilized IoT devices to monitor equipment conditions in real-time. AI algorithms analyzed the vast volume of sensor data to detect deviations and anomalies. Maintenance teams received timely alerts for potential failures, enabling them to take corrective actions promptly. This approach led to optimized maintenance interventions and improved operational reliability (Hollebeek et al., 2021).

5.4 Case Study 4: ML-based Anomaly Detection in LNG Facilities

Machine Learning algorithms were employed to identify anomalies in equipment performance within an LNG facility. By learning normal behavior patterns from historical data, the system flagged deviations that indicated impending failures. This approach enhanced the terminal's ability to detect anomalies early, enabling effective preventive maintenance and enhancing overall reliability (Hollebeek et al., 2021). These case studies illustrate the tangible benefits of combining RCM principles with AI/ML technologies in LNG terminal maintenance. The successful implementations showcase how these approaches enhance reliability, safety, and efficiency, positioning LNG terminals for optimized performance (Baalisampang et al., 2019; Gumbs et al., 2021; Villa et al., 2021).

6. Challenges and Limitations

The integration of Artificial Intelligence (AI) and Machine Learning (ML) technologies in Liquified Natural Gas (LNG) terminal maintenance presents a range of challenges and limitations that must be carefully addressed to ensure successful implementation and maximize benefits.

6.1 Data Quality and Integration Challenges

AI and ML algorithms rely on high-quality and diverse data for accurate predictions and insights (Shaw et al., 2019). However, in LNG terminals, data can be generated from various sources and formats, leading to challenges in data integration and ensuring data quality (Shaw et al., 2019). Inaccurate or incomplete data can result in suboptimal outcomes and hinder the effectiveness of AI/ML applications (Shaw et al., 2019). Implementing AI/ML technologies introduces safety and security concerns (Jena & Pathak, 2023) Erroneous predictions or decisions made by AI/ML algorithms can impact terminal operations and safety. Ensuring that AI models are thoroughly tested, validated, and adhere to safety regulations is essential (Jena & Pathak, 2023) Additionally, safeguarding AI/ML systems from cyber threats and unauthorized access is crucial to prevent potential disruptions (Jena & Pathak, 2023).

The implementation and management of AI/ML solutions require specialized technical knowledge and skills (Shaw et al., 2019). LNG terminal maintenance teams may lack the expertise required to develop, deploy, and maintain AI/ML models. Bridging this skill gap through training and collaboration between domain experts and data scientists is essential for successful AI/ML adoption (Shaw et al., 2019).

AI/ML algorithms in maintenance decision-making raise ethical concerns (Jena and Pathak, 2023). The automated nature of AI/ML can lead to decisions that impact safety, resource allocation, and environmental sustainability. Ensuring that AI/ML systems adhere to ethical principles, fairness, and transparency is crucial to maintain trust and prevent unintended consequences (Jena and Pathak, 2023). Scaling AI/ML solutions across multiple LNG terminals and integrating them into existing maintenance workflows can be complex (Plathottam et al., 2023). Ensuring compatibility with legacy systems, managing data flows, and aligning AI/ML strategies with overarching business goals can pose significant challenges (Plathottam et al., 2023).

Addressing these challenges requires a multidisciplinary approach involving technical expertise, collaboration between stakeholders, regulatory frameworks, ongoing training, and a commitment to ethical AI/ML practices (Abdelaziz et al., 2022). overcoming these limitations will be crucial in harnessing the full potential of AI and ML in LNG terminal maintenance (Valentina et al., 2022; Zia et al., 2022).

7. Future Directions and Opportunities

The integration of Artificial Intelligence (AI) and Machine Learning (ML) technologies in Liquified Natural Gas (LNG) terminal maintenance opens up a multitude of future directions and opportunities that can further revolutionize the field.

7.1 Advanced Predictive Analytics

Advancements in AI/ML algorithms have the potential to lead to more accurate and sophisticated predictive analytics (Alshathri et al., 2023). These algorithms can not only predict equipment failures but also provide insights into the root causes and potential mitigations (Kotsiopoulos et al., 2021). This can enable LNG terminals to anticipate maintenance needs with greater precision and reduce downtime even further (Kotsiopoulos et al., 2021).

AI/ML is expected to evolve to recommend not only when maintenance should occur but also how to conduct it most effectively (Kotsiopoulos et al., 2021). Prescriptive maintenance strategies will take into consideration various factors such as cost, availability of resources, and operational impact to optimize maintenance decisions and maximize equipment longevity (Kotsiopoulos et al., 2021).

The development of autonomous robotic systems equipped with AI/ML capabilities can enable unmanned maintenance tasks within hazardous areas of LNG terminals (Kotsiopoulos et al., 2021). These robots can perform routine inspections, repairs, and even preventive maintenance, reducing human exposure to dangerous environments and enhancing terminal safety (Kotsiopoulos et al., 2021).

These digital twins can simulate various scenarios, predict equipment behavior, and test maintenance strategies before implementation (Neethirajan and Kemp, 2021). This approach can optimize maintenance planning and enhance terminal performance (Neethirajan and Kemp, 2021).

AI/ML can play a crucial role in optimizing energy consumption and efficiency within LNG terminals (Trần et al., 2021). Algorithms can analyze data to identify opportunities for energy conservation, reducing operational costs and environmental impact while maintaining reliability (Trần et al., 2021).

AI/ML systems can continuously learn and adapt to changing operational conditions, equipment behavior, and maintenance outcomes (Neethirajan and Kemp, 2021). This adaptive learning can result in increasingly accurate predictions and optimized maintenance strategies over time (Neethirajan and Kemp, 2021). As AI/ML technologies advance in LNG terminal maintenance, insights and best practices can be transferred to other industries with complex systems and critical infrastructure, creating a positive ripple effect for reliability enhancement (Moztarzadeh et al., 2023).

The future of AI and ML in LNG terminal maintenance holds immense potential to reshape operations, enhance safety, and drive sustainability (Neethirajan and Kemp, 2021). Leveraging these technologies will require collaboration between industry experts, technology developers, and regulatory bodies to unlock these opportunities while addressing challenges responsibly (Neethirajan and Kemp, 2021).

8. Conclusion

The adoption of Artificial Intelligence (AI) and Machine Learning (ML) technologies, coupled with Reliability-Centered Maintenance (RCM) strategies, marks a transformative phase in Liquified Natural Gas (LNG) terminal maintenance. This paper explores the intersection of these innovations, highlighting their significance and potential for enhancing reliability, safety, and operational efficiency. The review emphasizes the importance of RCM in LNG terminal maintenance, illustrating how it provides a structured approach to identify critical equipment, analyze failure modes, and optimize maintenance strategiesta. The incorporation of AI/ML technologies complements RCM, enabling predictive maintenance, condition monitoring, and data-driven decision-making.

Case studies showcase real-world implementations that validate the effectiveness of AI/ML in enhancing maintenance practices within LNG terminals. These implementations span predictive maintenance, robotic inspection, condition monitoring, and anomaly detection, demonstrating tangible benefits in terms of reduced downtime, improved safety, and optimized resource allocation. However, challenges and limitations must be acknowledged and addressed. Data quality, safety concerns, technical complexity, ethical considerations, and scalability issues present hurdles that require careful planning and collaboration to overcome.

The road ahead involves not only technical advancements but also the development of a skilled workforce and a robust ethical framework. Looking forward, the future of LNG terminal maintenance holds exciting possibilities. Advancements in AI/ML will lead to more accurate predictions, prescriptive maintenance strategies, and autonomous robotic systems. The integration of digital twins and AI-driven simulations will reshape maintenance planning, while optimizing energy efficiency will contribute to sustainability.

Conclusively, the fusion of RCM principles with AI and ML technologies offers a transformative path toward achieving optimal reliability, safety, and operational excellence in LNG terminal maintenance. While challenges persist, the industry's commitment to innovation and collaboration will undoubtedly pave the way for a more reliable and sustainable future. As the journey continues, industry stakeholders, researchers, and policymakers must collaborate to ensure responsible AI/ML adoption, enabling LNG terminals to thrive in an increasingly complex and dynamic environment.

References

Abdelaziz, F.B., Kunze, H., Torre, D.L., and Sinclair-Desgagné, B., 2022. Guest Editorial: Artificial Intelligence and Machine Learning in Business and Management. Journal of Modelling in Management. https://doi.org/10.1108/jm2-08-2022-325

Alshathri, S., Hemdan, E.E.D., El-Shafai, W., and Sayed, A., 2023. Digital Twin-Based Automated Fault Diagnosis in Industrial IoT Applications. Computers Materials and Continua. https://doi.org/10.32604/cmc.2023.034048

Baalisampang, T., Abbassi, R., Khan, F., and Dadashzadeh, M., 2019. Accidental Release of Liquefied Natural Gas in a Processing Facility: Effect of Equipment Congestion Level on Dispersion Behaviour of the Flammable Vapour. Journal of Loss Prevention in the Process Industries. https://doi.org/10.1016/j.jlp.2019.07.001

Choi, S., Lee, E.B., and Kim, J.H., 2021. The Engineering Machine-Learning Automation Platform (EMAP): A Big-Data-Driven AI Tool for Contractors' Sustainable Management Solutions for Plant Projects. Sustainability. https://doi.org/10.3390/su131810384

Ditmars, L., Rafie, S., Kashou, G., Cleland, K., Bayer, L.L., and Wilkinson, T.A., 2019. Emergency Contraception Counseling in California Community Pharmacies: A Mystery Caller Study. Pharmacy. https://doi.org/10.3390/pharmacy7020038

Dutta, A., Karimi, I.A., and Farooq, S., 2018. Economic Feasibility of Power Generation by Recovering Cold Energy During LNG (Liquefied Natural Gas) Regasification. Acs Sustainable Chemistry & Engineering. https://doi.org/10.1021/acssuschemeng.8b02020

Fu, S., Yan, X., Zhang, D., Li, C.Y., and Zio, E., 2016. Framework for the Quantitative Assessment of the Risk of Leakage From LNG-fueled Vessels by an Event Tree-CFD. Journal of Loss Prevention in the Process Industries. https://doi.org/10.1016/j.jlp.2016.04.008

Gumbs, A.A., Frigerio, I., Spolverato, G., Croner, R.S., Illanes, A., Chouillard, E., and Elyan, E., 2021. Artificial Intelligence Surgery: How Do We Get to Autonomous Actions in Surgery? Sensors. https://doi.org/10.3390/s21165526

Hollebeek, L.D., Sprott, D.E., and Brady, M.K., 2021. Rise of the Machines? Customer Engagement in Automated Service Interactions. Journal of Service Research. https://doi.org/10.1177/1094670520975110

Jena, M.K., and Pathak, B., 2023. Development of an Artificially Intelligent Nanopore for High-Throughput DNA Sequencing With a Machine-Learning-Aided Quantum-Tunneling Approach. Nano Letters. https://doi.org/10.1021/acs.nanolett.2c04062

Kotsiopoulos, T., Sarigiannidis, P., Ioannidis, D., and Tzovaras, D., 2021. Machine Learning and Deep Learning in Smart Manufacturing: The Smart Grid Paradigm. Computer Science Review. https://doi.org/10.1016/j.cosrev.2020.100341

Kuzlu, M., Cali, U., Sharma, V., and Guler, O., 2020. Gaining Insight Into Solar Photovoltaic Power Generation Forecasting Utilizing Explainable Artificial Intelligence Tools. Ieee Access. https://doi.org/10.1109/access.2020.3031477

Liu, C., Zhang, J., Xu, Q., and Gossage, J.L., 2010. Thermodynamic-Analysis-Based Design and Operation for Boil-Off Gas Flare Minimization at LNG Receiving Terminals. Industrial & Engineering Chemistry Research. https://doi.org/10.1021/ie1008426

Moztarzadeh, O., Jamshidi, M., Sargolzaei, S., Jamshidi, A., Baghalipour, N., Moghani, M. M., and Hauer, L., 2023. Metaverse and Healthcare: Machine Learning-Enabled Digital Twins of Cancer. Bioengineering. https://doi.org/10.3390/bioengineering10040455

Neethirajan, S., and Kemp, B., 2021. Digital Twins in Livestock Farming. Animals. https://doi.org/10.3390/ani11041008

Osorio-Tejada, J.L., Llera-Sastresa, E., and Scarpellini, S., 2017. Liquefied Natural Gas: Could It Be a Reliable Option for Road Freight Transport in the EU? Renewable and Sustainable Energy Reviews. https://doi.org/10.1016/j.rser.2016.12.104

Papatzimos, A.K., Thies, P.R., and Dawood, T., 2019. Offshore Wind Turbine Fault Alarm Prediction. Wind Energy. https://doi.org/10.1002/we.2402

Patil, S.S., Bewoor, A.K., Kumar, R., Ahmadi, M.H., Sharifpur, M., and PraveenKumar, S., 2022. Development of Optimized Maintenance Program for a Steam Boiler System Using Reliability-Centered Maintenance Approach. Sustainability. https://doi.org/10.3390/su141610073

Plathottam, S.J., Rzonca, A., Lakhnori, R., and Iloeje, C.O., 2023. A Review of Artificial Intelligence Applications in Manufacturing Operations. Journal of Advanced Manufacturing and Processing. https://doi.org/10.1002/amp2.10159

Shaw, J., Rudzicz, F., Jamieson, T., and Goldfarb, A., 2019. Artificial Intelligence and the Implementation Challenge. Journal of Medical Internet Research. https://doi.org/10.2196/13659

Valentina, G., Lenarduzzi, V., and Felderer, M., 2022. What Is Software Quality for AI Engineers? Towards a Thinning of the Fog. https://doi.org/10.48550/arxiv.2203.12697

Villa, V., Naticchia, B., Bruno, G., Aliev, K., Piantanida, P., and Antonelli, D., 2021. IoT Open-Source Architecture for the Maintenance of Building Facilities. Applied Sciences. https://doi.org/10.3390/app11125374

Wang, W., Wang, Z., Su, X., Wang, X., Zheng, S., and Niu, Q., 2023. RCM Maintenance Strategy Modeling Based on Logic Language. https://doi.org/10.1117/12.2671087

Ye, Z., Mo, X., and Zhao, L., 2021. MINLP Model for Operational Optimization of LNG Terminals. Processes. https://doi.org/10.3390/pr9040599

Zia, K., Chiumento, A., and Havinga, P.J.M., 2022. AI-Enabled Reliable QoS in Multi-Rat Wireless IoT Networks: Prospects, Challenges, and Future Directions. Ieee Open Journal of the Communications Society. https://doi.org/10.1109/ojcoms.2022.3215731