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Towards Net-Zero Manufacturing: Integrating AI and Robotics for Carbon-Neutral Smart Factories

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Abstract: Integrating AI and robotics in manufacturing propels net-zero carbon emissions goal and sustainable production. These technologies can enhance carbon reduction efforts in manufacturing organizations due to the contribution of green innovation. This paper aims to examine the transformational power of AI-enhanced manufacturing robotics such as collaborative robots, predictive maintenance, and computer vision for quality inspection for net-zero manufacturing and carbon-neutral smart industries. The study employs empirical findings and case studies to support the argument that emerging trends like edge computing, digital twins, and reinforcement learning are fundamental for virtual simulations while intelligent factories use robotics, AI, and IoT to foster responsive factories. The advancements in AI and robotics are essential for achieving the net-zero carbon emission targets established by the Paris Agreement on climate change.

Keywords: *Net-Zero Manufacturing, Artificial Intelligence, Robotics, Carbon-Neutral Smart Factories, Green Manufacturing.*

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I. INTRODUCTION

Recent studies pinpoint the role of artificial intelligence (AI) and robotics in carbon emission reduction in manufacturing. These applications facilitate short- and long-term carbon neutralization while emphasizing the significance of AI and robotic technologies investments for sustainability [1]. In research on China's industrial sectors, intelligent manufacturing plays a massive role in inhibiting CO2 emissions, especially in industries with higher intelligence levels and carbon emissions [2, 3, 4]. Reduced emission is achieved through improved energy use efficiency and decreased fossil energy consumption in manufacturing.

Meanwhile, climate change urgency and industrial carbon footprints have been recognized as critical global concerns based on findings that industries contribute enormously to greenhouse gas emissions, prompting urgent action to reduce impacts on the environment [5]. Similarly, energy efficiency in industrial processes is critical for emissions reduction and promoting sustainability. Transiting to renewable energy sources and low-carbon technologies can improve environmental quality, while carbon footprint calculation and management through industrial lifecycles is required for sustainable development [6]. Therefore, climate goals can be achieved by implementing long-term policies, disintegrating energy demand from economic growth, and applying radical innovations via industrial sectors.

[7] wrote that one of the challenges of traditional manufacturing is transformation to smart factories, integrating advanced technologies like IoT, AI, and robotics for higher productivity and efficiency. Key obstacles like workforce upskilling, high investment requirements, and data security challenges exist. More so, green manufacturing grapples with safety management as a result of stringent regulations and hazardous chemicals [8]. Integrating AI also presents challenges in dynamic risk assessment, knowledge acquisition, and data fusion. Nonetheless, AI provides opportunities for resilience, improved precision, and

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personalized production [9] by optimizing workforce and energy requirements through data analytics, interconnected machines, and advanced robotics.

➢ *Aim and Objectives*

The aim of this research is to examine the role of artificial intelligence (AI) and robotics technologies in transforming manufacturing toward carbon neutrality and net-zero emissions.

The objectives are:

- To assess the contribution of AI and robotics to reduce carbon emissions in manufacturing processes
- To examine the impact of emerging industry 4.0 technologies on energy optimization and waste reduction
- To assess the challenges and opportunities in shifting from traditional to AI-driven smart factories for sustainable manufacturing
- To propose technological and policy recommendations for fast-tracking net-zero manufacturing according to global climate goals

The study is significant for its alignment with key United Nations Sustainable Development Goals (SDGs) like SDG 9 (industry, innovation, and infrastructure), SDG 12 (responsible consumption and production), and SDG 13 (climate action). According to [10], Industry 4.0 emphasizes the significance of AI and robotics to smart industrialization, facilitating sustainable infrastructure using data-driven optimization and automation. [11] report highlights the potential of smart factories and robotic automation to lower material waste for sustainable consumption trends, while AI-enhanced energy management also exists to reduce CO_2 emissions in manufacturing [12] [13].

II. LITERATURE REVIEW

A. Current Trends in Net-Zero Manufacturing

There is a growing focus on the adoption of net-zero emissions in manufacturing supply chains. According to [14], key drivers generally include economic, technological, and environmental factors. Additionally, polymer-based smart materials are considered a viable solution for sustainable manufacturing by leveraging efficiency-enhancing and waste-reduction properties [15].

Integrating Carbon Capture Technology (CCT) and Life Cycle Assessment (LCA) is required for achieving net-zero goals where emission reduction and energy management are identified as chief enablers. [16] also observed that circular economy practices can foster net-zero manufacturing, especially in developing countries with key factors including consumer awareness, government policies, and economic incentives.

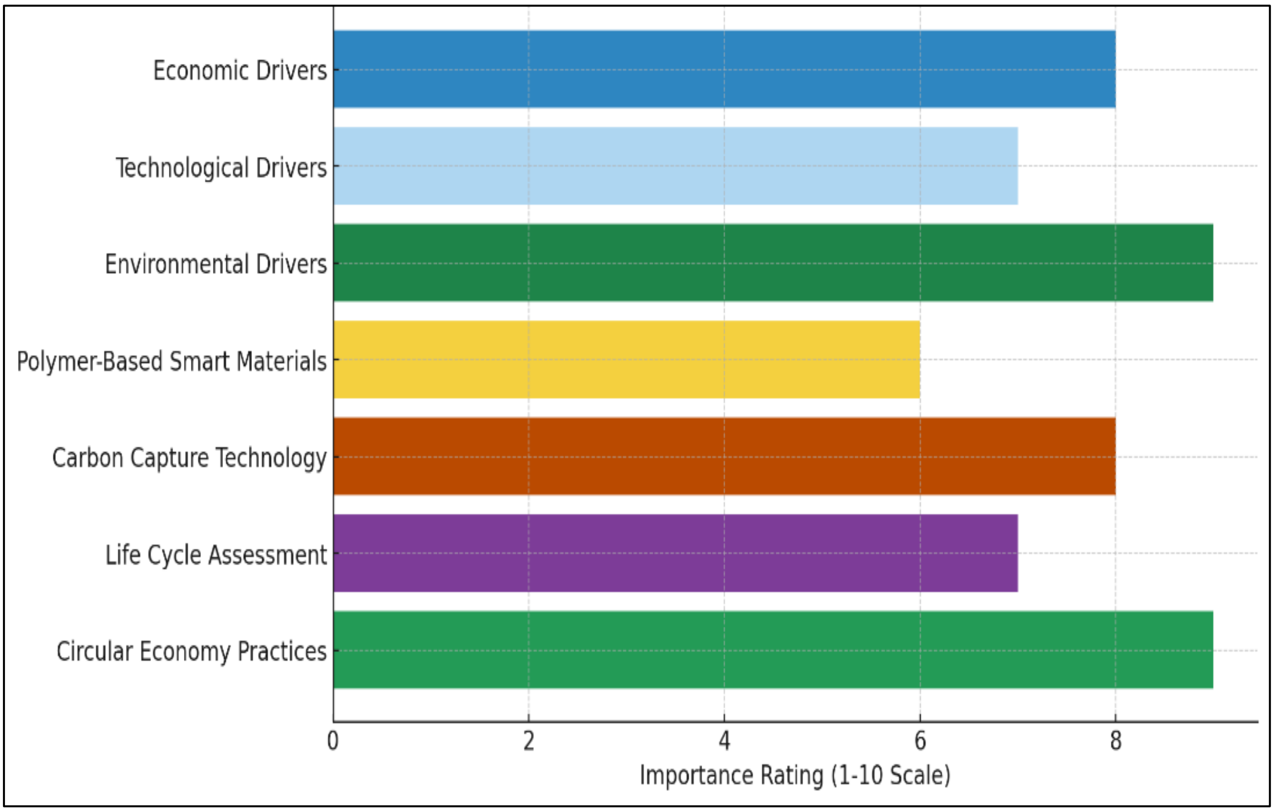

Fig 1: Key Trends and Enablers for Net-Zero Manufacturing Supply Chains

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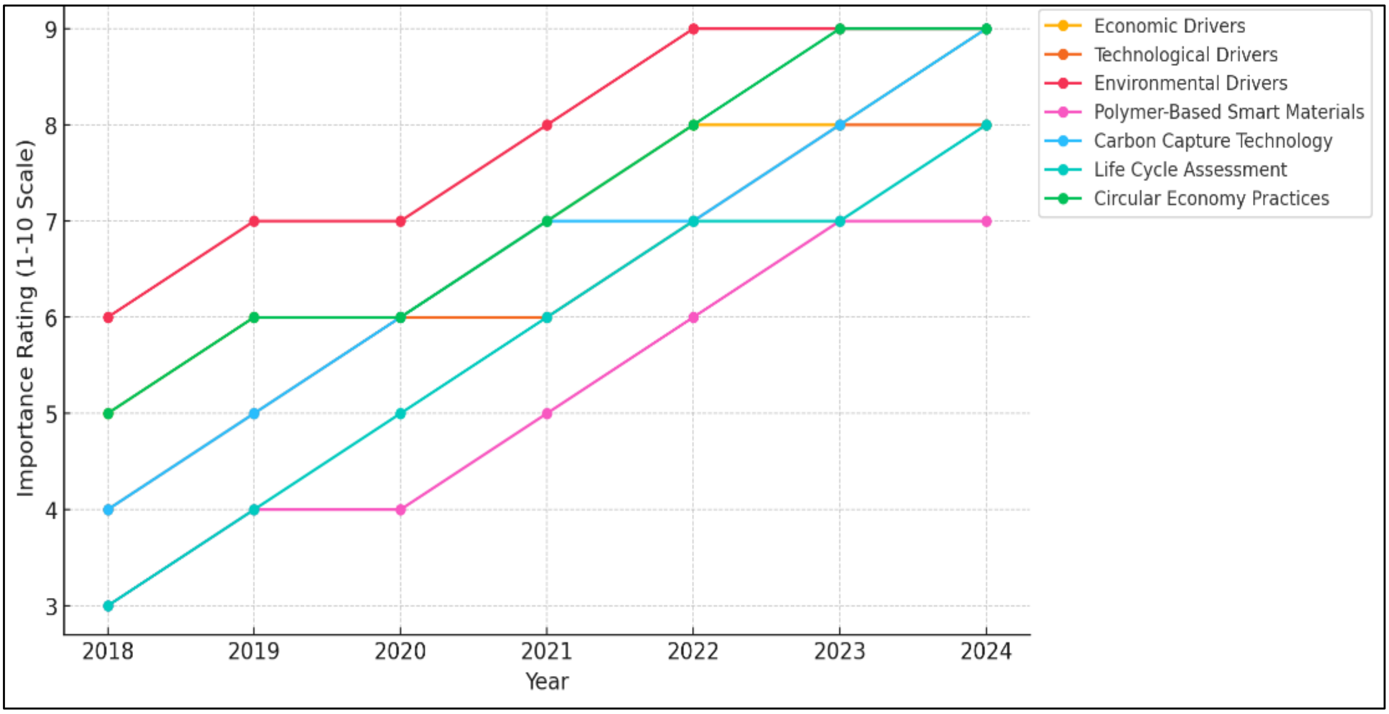

Fig 2: Net-Zero Manufacturing Trends (2018-2024).

B. AI Applications for Carbon-Neutral Smart Factories

Artificial intelligence (AI) and robotics are essential for achieving net-zero manufacturing through supply chain process optimization, waste reduction, and enhancement of environmental sustainability [17]. These advanced technologies in manufacturing firms help to reduce carbon emissions as green innovation strengthens the effect [18]. The AI-robotics synergy in Industry 4.0 results in predictive maintenance, increased automation, optimized operations, and collaborative robotics. Similarly, AI-driven manufacturing robotics use machine learning (ML) for computer vision for high-quality inspection and predictive maintenance [19, 20].

Artificial intelligence is transforming conventional approaches to strategic operations, creativity, and problem-solving in the energy sector, especially to accelerate carbon neutrality [21, 22]. In renewable energy systems, these technologies are used to improve solar power forecasting, smart controls, analyzing uncertainty, and detecting fault [23]. Besides, transitioning to carbon-neutral electricity poses major challenges in grid planning and operation, and artificial intelligence can contribute transformative impact by addressing machine learning tasks and other decision-making processes [24]

C. Robotics in Waste Reduction and Precision Automation

Robotics and automation are applied in precision agriculture and waste management practices for higher efficiency and sustainability. [19] noted that robots are used for sorting waste while they are also effective for nuclear waste management in the UK. Moreover, post-disaster waste management can take advantage of the potential of robotics, although they are constrained by funding constraints and expertise challenges. Robotics and automation in agriculture serves multiple purposes such as planting, spraying, inspection, and harvesting, to mitigate environmental impact and maximize productivity [25, 26]. Integrating AI and mobile apps also helps to provide scalable solutions for African cities experiencing rapid urbanization [27].

III. ANALYSIS, CASE STUDIES, & DISCUSSION

A. Energy Savings from AI Adoption

Employing AI in manufacturing has proven the capability to ensure substantial efficiency enhancement and energy savings. Experts have identified how AI can reduce electrical consumption by at least 20% in smart households and the manufacturing sector [28]. Using industrial robots has also contributed to higher energy efficiency in Chinese manufacturing companies through technological advancement [29]. With AI-driven data analytics capable of enhancing productivity, worker safety, and product quality in manufacturing, manufacturers can leverage AI-intensive demand forecasting for optimal energy consumption and higher sustainability [30].

Other benefits such as improved forecast accuracy, economic efficiency, and sustainability are obtainable through advanced ML algorithms and real-time data [31]. In a study by [28], the use of AI contributes to a 25% reduction in carbon emissions in the manufacturing sector, highlighting the potential of artificial intelligence to foster sustainability and energy efficiency in manufacturing. Meanwhile, limitations such as the scope of AI implementation and its constraints by data availability, the complexity of manufacturing systems, and the need for specialized and expert training are common challenges. In essence, challenges remain in leveraging the technology for high-level processes and data dependencies in manufacturing [32].

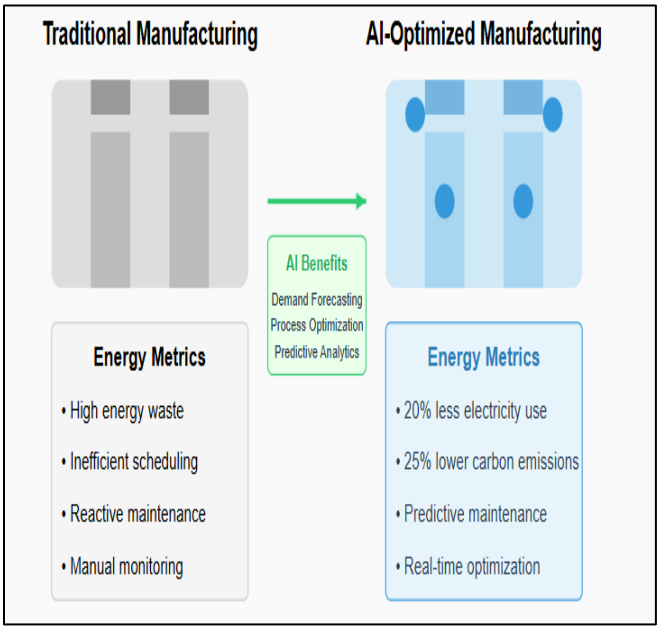

Fig 3: AI-Powered Manufacturing Energy Efficiency Comparison: Pre-AI vs AI-Enhanced Manufacturing Processes [28].

B. *Case Studies*

➢ *AI-Driven Energy Management at Siemens Amberg Electronics Plant*

The Germany-based Electronics Plant is the benchmark for energy optimization in smart manufacturing. Siemens' facility implemented an AI-powered system known as Energy Manager integrates machine learning algorithms to predict energy demand patterns at 95% accuracy, real-time Internet of Things (IoT) sensors monitoring gas, compressed air usage, and electricity for more than 1000 machines, and adaptive control systems for automated adjustment of production schedules and machine parameters during periods of peak tariff [33].

In an analysis, the integration of AI-driven energy management contributed 19% reduction in annual energy consumption, a 23% reduction in carbon emissions (8,400 tons CO_2 e/year), and a 5.2% improvement in the effectiveness of the equipment. Similarly, the system's neural networks undergo continuous learning from production data to attain closed-loop energy intelligence, demonstrating the potential of AI to transform conventional energy management into active optimization.

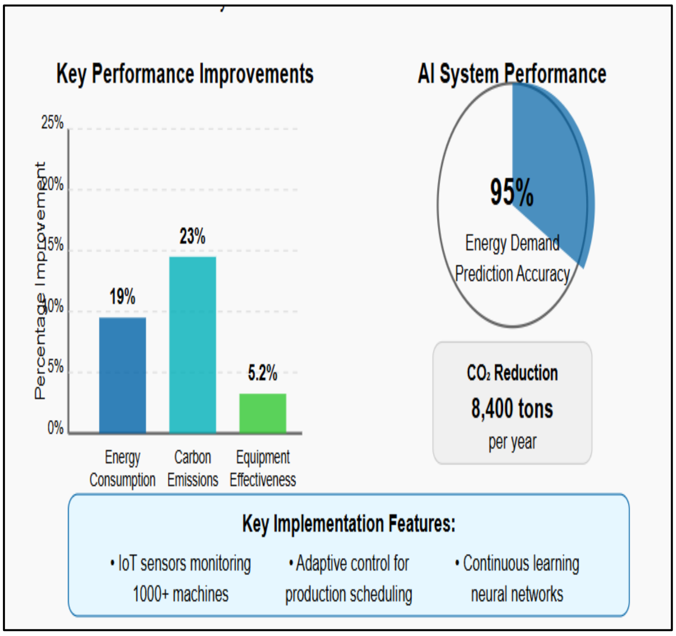

Fig 4: Siemens' AI-Driven Energy Management Outcomes [Germany-Based Electronics Plant Performance Metrics] [34].

➢ *Robotics for Circular Production at Schneider Electric's Le Vaudreuil Factory*

There is evidence of robotic circular production at France-based Schneider Electric's Zero Waste to Landfill factory. Using an integrated system, the company used computer vision-guided sorting, identifying reusable components at the rate of 0.8 seconds/item. In addition, AI-powered quality control helped to achieve 92% recovery of materials for virgin-grade standards, while ABB YuMi collaborative robots disassemble products returned to the company with a 99.7% recovery accuracy [35]. Peer-reviewed research highlights the creation of 12 novel circular economy jobs for every production line, a 76% reduction in carbon footprint versus traditional linear production, and an 89% decrease in consumption of raw materials using robotic remanufacturing and reengineering.

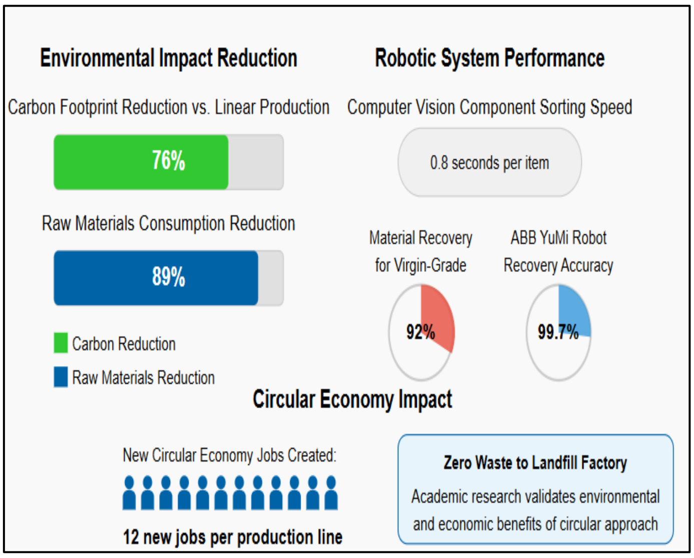

Fig 5: Schneider Electric Circular Production Outcomes: Le Vaudreuil Factory Zero Waste Initiative Results [36]

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These case studies derive from industry whitepapers with academic underpinning as evidence of AI and robotics for net-zero manufacturing transformations.

IV. DISCUSSION

The synergy between AI and robotics is enhancing automation, human-AI collaboration, and transforming industries [37] [38]. The integration is especially significant in the Fourth Industrial Revolution and relevant applications such as predictive maintenance, manufacturing processes, and supply chain operations. However, its development and deployment must consider sustainability to address different impacts on society [39]. According to [40], sustainable AI practices are vital for realizing the potential of the technology while mitigating and addressing the impacts of challenges like workforce displacement. The AI-sustainability intersection has significant implications for businesses, governments, environments, and the planet to accelerate the UN Sustainable Development Goals and address ethical factors while implementing best practices for optimal benefits [41] [37].

Meanwhile, such integration is not devoid of challenges. [42] noted that high advanced costs of software, hardware, and infrastructure are significant obstacles. Investment in education and training to develop the requisite expertise is driven by skill gaps in the employment domain. Similarly, there are likely interoperability issues due to various communication platforms and protocols, which hinder viable inter-system communication and data exchange which can be addressed by adopting a suitable framework for interoperability in the Fourth Industrial Revolution, comprising integration design, smart industrial infrastructure, data management, and communication protocols [43, 44].

Furthermore, carbon-neutral policies can impact human skills and tangible resources in the modern-day manufacturing environment, promoting operational performance and enhancing carbon-neutral potentials [45, 46]. Shifting to a low-carbon economy can be accelerated by leveraging AI-driven cyber-physical systems to manage complex electrified systems [47]. Therefore, against the backdrop of persisting challenges, policymakers should support research and development, implement carbon pricing, and develop emissions standards that industries must adhere to [48].

V. CONCLUSION & FUTURE DIRECTIONS

This study has examined the transformative potential of AI and robotics in achieving net-zero manufacturing. Our exploration indicates that these technologies enable significant reductions in carbon emissions as case studies show decreases of up to 23% in carbon outputs alongside 19% reductions in energy usage. The examples from Siemens and Schneider Electric demonstrate how AI-driven energy management combined with robotic circular production achieves substantial environmental benefits together with enhanced operational efficiency.

Even with obstacles such as high investment costs, skill gaps, and interoperability issues, the advantages reach beyond sustainability to include enhanced productivity worker safety, and product quality.

However, there is a need for enhanced collaboration between technology developers, manufacturing industries, academic institutions, and government agencies to speed up carbon-neutral production technology implementation. Research and development efforts in green robotics must also focus on creating energy-efficient robots with advanced materials and energy recovery systems while integrating circular design principles for robotic systems alongside AI-powered real-time lifecycle assessment tools and optimized human-AI-robot collaborative frameworks supported by open standards for sustainable manufacturing interoperability.

These efforts require government support through specific financial allocations, tax benefits, and regulatory structures. The manufacturing sector faces mounting pressure to meet climate targets by hastening its transition to carbon neutrality through ongoing investment, joint innovation efforts, and intersectoral collaborations.

➢ *Authors' Contributions*

- Babatunde I. Keshinro conceptualized the study framework and conducted the primary research on AI-powered energy optimization models in manufacturing.
- Ibrahim A. Ogundeko contributed to the literature review and provided industrial insights building insulation practices.
- Odetoran Akinrotimi assisted with data curation and case study analysis, especially regarding predictive maintenance and robotics.
- Victor O. Hammed led the overall manuscript development, coordinated the integration of robotics for carbon-neutral solutions, and supervised the research direction.
- Cosby O. Oni analyzed environmental dynamics and contributed to the discussion on AI integration in smart factories and circular production.
- Oluyinka J. Adedokun offered expertise in systems engineering and reviewed the technical aspects of AI and digital twin deployment for smart manufacturing.

REFERENCES

[1]. Y. Shang, Q. Yang, Y. Pu and F. Taghizadeh-Hesary, "Employing Artificial Intelligence and Enhancing Resource Efficiency to Achieve Carbon Neutrality," Resources Policy, 2024.

[2]. H. Lv, B. Shi, N. Li and R. Kang, "Intelligent Manufacturing and Carbon Emissions Reduction: Evidence from the Use of Industrial Robots in China," International Journal of Environmental Research and Public Health, vol. 19, 2022.

[3]. M. Azeez, C. T. Nenebi, V. Hammed, L. K. Asiam and E. James, "Developing Intelligent Cyberthreat Detection Systems Through Quantum Computing," International Journal of Science and Research Archive, vol. 12, no. 2, pp. 1297-1307, 2024.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25may028

[4]. T. S. Lawrence, P. Oyirinnaya and A. A. Adesola, "The Crucial Role of Artificial Intelligence in Fintech for Suptech and Regtech Supervision in Banking and Financial Organizations," International Journal of Artificial Intelligence Research and Development (IJAIRD), vol. 3, no. 1, pp. 38-50, 2025.

[5]. M. Bargavi, B. Saraswat, P. Naval and K. S. Kulhar, "Industrial Energy Efficiency and Climate Change Mitigation in Smart Cities: A Comprehensive Review," in 1st International Conference on Power and Energy Systems, 2024.

[6]. R. Alvarez, S. Z. Minguez and R. Martinez, "Carbon Footprint and the Industrial Life Cycle: From Urban Planning to Recycling," 2017.

[7]. K. Musaeva, I. Vyachina and M. Aliyeva, "Smart Factories and Their Impact on Modern Manufacturing Enterprises: Prospects and Challenges in the Era of the Digital Economy," E3S Web of Conferences , 2024.

[8]. S. Mao, B. Wang, Y. Tang and F. Qian, "Opportunities and Challenges of Artificial Intelligence for Green Manufacturing in the Process Industry," Engineering, 2019.

[9]. Kovalenko, K. Barton, J. R. Moyne and D. M. Tilbury, "Opportunities and Challenges to Integrate Artificial Intelligence Into Manufacturing Systems: Thoughts from a Panel Discussion [Opinion]," IEEE Robotics & Automation Magazine, pp. 109-112, 2023.

[10]. K. Schwab, "The Fourth Industrial Revolution," Crown Business, 2017.

[11]. UNEP, "Sustainable Manufacturing and Industry 4.0. United Nations," UNEP, 2021. [Online]. Available: https://www.unep.org. [Accessed 1 April 2025].

[12]. Y. Zhang, X. Li and Q. Wang, "Artificial Intelligence for Carbon-Neutral Manufacturing: Evidence from China's Industrial Sector," Journal of Cleaner Production, p. 278, 2021.

[13]. E. Chanson, C. Nwakile and V. O. Hammed, "Carbon Capture, Utilization, and Storage (CCUS) Technologies: Evaluating the Effectiveness of Advanced CCUS Solutions for Reducing CO2 Emissions," Results in Surfaces and Interfaces, 2024.

[14]. Yadav, A. Sachdeva, R. K. Garg, K. M. Qureshi, B. G. Mewada, M. R. Qureshi and M. Mansour, "Assessing Drivers Influencing Net-Zero Emission Adoption in Manufacturing Supply Chain: A Hybrid ANN-Fuzzy ISM Approach," Sustainability, vol. 16, no. 17, 2024.

[15]. K. M. Qureshi, A. Yadav, R. K. Garg, A. K. Sachdeva, A. Abdulrahman, S. Y. Alghamdi and M. R. Qureshi, "Are Polymer-Based Smart Materials Unlocking the Path to Sustainable Manufacturing for a Net-Zero Economy? Current Trends and Potential Applications," IEEE Access, vol. 13, pp. 284-296, 2025.

[16]. R. Kumar, S. Gupta and U. Ur-Rehman, "Circular Economy a Footstep Toward Net Zero Manufacturing: Critical Success Factors Analysis with Case Illustration," Sustainability, p. 15, 2023.

[17]. B. P. Sah, S. Begum, M. R. Bhuiyan and M. Shahjalal, "The Role of AI in Promoting Sustainability Within the Manufacturing Supply Chain: Achieving Lean and Green Objectives," Academic Journal on Business Administration, Innovation & Sustainability, vol. 4, no. 3, 2024.

[18]. Y. Chen and S. Jin, "Aritifical Intelligence and Carbon Emissions in Manufacturing Firms: The Moderating Role of Green Innovation," Processes, vol. 11, 2023.

[19]. R. A. Adebayo, N. C. Obiuto, O. K. Olajiga and I. C. Festus-Ikhuoria, "AI-Enhanced Manufacturing Robotcis: A Review of Applications and Trends," World Journal of Advanced Research and Reviews, vol. 21, no. 3, pp. 2060-2072, 2024.

[20]. B. Keshinro, "Image Detection and Classification: A Machine Learning Approach," 2022.

[21]. C. Li, "AI-Powered Energy Internet Towards Carbon Neutrality: Challenegs and Opportunities," 2021.

[22]. Y. A. Alli, A. Bamisaye, M. O. Bamidele, N. O. Etafo, S. Chikirida, A. Lawal and H. Al-Nageim, "Transforming Waste to Wealth: Harnessing Cabondioxide for Sustainable Solutions," Results in Surfaces and Interfaces, 2024.

[23]. Y. Zhou, "Artificial Intelligence in Renewable Systems for Transformation Towards Intelligent Buildings: Energy and Ai," 2022.

[24]. L. Xie, T. Huang, X. Zheng, Y. Liu, M. Wang, V. Vittal, P. R. Kumar, S. Shakkotai and Y. Cui, "Energy System Digitization in the Era of AI: A Three-Layered Approach Toward Carbon Neutrality," Patterns Perspective, 2022.

[25]. M. S. Mahmud, M. S. Abidin, A. A. Emmanuel and H. S. Hasan, "Robotics and Automation in Agriculture: Present and Future Applications," 2020.

[26]. V. O. Hammed, A. B. Bello, O. O. Olatunji and O. Owoyomi, "Innovative Approaches to Upcycling Plastic Waste Into Sustainable Construction Materials: Addressing the Global Plastic Pollution Crisis," 2024.

[27]. Adebayo, "Harnessing Robotics for Sustainable Waste Management: Insights from the UK And African Cities," Journal of Advanced Research and Multidisciplinary Studies, 2025.

[28]. H. Nurhaeni, A. Delhi, M. D. O. Plane, S. Aulia-Anjani and N. Aprila-Yusuf, "Optimizing Electrical Energy Use through AI: An Integrated Approach for Efficiency and Sustainability," International Transactions on Artificial Intelligence (ITALIC), 2024.

[29]. J. Liu, Y. Qian, Y. Yang and Z. Yang, "Can Artificial Intelligence Improve the Energy Efficiency of Manufacturing Companies? Evidence from China.," Internatinoal Journal of Environmental Research and Public Health, vol. 19, 2022.

[30]. N. Sukdeo and D. Mothilall, "The Impact of Artificial Intelligence on the Manufacturing Sector: A Systematic Literature Review of the Printing and Packaging Industry.," in 2023 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems, 2023.

[31]. Rojek, D. Mikolajewski, A. Mrozinski and M. Macko, "Green Energy Management in Manufacturing Based on Demand Prediction by Artificial Intelligence—A Review," Electronics, p. 3338, 2024.

[32]. T. Rizvi, A. Haleem, S. Bahl and M. Javaid, "Artificial Intelligence (AI) and Its Applications in Indian Manufacturing: A Review," Current Advances in Mechanical Engineering, pp. 825-835, 2021.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25may028

[33]. SiemensAG, "Sustainability Report 2022: Digitalization for Decarbonization," Siemens AG, 2022. [Online]. Available: https://www.siemens.com/global/en/company/sustainability.html. [Accessed April 2025].

[34]. S. Weigel, J. Fischer and T. Bauernhansl, "AI-Based Energy Management in Smart Factories: Empirical Evidence from Siemens' Amberg Plant.," Journal of Cleaner Production, vol. 385, 2023.

[35]. Schneider-Electric, "Zero Waste to Landfill: Circular Manufacturing with Robotics at Le Vaudreuil Factory [White Paper]," Shneider Electric Sustainability Hub, 2023.

[36]. Lefeuvre, S. Garnier, P. Jacquin and R. Bounaceur, "Robotic Disassembly for Circular Manufacturing: A Case Study of Schneider Electric's Sustainable Factory," Resources, Conservation & Recycling, vol. 180, 2022.

[37]. S. Wani and G. Nemade, "The Synergy between Artificial Intelligence and Robotics," International Journal of Scientific Engineering and Research, 2023.

[38]. B. Keshinro, Y. Seong and S. Yi, "Deep Learning-Based Human Activity Recognition Using RGB Images in Human-Robot Collaboration," in Proceedings of the Human Fctors and Ergonomics Society Annual Meeting, Los Angeles, CA, 2022.

[39]. S. Banipal, S. Asthana and S. Mazumder, "Sustainable AI-Standards, Current Practices and Recommendations," in Future Technologies Conference, 2023.

[40]. R. Mia and J. Shuford, "Exploring the Synergy of Artificial Intelligence and Robotics in Industry 4.0 Applications," Journal of Artificial Intelligence General Science (JAIGS), vol. 1, no. 1, 2024.

[41]. M. A. Goralski and T. K. Tan, "Artificial Intelligence and Sustainable Development," International Journal of Management Education, 2020.

[42]. U. B. Mir, S. Sharma, A. K. Kar and M. P. Gupta, "Critical Success Factors for Integrating Artificial Intelligence and Robotics," 2020.

[43]. B. Rathore, "The Next Frontier: How the Integration of AI Transforms Manufacturing for a Sustainable Future," International Journal of New Media Studies, vol. 3, no. 2, 2016.

[44]. Windmann, P. Wittenberg, M. Schieseck and O. Niggemann, "Artificial Intelligence in Industry 4.0: A Review of Integration Challenges for Industrial Systems," in 2024 IEEE 22nd International Conference on Industrial Informatics (INDIN), 2024.

[45]. S. Bag, M. S. Rahman, S. Ghai, S. K. Srivastava, R. K. Singh and R. Mishra, "Unveiling the Impact of Carbon-Neutral Policies on Vital Resources in Industry 4.0 Driven Smart Manufacturing: A Data-Driven Investigation," Comput. Ind. Eng. , vol. 187, 2023.

[46]. B. Keshinro, "Predicting and Evaluating the Impact of Social Media Performance Metrics on Brand Management: A Machine Learning Approach," 2022.

[47]. T. Jelinek, A. Bhave, N. Buchoud, M. M. Buhler, P. Glauner, O. Inderwildi, M. Kraft, C. Mok, K. Nubel and A. Voss, "International Collaboration: Mainstreaming Artificial Intelligence and Cyberphysical Systems for Carbon Neutrality," IEEE Transactions on Industrial Cyber-Physical Systems, pp. 26-34, 2024.

[48]. J. Rissman, C. Bataille, E. Masanet, N. T. Aden, W. R. Morrow, N. Zhou, N. Elliott, R. W. Dell, N. Heeren, B. D. Huckestein, J. Cresko, S. A. Miller, J. Roy, P. S. Fennell, B. Cremmins, T. K. Blank, D. Hone, E. D. Williams, S. DeLaRueDuCan, B. Sisson and e. al, "Technologies and Policies to Decarbonize Global Industry: Review and Assessment of Mitigation Drivers Through 2070," Applied Energy, 2020.