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EFFECTS OF ARTIFICIAL INTEGRATION AND BIG DATA ANALYSIS ON ECONOMIC VIABILITY OF SOLAR MICROGRIDS: MEDIATING ROLE OF COST BENEFIT ANALYSIS

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Abstract*: The escalating environmental alterations have precipitated a transition towards renewable energy sources. Concurrently, recent technological advancements, such as big data and artificial intelligence, have fundamentally altered the landscape of decision-making processes. Consequently, this research endeavors to assess the impact of integrating big data and AI on the economic feasibility of solar microgrids in the rural context of Jordan. Furthermore, the study investigates several mediating factors, including adoption rates, costs, economic benefits, decision-making processes, investments, and community acceptance. The data were gathered from 250 professionals involved in solar microgrid initiatives, utilizing a quantitative deductive approach and employing questionnaires as the primary data collection tool. Subsequently, the collected data underwent statistical analysis through SPSS and PLS-SEM. The findings of the study indicate a positive and significant influence of big data and AI integration on adoption rates, costs, economic benefits, decision-making processes, investments, and community*

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acceptance. Moreover, the results suggest that economic benefits are influenced by adoption rates, costs, economic benefits, decision-making processes, investments, and community acceptance. Importantly, all identified mediation paths were found to be statistically significant. These outcomes underscore the potential of big data and AI integration to enhance decision-making processes in favour of adopting solar microgrids by providing crucial insights into their benefits. The study concludes with a discussion on research limitations and outlines potential directions for future investigations.

***Keywords**: Solar Microgrids, Artificial Intelligence, Big Data Analytics, Economic Viability, Renewable Energy, Jordan, Community Acceptance, Technological Infrastructure.*

1. Introduction

Climate change has surfaced as a consequential issue attributed to the continual combustion of fossil fuels within the energy sector. Its ramifications transcend localized boundaries and have evolved into a pervasive global concern necessitating collective resolution. Consequently, numerous nations have instituted targets for the reduction of greenhouse gas emissions as part of their proactive measures in addressing this overarching challenge (UNFCCC, 1992). In response to this challenge, the operational dynamics of the power industry are undergoing transformation, with concerted measures being implemented to mitigate adverse environmental effects. Substantial endeavours are underway within the power sector to cultivate environmental sustainability, characterized by a dedicated focus on curtailing greenhouse gas emissions. A noteworthy initiative entails the adoption of small-capacity renewable power sources, exemplified by the proliferation of microgrids, which consistently augment and provide energy to community locales (Mun et al., 2021) Renewable power sources, as highlighted by (Ang et al., 2022), tend to engender environmentally friendly, sustainable, and economically advantageous power generation. This renders them economically viable in comparison to conventional fossil fuels.

It is noteworthy to acknowledge that predominant electricity generation relies heavily on the combustion of fossil fuels. The post-COVID-19 landscape has witnessed heightened energy demand and escalating fossil fuel prices, compelling numerous nations to contemplate transitioning to sustainable energy production aligned with Net Zero objectives. In this context, renewable energy has emerged as a consequential solution to address surging costs and achieve sustainability goals, primarily attributed to its cost-effectiveness (Al-Habaibeh et al., 2023). An additional scholarly inquiry posited that the combustion of fossil fuels is yielding adverse environmental consequences, precipitating accelerated resource depletion. This underscores the imperative to transition towards the utilization of renewable resources for energy production to realize sustainability objectives. Renewable energy resources, notably solar, wind, and biomass, are posited as viable alternatives for sustainable power generation over the long term. It is noteworthy that, in recent years, several nations have strategically prioritized transitioning their power generation loads to renewable sources in pursuit of sustainability (Aziz et al., 2020). It is pertinent to highlight that developing nations often face resource constraints hindering substantial investments in transitioning from fossil fuel-based to renewable energy production. Consequently, numerous countries continue to depend on diesel generators for energy generation, thereby contributing adversely to environmental degradation (Guerrero Hernandez & de Arruda, 2021). Given these circumstances, it becomes imperative to ascertain strategies for developing micro-level resources in countries, facilitating a transition toward renewable energy production. These renewable energy resources, besides being cost-effective, exhibit heightened community acceptance, as surplus energy generated is seamlessly integrated back into the primary power generation system, thereby yielding monetary benefits (Ang et al., 2022). While the cost-effectiveness and myriad advantages associated with renewable energy are evident, it is imperative not to overlook the indispensable role of contemporary technologies, notably AI and big data (Li et al., 2019), in fostering the economic viability of solar microgrids.

Jordan, like many other countries, grapples with power generation challenges exacerbated by a growing population. The surge in urbanization further intensifies the pressure on the nation to meet escalating energy demands while also addressing environmental concerns. Despite having ample domestic petroleum reserves, Jordan relies heavily on importing petroleum products to cater to increasing urbanization, consequently leading to heightened reliance on fossil fuel combustion for power consumption (Al-Habaibeh et al., 2023). In light of this, the present study asserts the imperative of addressing this concern within the specific context of Jordan. It underscores the necessity of devising a viable solution that can effectively cater to the demands of surging urbanization while simultaneously alleviating the pressure to transition towards environmental sustainability.

It is noteworthy that the deployment and production of microgrids are contingent upon the power consumption patterns within a community. Additionally, these factors are influenced by considerations such as investment, quality, and the capacity for energy reproduction. Various nations across the world are actively adopting microgrids for diverse purposes (Mun et al., 2021). Nevertheless, substantial endeavours are still requisite. Hence, it is imperative to discern the factors that can underpin the economic feasibility of solar microgrids. Consequently, the current study endeavours to furnish empirical evidence elucidating the interplay of technology-related factors in the installation of solar microgrids and their economic viability within the Jordanian context. Remarkably, Jordan has recorded noteworthy achievements in its power generation transformation, as indicated by the 2022 report from the National Electric Power Company, revealing the production of 953 and 622 megawatts through solar and wind generation capacities, respectively (NEPCO, 2021). Furthermore, residences employ solar and water heating technologies to meet their hot water requirements. The adoption of solar water heaters is on the rise in Jordan, with an estimated installation of 26,000 units facilitated by the Jordan Renewable Energy & Energy Efficiency Fund (JREEEF) (Hamedi et al., 2021). While these efforts are commendable, there remains a considerable distance to cover. Consequently, the current study is oriented towards examining the factors that can contribute to the viability of solar microgrids in rural areas of Jordan.

The significance of big data in facilitating the seamless integration of solar microgrids cannot be understated. Notably, the domain of big data science has witnessed substantial proliferation in recent years across various facets of life. Diverse datasets are employed for analysis and critical decision-making, providing actionable insights for practitioners. The capacity of data science to aggregate, structure, and reveal patterns in renewable energy resources equips stakeholders with the capability to make informed decisions and implement effective actions (Jalli et al., 2023) . It is noteworthy that the incorporation of big data and AI into solar microgrids has the potential to yield novel and valuable insights into energy production (Sallam, Barakat, & Sallam, 2023). By enhancing the efficiency and feasibility of solar energy systems, big data-driven power generation presents numerous advantages. This includes aiding decision-making processes, informing investment decisions, and enhancing cost-effectiveness, especially in the context of the economic viability of energy generation. Nevertheless, further research is warranted to comprehensively discern the implications of big data-driven energy production on society, industry, and government (Li et al., 2019). Consequently, the present study has examined the influence of big data on various facets within solar energy microgrids, encompassing adoption rates, costs, economic benefits, decision-making processes, investment dynamics, and community acceptance.

Moreover, the energy sector is undergoing rapid expansion, encountering challenges in production, demand patterns, and cost considerations. AI can play a pivotal role in enhancing forecasting accuracy, operational efficiency, and overall accessibility within this domain (Chen et al., 2021). Similarly, the present investigation asserts that solar microgrids integrated with AI exhibit enhanced performance in terms of economic viability. Moreover, AI contributes to discerning data patterns and facilitating cost-benefit analyses within the context of solar microgrids. This study specifically concentrates on the technological aspects, namely AI integration and big data, in relation to the economic viability of renewable energy resources, such as solar microgrids. Economic viability, in this context, pertains to the affordability of the energy resource, encompassing return on investment, operational efficiency, and the long-term financial sustainability of energy projects. Despite Jordan's efforts to embrace renewable energies, challenges persist regarding the economic viability, necessitating strategic measures to enhance the scalability of solar microgrid operations, taking into account financial considerations (Al-Quraan, Darwish, & Malkawi, 2023). Furthermore, the consideration of economic viability is paramount, as an inaccurate estimation may lead to underinvestment (Shah et al., 2023) a circumstance particularly challenging for nations such as Jordan grappling with financial constraints. It is noteworthy that the existing literature on the amalgamation of AI and big data technologies in the context of power generation and economic viability is limited (Ali et al., 2023). Hence, this research constitutes a noteworthy contribution to the scholarly discourse as it delves into pivotal aspects of energy production and sustainability. Moreover, it employs questionnaires for data collection, a departure from the prevalent reliance on financial reports data within existing literature. The research framework is constructed upon contemporary issues and employs advanced analytical techniques, including PLS-SEM, to empirically evaluate the hypothesized relationships. The study is structured into four sequential chapters, encompassing a literature review, research methodology, data analysis and results, and a final chapter devoted to discussion and conclusion.

2. Literature Review

2.1 Hypothesis Development

Solar electricity may not be universally feasible, yet microgrids present a viable and cost-effective solution for supplying electricity in rural areas (Akshay, 2023). An additional scholarly inquiry posited that predictive maintenance has emerged as a pressing requirement in the realm of microgrid operational management. These technologies facilitate the early detection of potential failures, thereby reducing downtimes and minimizing costs. The integration of AI in these technologies ensures optimal functioning of microgrids, leading to superior performance, accurate prediction of potential failures, and effective problem diagnosis. This not only enhances the potential output but also contributes to extending the lifespan and overall health of the microgrid (Arafat, Hossain, & Alam, 2024). As an illustration, the integration of AI enhances precision and efficiency in solar inspections, thereby diminishing time requirements and mitigating operational costs (Center, 2023). A previous study by Yousef, Yousef, and Rocha-Meneses (2023) Propose that the incorporation of AI-based diagnostics into the energy system results in diminished issues, early issue prediction, and enhanced system recovery capabilities in case of disruptions. Consequently, the overall economic viability of solar microgrids is anticipated to increase with AI integration, attributed to the reduction in operational and maintenance costs. Therefore, it is posited that.

H1: *Cost is a significant mediator between the relationship of AI integration and economic viability of solar microgrids.*

Big data also assumes a crucial role in actualizing the prospective economic advantages associated with solar microgrids. A recent study asserted that contemporary industrial systems heavily rely on data analytics. The traditional paradigm of electricity distribution has evolved, incorporating an information layer designed to gather a diverse array of data pertaining to the distribution process. This collected data is subsequently analysed through the utilization of smart meters and sensors (Zhang, Huang, & Bompard, 2018). It asserts that big data analytics can be employed for acquiring information and making decisions concerning solar microgrids. As per another study, energy systems have undergone increased complexity, necessitating the implementation of new technologies, such as big data, for the collection of data related to energy transmission, storage, generation, and consumption (Psomopoulos, Leligou, & Ponci, 2022). This study posits that the substantial volume of data associated with microgrids, when subjected to processing, can unveil valuable insights pertaining to the maintenance and transmission management of energy. Consequently, it guides decision-making towards an economically viable direction. A recent study by Ohalete et al. (2023) propose that the application of big data analytics has the potential to enhance economic outcomes in the realm of renewable energy. The utilization of big data in the context of renewable energy can yield manifold benefits, encompassing areas such as management, operational planning, monitoring, organization, and fault detection (Mostafa, Ramadan, & Elfarouk, 2022). The economic feasibility of solar microgrids is anticipated to augment through the implementation of big data, as it enhances economic benefits by enabling improved monitoring and control of power generation over time. Therefore, it is posited that.

H2: *Economic benefits is a significant mediator between the relationship of big data and economic viability of solar microgrids.*

AI assumes a pivotal role in decision-making processes and has found extensive application across various facets of human existence. The integration of AI into solar microgrids is poised to enhance their reliability in providing electricity to rural areas. For example, the incorporation of ZigBee technology contributes to the mobility and robustness of the microgrids (Talaat et al., 2023). Utilizing AI as a decision support system in microgrids is feasible owing to its capacity to process substantial volumes of data, enabling timely decision-making characterized by heightened accuracy and reliability (Gupta & Chaturvedi, 2023). An additional scholarly inquiry posited that the popularity of microgrids is on the rise owing to their efficacy in energy distribution. Traditional control techniques have lost their validity and reliability in sustaining these systems. Conversely, the integration of AI has emerged as a pivotal factor capable of furnishing promising solutions for enhancing and controlling microgrid operations, as well as improving decision-making processes. Therefore, it is hypothesized that.

H3: *Decision making is a significant mediator between the relationship of AI integration and economic viability of solar microgrids.*

It is noteworthy that the incorporation of big data analytics into the energy sector is a forefront contributor to the development of the energy internet. The integration of microgrids with big data analytics remains a considerable challenge yet to be addressed. Despite the challenges, big data analytics facilitates data collection and judicious utilization for decision-making, imparting specific advantages to the realm of renewable energy production (Mostafa et al., 2022). Nonetheless, garnering community acceptance for such microgrids is imperative. A prior study argued that the social acceptance of renewable energy entails the active involvement of all societal members, leading to a broader acceptance of a particular phenomenon (Safari et al., 2020). It is important to underscore that the establishment of renewable energy infrastructures is imperative for environmental preservation, particularly in alignment with net-zero policies as a strategic response to climate change challenges. Nevertheless, there exist various barriers and a lack of community acceptance, as indicated by (Roddis et al., 2020), which can be effectively addressed through the utilization of big data. These technologies have the capacity to furnish precise data regarding the advantages of solar microgrids, thereby augmenting acceptance levels and enhancing economic viability. Therefore, the present study contends that community acceptance of the integration of big data analytics in microgrids is indispensable to ensure its viability. In accordance with another study conducted by Kenney and Zysman (2020), it is posited that the application of big data analytics has the potential to augment community acceptance, subsequently impacting economic viability.

H4: *Community acceptance is a significant mediator between the relationship of big data and economic viability of solar microgrids.*

The swiftly occurring technological advancements are exerting a notable impact on the domain of renewable energy. For instance, big data analytics is playing a pivotal role in guiding investment decisions within this context. These technologies systematically capture extensive datasets encompassing variables such as temperature, humidity, light, power generation, and consumption. By providing comprehensive information, big data analytics becomes a valuable resource for investors, furnishing essential insights necessary for prudent decision-making in the microgrid sector. The breadth of collected data, inclusive of the diverse impacts arising from different geographical locations and seasonal climates on installed equipment, substantially enhances the precision of investment decisions (Liang & Hou, 2023). Consequently, this current study posits that big data analytics can provide enhanced guidance for investment decision-making, thereby enhancing economic viability in rural areas of Jordan. Hence, the following hypothesis is formulated.

H5: *Investment is a significant mediator between the relationship of big data and economic viability of solar microgrids.*

Big data analytics has the potential to elevate the adoption rate of solar microgrids. Its positive impact on the adoption rate stems from its capacity to provide comprehensive monitoring of solar microgrids (Neiditch, 2019). An additional scholarly inquiry asserted the indispensability of big data analytics in managing renewable energy resources, particularly in the case of solar energy. Leveraging satellite imagery, weather data, and geographical information, it has the capability to furnish precise and valuable information for stakeholders. The integration of big data enhances monitoring, control, and information sharing, thereby contributing to an augmented adoption rate (Raaj, 2023). Big data has emerged as a consequential technology capable of extracting substantial volumes of data from diverse sources, and the processing of this extracted data yields meaningful information. Consequently, this study asserts that the data extracted, specifically concerning the success of solar microgrids through the application of big data, has the potential to augment the adoption rate within the community (Mostafa et al., 2022). Consequently, it can also underscore the economic feasibility of solar microgrids. Another scholarly investigation indicated that exposure to big data analytics and heightened awareness correlates with an increased readiness to embrace the latest technologies (Khan et al., 2023; Koot, Mes, & Iacob, 2021). Thus, the ensuing hypotheses are formulated.

H6: *Adoption rate is a significant mediator between the relationship of the big data and economic viability of solar microgrids.*

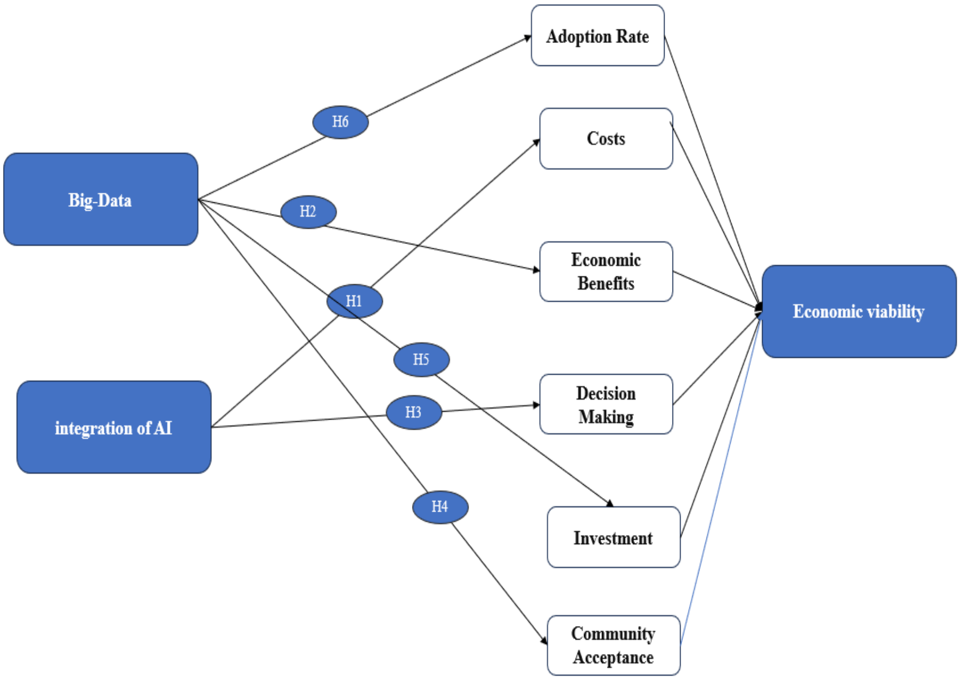

Figure 1: Conceptual Framework.

3. Methodology

The study adhered to a positive research philosophy. Consequently, a quantitative deductive approach was employed to empirically assess the hypothesized relationships. The primary objective of the study is to investigate the roles of big data and AI in influencing the economic viability of solar microgrids. The study population comprised professionals engaged in solar microgrid activities. Given the regional divisions of Jordan into governorates, the study adopted a cluster sampling method, categorizing Jordan into North, Central, and South regions. Subsequently, three provinces, namely Irbid, Amman, and Karak, were selected due to their higher population density within their respective regions. Data were collected from 350 professionals involved in solar microgrid activities within these provinces. Permissions were secured from their respective organizations, and a structured questionnaire, derived from prior studies, was distributed among the respondents. Of the distributed questionnaires, 250 were returned. The questionnaire included items adapted from previous studies, and the research instruments were measured using adapted items from the study. The analysis of big data was conducted using three items derived from a previous study (Chatterjee et al., 2023; Lutfi et al., 2022). The assessment of AI integration was conducted using three items, which were adapted from a prior study of (Chatterjee et al., 2023). The evaluation of economic viability, or economic sustainability, was gauged using four items derived from a previous study (Lutfi et al., 2022). The assessment of cost-benefit analysis encompassed various dimensions, including adoption rate, acceptance rate, economic benefits, investments, and costs. Within these dimensions, adoption intention was gauged using three items, while economic benefits were evaluated using four items. These items were adapted from a previous study of (Chuah et al., 2021). The measurement of cost involved the use of four items, which were adapted from a prior study of (Ali et al., 2023). All the measures employed in the study were evaluated utilizing a 5-point Likert scale (Asmelash et al., 2020; Bourret et al., 2023).

4. Data Analysis

The research incorporated both descriptive and inferential analyses, which are elaborated upon in the subsequent two sections.

4.1 Demographic Analysis

The survey was disseminated electronically through professional networks, industry forums, and specific social media platforms dedicated to renewable energy discussions in Jordan. An online survey tool was employed for efficient distribution and collection of responses. Bi-weekly reminders were dispatched to enhance the response rate, and the survey remained accessible for one month to afford sufficient time for participation. The significance of these respondents lies in their ability to offer a comprehensive insight into the operational, technical, economic, and social aspects related to the incorporation of AI and big data analytics in solar microgrids. Previous studies, like those by Gielen et al. (2019) demonstrated that incorporating input from a diverse array of stakeholders enhances the richness of data and ensures the robustness and reflection of actual conditions and sentiments within the renewable energy sector. The insights provided by these stakeholders make substantial contributions to formulating practical and policy recommendations deeply rooted in the practicalities of the field.

Table 1: Descriptive Statistics of Respondents.

Description	Percentage (%)
Gender	
Male	80%
Female	20%
Age	
25-30	24%
31-35	36%
36-40	20%
41-45	11%
Above 45	9%
Profession	
Engineers and Technicians	40%
Policymakers	20%
Investors	15%
Community Leaders	10%
Residents	15%

5.2 Common Method Bias Test

While gathering data through surveys, Common Method Bias (CMB) emerges as a potential apprehension. It denotes variance attributed to the measurement method itself rather than to the constructs the measures intend to represent. In our study, where data are sourced from a single point in time and a single respondent, there exists a risk that CMB could potentially exaggerate the relationships among variables. To evaluate the presence of common method bias, various tests are at our disposal, including Harman's single-factor test, the marker variable technique, and the utilization of statistical controls, such as introducing a method factor in confirmatory factor analysis (Aguirre-Urreta & Hu, 2019). The most appropriate test for our study is Harman's single-factor test, given its extensive usage and suitability for the exploratory phase of our research. This test entails performing an exploratory factor analysis (EFA) on all items in the questionnaire to ascertain the number of factors required to explain the variance in the variables. If a single factor emerges, or if one overarching factor explains the majority of the covariance among measures, it may indicate the presence of common method bias (Aguirre-Urreta & Hu, 2019).

Table 2: Harman's Single-Factor Test Results.

Factor	Variance Explained (%)
1	22.50%
2	18.70%
3	12.30%
...	...
Total	53.50%

The outcomes of the EFA depicted in Table 2 above reveal that the initial factor elucidates 22.5% of the variance, and the cumulative variance explained by all extracted factors amounts to 53.5%. Notably, no single factor dominates in explaining the majority of the variance, implying that common method bias does not appear to be a substantial concern in this study. This deduction is pivotal as it reinforces the validity of our findings, suggesting that the observed relationships between AI, big data analytics, and the economic viability of solar microgrids likely stem from actual relationships rather than being artefacts of the measurement method. Previous studies, such as tho Chang, van Witteloostuijn, and Eden (2020), advocated for the utilization of Harman's single-factor test as an initial evaluation of common method bias, affirming its suitability for our chosen research methodology (Aguirre-Urreta & Hu, 2019).

4.3 Inferential Analysis

The inferential analysis was conducted through two measurements, namely, structural models, both of which are deliberated upon in the subsequent two sections.

5. Measurement Model

5.1 Convergent Validity

To evaluate the reliability of the constructs in our survey, we conducted a reliability analysis, encompassing the calculation of Cronbach's alpha for each construct. A robust Cronbach's alpha, typically exceeding 0.7, signifies satisfactory internal consistency among the items constituting a construct. Convergent validity was scrutinized through the examination of the Average Variance Extracted (AVE) and the factor loadings of the items. Convergent validity is affirmed when the AVE for each construct surpasses 0.5, and the majority of factor loadings exceed 0.7, indicating that the items effectively measure the intended construct (Hair et al., 2017). The findings reveal that each construct examined in the survey exhibits substantial reliability. The Cronbach's alpha values for Economic Viability, AI Integration, and Big Data Analytics Capability all exceed the 0.7 threshold, indicating consistent measurement of the same underlying concept across the items within each construct. Additionally, AVE values surpass 0.5 for all constructs, meeting the criteria for convergent validity. This indicates that a substantial portion of the variance in the items is explained by their respective constructs. Furthermore, the factor loadings, all exceeding the 0.7 cut-off, affirm a robust and positive relationship between the items and the constructs they aim to assess (Hair et al., 2017). All the aforementioned results are anticipated in the following Table 3.

Table.3: Reliability and Convergent Validity Results.

	Cronbach's alpha	Composite reliability	Composite reliability	AVE
AR	0.860	0.869	0.917	0.788
Big Data	0.855	0.863	0.895	0.631
CA	0.813	0.813	0.890	0.729
Co	0.819	0.824	0.896	0.746
DM	0.752	0.843	0.844	0.645
EB	0.789	0.798	0.876	0.703
Economic Viability	0.853	0.875	0.892	0.583
Integration of AI	0.844	0.860	0.896	0.683
Inv	0.755	0.758	0.860	0.673

5.2 Discriminant Validity

Discriminant validity examines whether concepts or measurements that are not intended to be correlated demonstrate actual independence. In our study, this entails confirming the distinctiveness of the constructs Economic Viability, AI Integration, and Big Data Analytics Capability. The prevalent method for assessing discriminant validity is the Fornell-Larcker criterion, which is satisfied when the square root of the AVE for each construct surpasses its highest correlation with any other construct (Hair et al., 2019). The values presented in Table 4 indicate that all diagonal elements are higher than the corresponding elements below them.

Table. 4: Discriminant Validity Results.

	AR	Big Data	CA	Co	DM	EB	Economic Viability	Integration of AI	Inv
AR	**0.888**								
BDA	0.795	**0.842**							
CA	0.648	0.744	**0.909**						
Co	0.611	0.682	0.851	**0.864**					
DM	0.605	0.721	0.614	0.557	**0.803**				
EB	0.657	0.758	0.814	0.713	0.612	**0.838**			
EV	0.654	0.754	0.773	0.684	0.646	0.764	**0.884**		
Integration of AI	0.636	0.685	0.663	0.698	0.58	0.619	0.572	**0.827**	
Investment	0.724	0.755	0.675	0.596	0.616	0.738	0.816	0.557	**0.821**

Note: AR-adoption intention, BI-big data, EB-economic benefits, CA-community acceptance, integration of AI, EV-economic viability, BDA-big data analysis, EB-economic benefit analysis.

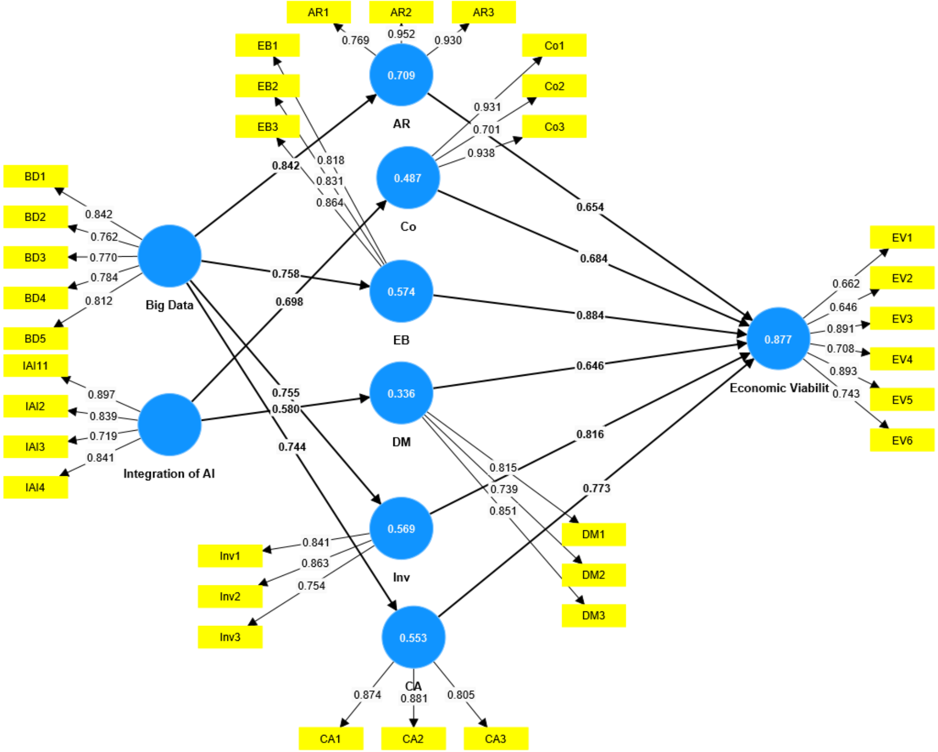

Figure 2. Measurement Model.

2.3 Structural Model (Hypothesis Results)

The suggested threshold for CFI and TLI is 0.95, as recommended by the literature (Hair et al., 2019). All the values exceeded 0.95. Conversely, for RMSEA, the recommended threshold is below 0.06, and the observed values were below 0.06, indicating the model's good fit (Hair et al., 2019). Upon completing the measurement testing phase of the study, the subsequent step involves scrutinizing the study hypotheses. The initial hypothesis outcomes reveal a significant and positive mediation of cost between artificial intelligence and economic viability, aligning with the proposed hypothesis. Similarly, the results of the second hypothesis demonstrate a significant mediation of economic benefits between big data analysis and economic viability, supporting the proposed hypothesis. The findings for the third hypothesis indicate that decision-making significantly mediates between AI integration and economic viability, endorsing the proposed hypothesis 3. Additionally, the fourth hypothesis results manifest that community acceptance significantly and positively mediates between AI integration and economic viability, corroborating hypothesis 4. Further exploration reveals that investment serves as a significant and positive mediator in the relationship between big data and the economic viability of solar microgrids, aligning with proposed hypothesis 5. Lastly, adoption rate also exhibits a positive and significant mediation between the relationship of big data and economic viability of solar microgrids. All the aforementioned results are presented in the subsequent Table 5.

Table.5: Hypothesis Results.

		Beta	**Standard deviation**	**T Value**	**P values**	**Results**
H1	Integration of AI -> Co -> Economic Viability	0.249	0.044	5.637	0.000	Supported
H2	Big Data -> EB -> Economic Viability	0.742	0.057	13.007	0.000	Supported
H3	Integration of AI -> DM -> Economic Viability	0.058	0.017	3.452	0.001	Supported
H4	Big Data -> CA -> Economic Viability	0.487	0.074	6.570	0.000	Supported
H5	Big Data -> Inv -> Economic Viability	0.234	0.032	7.267	0.000	Supported
H6	Big Data -> AR -> Economic Viability	0.058	0.024	2.425	0.016	Supported

Note: AR-adoption intention, BI-big data, EB-economic benefits, CA-community acceptance, integration of AI, EV-economic viability, BDA-big data analysis, EB-economic benefit analysis.

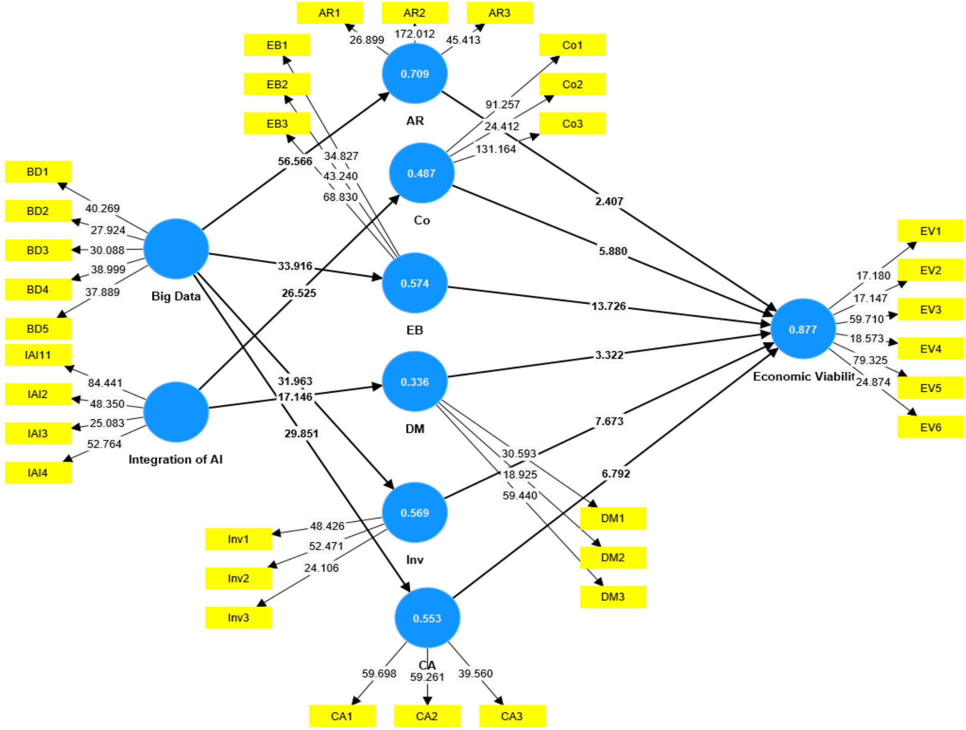

Figure 3. Structural Model.

6. Discussion and Conclusion

The study sought to examine the impact of integrating big data & AI on the economic viability of solar microgrids in the rural areas of Jordan. Data collection was conducted through a questionnaire and analysed using PLS-SEM. The study outcomes indicated that AI integration significantly influences decision-making, thereby enhancing the economic viability of solar microgrids. These findings align with prior research suggesting that AI possesses the capability to make real-time decisions utilizing pre-configured algorithms and computing technologies based on data analysis. Moreover, AI exhibits the ability to learn from patterns present in the data (Rodgers et al., 2023). These results corroborate that the integration of AI aids in the efficient and effective processing of available data, leading to optimal decision-making and, consequently, contributing to the economic viability of solar microgrids.

Moreover, the study's results demonstrated a significant influence of big data on investment. These findings align with previous research; for instance, Korherr and Kanbach (2023) argued that while data itself may not appear to be inherently valuable, its strategic processing can create substantial value. In line with this, the processing of big data tends to yield valuable outcomes, such as making sound investments that contribute to the economic viability of solar grids. The study's findings underscore that extensive data processing, particularly concerning electric and solar energy production costs, can elucidate the benefits of solar microgrids. Consequently, informed investment decisions in solar infrastructure may enhance the economic viability of solar microgrids. Moreover, the results indicate a significant association between AI integration, costs, and economic viability. These findings suggest that integrating AI into operations leads to cost reduction, emphasizing the economic viability of solar microgrids. This aligns with prior research; for example, Pan et al. (2022) Pan et al. (2022)argued that the application of AI in business operations tends to decrease costs and improve efficiency. In the context of solar microgrids, the current study establishes that increased efficiency and reduced costs resulting from AI integration contribute to the economic viability of solar microgrids.

Additionally, the study investigated the indirect relationship between big data and economic viability, employing both community acceptance and adoption rate as mediators. The results indicated that big data indirectly influences economic viability through the mediating factors of community acceptance and adoption rate. This implies that information derived from the processing of big data related to the adoption of solar energy can contribute to the creation of economic viability. Previous research has similarly reported findings connecting big data and the economic viability of solar microgrids. Businesses necessitate the processing of vast amounts of data to make informed decisions, and contemporary technologies like big data aid in this data processing (Koot et al., 2021). In accordance with this, the current study posits that the extensive processing of data by big data technologies regarding the benefits and cost savings of solar microgrids may lead to heightened adoption and community acceptance. In summary, the findings of the study establish that contemporary technologies, specifically big data and AI integration, can assist Jordan in fostering community acceptance, making cost-effective decisions, and guiding investment choices related to solar microgrids, thereby presenting them as economically viable solutions to address prevailing energy challenges.

Accordingly, drawing from prior discourse, it is determined that the research affirms the significance of incorporating big data & AI in bolstering the economic feasibility of solar microgrids in rural areas of Jordan. The investigation corroborates that the integration of AI plays a pivotal role in augmenting the decision-making process, thereby contributing to heightened economic viability. Furthermore, the study establishes the crucial influence of big data on investment decisions, thereby fostering the overall economic sustainability of solar microgrids. The findings also underscore the indirect impact of big data on economic viability, mediated by factors such as community acceptance and adoption rates. In essence, the deployment of advanced technologies, including big data and AI, emerges as a strategic paradigm for addressing energy challenges in Jordan, fostering community acceptance, facilitating informed decision-making, and ensuring the economic viability of solar microgrid initiatives.

7. Implications of the Study

The present investigation bears implications for both theoretical understanding and practical applications. Theoretically, this study represents a substantial contribution to the existing literature by scrutinizing the economic viability of solar microgrids. It enhances comprehension regarding the determinants influencing the economic feasibility of such microgrids. Furthermore, this study is a valuable addition to the scholarly discourse as it furnishes empirical evidence elucidating the potential impact of advanced technologies, specifically AI and big data, on the economic viability of solar microgrids within the Jordanian rural context. Based on the empirical findings, it is recommended that the integration of cutting-edge technologies into power generation be pursued. Notably, the incorporation of AI and big data is advocated, as these technologies exhibit the potential to propel positive advancements in sustainable power generation. Additionally, beyond their role in power generation, these technologies offer ancillary benefits that contribute to rendering renewable energy economically viable. The integration of AI and big data into power generation is suggested for their capacity to provide enhanced control and monitoring. The adaptive learning capabilities of AI, for instance, enable accurate failure prediction. Moreover, AI facilitates optimal power generation and production over time, ensuring productive management. In conclusion, the application of AI and big data to power generation is recommended for optimizing control, monitoring, production, and consumption of electricity, ultimately fostering economic viability.

8. Limitation of the Study

The current investigation presents certain limitations that warrant attention in subsequent studies. Primarily, data for this study were acquired through the use of questionnaires. Therefore, it is recommended that future research endeavours consider sourcing data from organizational financial statements to assess the efficacy of investments in AI and big data on decision-making efficiency. Additionally, it is advised to incorporate industry size as a control variable in future studies to examine economic viability, alongside an exploration of import policies related to solar technology. Furthermore, it is imperative to exercise caution in interpreting the findings, as the study's scope is confined to the rural context of Jordan. Consequently, future research is encouraged to extend the study framework to encompass developed countries, thereby enhancing the generalizability and applicability of the research outcomes.

References

Aguirre-Urreta, M. I., & Hu, J. (2019). Detecting common method bias: Performance of the Harman's single-factor test. ACM SIGMIS Database: the DATABASE for Advances in Information Systems, 50(2), 45-70. https://doi.org/10.1145/3330472.3330477

Akshay. (2023). Solar Microgrids: Designing and Implementing Off-Grid Solutions for Resilient Energy Supply. https://arka360.com/ros/solar-microgrids-off-grid-solutions/

Al-Habaibeh, A., Al-haj Moh'd, B., Massoud, H., Nweke, O. B., Al Takrouri, M., & Badr, B. E. A. (2023). Solar energy in Jordan: Investigating challenges and opportunities of using domestic solar energy systems. World Development Sustainability, 3, 100077. https://doi.org/10.1016/j.wds.2023.100077

Al-Quraan, A., Darwish, H., & Malkawi, A. M. A. (2023). Renewable Energy Role in Climate Stabilization and Water Consumption Minimization in Jordan. *Processes, 11*(8). doi:https://doi.org/10.3390/pr11082369

Ali, S., Yan, Q., Dilanchiev, A., Irfan, M., & Fahad, S. (2023). Modeling the economic viability and performance of solar home systems: a roadmap towards clean energy for environmental sustainability. Environmental Science and Pollution Research, 30(11), 30612-30631. https://doi.org/10.1007/s11356-022-24387-6

Ang, T.-Z., Salem, M., Kamarol, M., Das, H. S., Nazari, M. A., & Prabaharan, N. (2022). A comprehensive study of renewable energy sources: Classifications, challenges and suggestions. Energy Strategy Reviews, 43, 100939. https://doi.org/10.1016/j.esr.2022.100939

Arafat, M. Y., Hossain, M. J., & Alam, M. M. (2024). Machine learning scopes on microgrid predictive maintenance: Potential frameworks, challenges, and prospects. Renewable and Sustainable Energy Reviews, 190, 114088. https://doi.org/10.1016/j.rser.2023.114088

Asmelash, E., Prakash, G., Gorini, R., & Gielen, D. (2020). Role of IRENA for Global Transition to 100% Renewable Energy. In T. S. Uyar (Ed.), Accelerating the Transition to a 100% Renewable Energy Era (pp. 51-71). Springer International Publishing. https://doi.org/10.1007/978-3-030-40738-4_2

Aziz, A. S., Tajuddin, M. F. N., Adzman, M. R., Mohammed, M. F., & Ramli, M. A. M. (2020). Feasibility analysis of grid-connected and islanded operation of a solar PV microgrid system: A case study of Iraq. Energy, 191, 116591. https://doi.org/10.1016/j.energy.2019.116591

Bourret, M., Ratelle, C. F., Plamondon, A., & Châteauvert, G. B. (2023). Dynamics of parent-adolescent interactions during a discussion on career choice: The role of parental behaviors and emotions. Journal of Vocational Behavior, 141, 103837. https://doi.org/10.1016/j.jvb.2022.103837

Center, T. D. (2023). Lowering Maintenance Costs in Solar Farms with Drones and AI Technology. https://www.linkedin.com/pulse/lowering-maintenance-costs-solar-farms-drones-ai-technology/

Chang, S.-J., van Witteloostuijn, A., & Eden, L. (2020). Common Method Variance in International Business Research. In L. Eden, B. B. Nielsen, & A. Verbeke (Eds.), Research Methods in International Business (pp. 385-398). Springer International Publishing. https://doi.org/10.1007/978-3-030-22113-3_20

Chatterjee, S., Chaudhuri, R., Kamble, S., Gupta, S., & Sivarajah, U. (2023). Adoption of Artificial Intelligence and Cutting-Edge Technologies for Production System Sustainability: A Moderator-Mediation Analysis. Information Systems Frontiers, 25(5), 1779-1794. https://doi.org/10.1007/s10796-022-10317-x

Chen, C., Hu, Y., Karuppiah, M., & Kumar, P. M. (2021). Artificial intelligence on economic evaluation of energy efficiency and renewable energy technologies. Sustainable Energy Technologies and Assessments, 47, 101358. https://doi.org/10.1016/j.seta.2021.101358

Chuah, S. H.-W., Tseng, M.-L., Wu, K.-J., & Cheng, C.-F. (2021). Factors influencing the adoption of sharing economy in B2B context in China: Findings from PLS-SEM and fsQCA. Resources, Conservation and Recycling, 175, 105892. https://doi.org/10.1016/j.resconrec.2021.105892

Gielen, D., Boshell, F., Saygin, D., Bazilian, M. D., Wagner, N., & Gorini, R. (2019). The role of renewable energy in the global energy transformation. Energy Strategy Reviews, 24, 38-50. https://doi.org/10.1016/j.esr.2019.01.006

Guerrero Hernandez, A. S., & de Arruda, L. V. R. (2021). Economic viability and optimization of solar microgrids with hybrid storage in a non-interconnected zone in Colombia. Environment, Development and Sustainability, 23(9), 12842-12866. https://doi.org/10.1007/s10668-020-01188-w

Gupta, R., & Chaturvedi, K. T. (2023). Adaptive Energy Management of Big Data Analytics in Smart Grids. *energies, 16*(16). https://doi.org/10.3390/en16166016

Hair, J., Hollingsworth, C. L., Randolph, A. B., & Chong, A. Y. L. (2017). An updated and expanded assessment of PLS-SEM in information systems research. Industrial management & data systems, 117(3), 442-458. https://doi.org/10.1108/IMDS-04-2016-0130

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. European Business Review, 31(1), 2-24. https://doi.org/10.1108/EBR-11-2018-0203

Hamedi, Z., Korban, R., Gönül, G., Nagpal, D., & Zawaydeh, S. (2021). Renewables Readiness Assessment: The Hashemite Kingdom of Jordan. *Renewable Energy Agency, Abu Dhabi.* Retrieved from https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Feb/IRENA RRA Jordan 2021.pdf

Jalli, R., Kumar, P. P., Nuvvula, R. S. S., Haroon, N. H., Srinivasarao, B., & Siddiqui, A. (2023). Data Science Applications in Renewable Energy: Leveraging Big Data for Sustainable Solutions. In 2023 12th International Conference on Renewable Energy Research and Applications (ICRERA) (pp. 465-471). https://doi.org/10.1109/ICRERA59003.2023.10269385

Kenney, M., & Zysman, J. (2020). The platform economy: restructuring the space of capitalist accumulation. Cambridge journal of regions, economy and society, 13(1), 55-76. https://doi.org/10.1093/cjres/rsaa001

Khan, A. A., Laghari, A. A., Rashid, M., Li, H., Javed, A. R., & Gadekallu, T. R. (2023). Artificial intelligence and blockchain technology for secure smart grid and power distribution Automation: A State-of-the-Art Review. Sustainable Energy Technologies and Assessments, 57, 103282. https://doi.org/10.1016/j.seta.2023.103282

Koot, M., Mes, M. R. K., & Iacob, M. E. (2021). A systematic literature review of supply chain decision making supported by the Internet of Things and Big Data Analytics. Computers & Industrial Engineering, 154, 107076. https://doi.org/10.1016/j.cie.2020.107076

Korherr, P., & Kanbach, D. (2023). Human-related capabilities in big data analytics: a taxonomy of human factors with impact on firm performance. Review of Managerial Science, 17(6), 1943-1970. https://doi.org/10.1007/s11846-021-00506-4

Li, F. G. N., Bataille, C., Pye, S., & O'Sullivan, A. (2019). Prospects for energy economy modelling with big data: Hype, eliminating blind spots, or revolutionising the state of the art? Applied Energy, 239, 991-1002. https://doi.org/10.1016/j.apenergy.2019.02.002

Liang, X., & Hou, D. (2023). Solar Investment Decision Application System Based on Big Data Technology. *2023 IEEE 3rd International Conference on Information Technology, Big Data and Artificial Intelligence (ICIBA). 3* (pp. 764-768). IEEE. https://doi.org/10.1109/ICIBA56860.2023.10164887

Lutfi, A., Alsyouf, A., Almaiah, M. A., Alrawad, M., Abdo, A. A., Al-Khasawneh, A. L., Ibrahim, N., & Saad, M. (2022). Factors Influencing the Adoption of Big Data

Analytics in the Digital Transformation Era: Case Study of Jordanian SMEs. Sustainability, 14(3). https://doi.org/10.3390/su14031802

Mostafa, N., Ramadan, H. S. M., & Elfarouk, O. (2022). Renewable energy management in smart grids by using big data analytics and machine learning. Machine Learning with Applications, 9, 100363. https://doi.org/10.1016/j.mlwa.2022.100363

Mun, H., Moon, B., Park, S., & Yoon, Y. (2021). A study on the economic feasibility of stand-alone microgrid for carbon-free Island in Korea. energies, 14(7), 1913. https://doi.org/10.3390/en14071913

Neiditch, D. (2019). Big Data and Solar Energy Are a Match Made in Heaven. https://www.entrepreneur.com/business-news/big-data-and-solar-energy-are-a-match-made-in-heaven/342714

NEPCO. (2021). National Electric Power Company Annual Report. https://www.nepco.com.jo/store/docs/web/2021_en.pdf

Ohalete, N. C., Aderibigbe, A. O., Ani, E. C., & Efosa, P. (2023). AI-driven solutions in renewable energy: A review of data science applications in solar and wind energy optimization. https://doi.org/10.30574/wjarr.2023.20.3.2433

Pan, Y., Froese, F., Liu, N., Hu, Y., & Ye, M. (2022). The adoption of artificial intelligence in employee recruitment: The influence of contextual factors. The International Journal of Human Resource Management, 33(6), 1125-1147. https://doi.org/10.1080/09585192.2021.1879206

Psomopoulos, P. D. C. S., Leligou, D. H. C., & Ponci, P. D. F. (2022). Big Data and Advanced Analytics in Energy Systems and Applications. https://www.mdpi.com/journal/energies/special_issues/Big_Data_Energy_Syst_App

Raaj, A. (2023). Harnessing Big Data for Rapid Renewable Energy Adoption in West Africa: A Call to Action for ECOWAS. https://www.linkedin.com/pulse/harnessing-big-data-rapid-renewable-energy-adoption-abdul/

Roddis, P., Roelich, K., Tran, K., Carver, S., Dallimer, M., & Ziv, G. (2020). What shapes community acceptance of large-scale solar farms? A case study of the UK's first 'nationally significant' solar farm. Solar Energy, 209, 235-244. https://doi.org/10.1016/j.solener.2020.08.065

Rodgers, W., Murray, J. M., Stefanidis, A., Degbey, W. Y., & Tarba, S. Y. (2023). An artificial intelligence algorithmic approach to ethical decision-making in human resource management processes. Human Resource Management Review, 33(1), 100925. https://doi.org/10.1016/j.hrmr.2022.100925

Safari, M. A., Masseran, N., Jedi, A., Mat, S., Sopian, K., Bin Abdul Rahim, A., & Zaharim, A. (2020). Rural Public Acceptance of Wind and Solar Energy: A Case Study from Mersing, Malaysia. energies, 13(15). https://doi.org/10.3390/en13153855

Sallam, M., Barakat, M., & Sallam, M. (2023). Pilot testing of a tool to standardize the assessment of the quality of health information generated by artificial intelligence-based models. Cureus, 15(11). https://assets.cureus.com/uploads/original article/pdf/207949/20231125-32570-1xqm6nc.pdf

Shah, H. H., Amin, M., Pepe, F., Mancusi, E., & Fareed, A. G. (2023). Overview of environmental and economic viability of activated carbons derived from waste biomass for adsorptive water treatment applications. Environmental Science and Pollution Research. https://doi.org/10.1007/s11356-023-30540-6

Talaat, M., Elkholy, M. H., Alblawi, A., & Said, T. (2023). Artificial intelligence applications for microgrids integration and management of hybrid renewable energy sources. Artificial Intelligence Review, 56(9), 10557-10611. https://doi.org/10.1007/s10462-023-10410-w

UNFCCC, Â. (1992). United Nations framework convention on climate change. https://treaties.un.org/doc/source/recenttexts/unfccc eng.pdf

Yousef, L. A., Yousef, H., & Rocha-Meneses, L. (2023). Artificial Intelligence for Management of Variable Renewable Energy Systems: A Review of Current Status and Future Directions. energies, 16(24). https://doi.org/10.3390/en16248057

Zhang, Y., Huang, T., & Bompard, E. F. (2018). Big data analytics in smart grids: a review. Energy Informatics, 1(1), 8. https://doi.org/10.1186/s42162-018-0007-5