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Energy Sustainability Considering Stand-Alone Hybrid Systems for Remote Areas with the Present of Electric Vehicles

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Abstract:
Energy sustainability in isolated areas is a critical challenge, and off-grid hybrid systems can be a viable solution with the help of Renewable Energy Sources (RESs). These systems combine multiple energy sources to ensure a reliable and continuous power supply. Energy accessibility is a hot topic due to the energy demand from consumers in residential and industrial areas. The main purpose of writing this article is to examine energy sustainability based on exploited RESs in remote areas in order to meet Sustainable Development Goals (SDGs). In this regard, MATLAB software is used to evaluate the technical and economic analysis of the proposed system.

Keywords: Energy sustainability, Off-grid, RESs, MATLAB.

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استدامة الطاقة مع الأخذ في الاعتبار الأنظمة الهجينة القائمة بذاتها للمناطق النائية مع وجود المركبات الكهربائية

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الملخص
تمثل استدامة الطاقة في المناطق المعزولة تحديًا بالغ الأهمية، ويمكن أن تكون الأنظمة الهجينة خارج الشبكة حلاً قابلاً للتطبيق بمساعدة مصادر الطاقة المتجددة (RESs). تجمع هذه الأنظمة بين مصادر طاقة متعددة لضمان مصدر طاقة موثوق ومستمر. يعد الوصول إلى الطاقة موضوعًا مهمًا جدًا بسبب الطلب على الطاقة من المستهلكين في المناطق السكنية والصناعية. الغرض الرئيسي من كتابة هذا المقال هو دراسة استدامة الطاقة بناءً على موارد الطاقة المستغلة في المناطق النائية من أجل تحقيق أهداف التنمية المستدامة (SDGs). في هذا الصدد، تم استخدام برنامج ماتلاب MATLAB لتقييم التحليل الفني والاقتصادي للنظام المقترح.

الكلمات المفتاحية: استدامة الطاقة، خارج الشبكة، RESs، ماتلاب.

1. Introduction

Energy accessibility considering multiple resources improves the power supply sustainability, lower generation cost, and decreases Greenhouse Gas (GHG) [1]. However, to achieve energy sustainability triangle objectives that make an impact on (people, profit, and the planet) by switching to green sources [2]. A group of 17 worldwide objectives known as the Sustainable Development Goals (SDGs) were adopted by the United Nations in 2015 [3]. In order to establish a more sustainable world by 2030 [4], they offer a framework for solving different social [5], economic [6], and environmental issues [7]. The objectives address a variety of topics, such as the eradication of poverty [8], high-quality education, gender equality, sustainable energy, responsible consumption and production, and climate action [9]. The SDGs seek to safeguard the environment while advancing world peace, prosperity, and well-being for all of goals [10]. To make everyone's future better, numerous nations and organizations around the world work to achieve these objectives [11]. Electricity in rural areas is facing power challenges to meet the power demand because of the distances of the energy sources or the higher cost of connecting to the public grid [12].

Based on current literature, several technologies have been employed for Low Voltage (LV) distribution networks along with the integration with various sources [3]. Furthermore, addressing power issues when considering more than one source is a hot topic and has been taken into consideration by numerous scholars in choosing the optimal method when integrating EV and without EV [13]. Additionally, battery degradation is overcome by the RESs integration to gain an optimal battery capacity for a hybrid grid-connected system [14]. Energy generation systems considering PV connected along with other sources to charge the EV and other domestic appliances leads to achieving sustainable development goals [15]. Energy management strategy and controls for EVs are conducted in [16]. In addition, metaheuristic algorithms are used in order to address sizing and optimality for the engineering system as mentioned in [17], [18].

In contrast, RESs face various challenges as mentioned in [19]. Several optimization algorithms are presented in the literature for integrated microgrid systems for distributed energy considering renewable energy sources [20]. Simultaneously, a new study considering a stochastic Monte Carlo is implemented along with a sensitivity analysis conducted in order to assess the charging operation for the Vehicle-to-Home (V2H) strategy [21].

The article contributes to the knowledge by presenting and analyzing the climatology data for the case study and listing a solution to sustainable life by meeting sustainable goals. The rest of the article is organized as follows: Section 2 renewable energy and sustainable development in the case study along with the roles of RESs. The technical analysis that listed the load demand, and climatology analyzed data in Section 3. The discussion of obtained result has been discussed in Section 4 in order to present the charge and discharge energy along with the output power from renewables. Eventually, the conclusion and references.

2. Renewable energy and sustainable development in the case study

Generally, electricity has been generated from various sources considering either conventional power plants such as unclear and coal or renewables such as solar panels and wind turbines [22]. Due to the benefits proved by the hybrid system such as assessing energy demand [23], resources assessments [24], system design [25], and environmental impacts [26], and leads to meeting sustainable development goals as demonstrated in Figure 1 [2].

Figure 1. Sustainable development goals.

2.1 RESs roles for GHG reduction

There are different aims of RES such as reducing the GHG [27]. Based on the IEA collected data, the comparison of GHG is illustrated in Figure 2 [4].

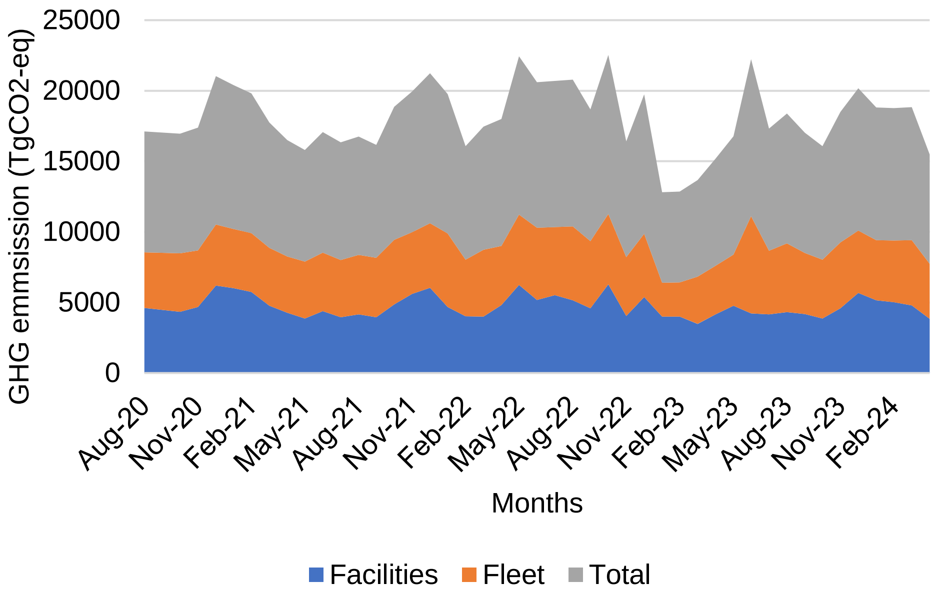

Figure 2. Greenhouse Gas emission percentage.

2.2 Renewable energy in the case study

The integration of Energy sources in the proposed hybrid system as shown in Figure 3 is based on an off-grid system that aims to charge EV and domestic devices from RESs (PV and WT) [28].

Figure 3. Proposed diagram.

3. Technical analyses

The utilized load demand for the case study is demonstrated in Figure 4 [29]. The monthly load demand for the whole of the year considering the first 24 hours.

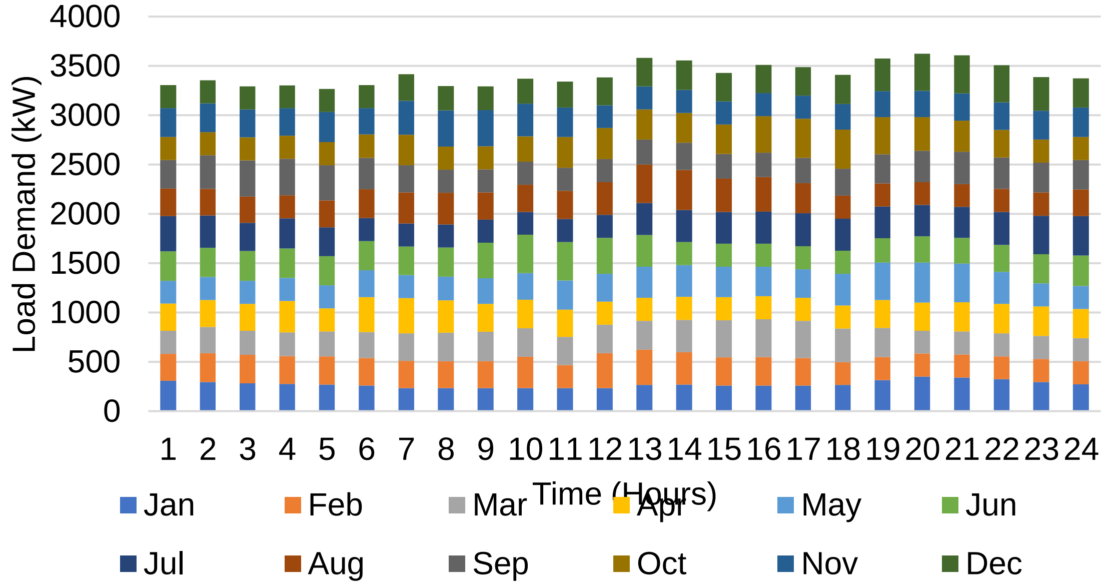

Figure 4. Load demand

3.1 PV analysis output power

Based on the mathematical equation utilized in the literature with the help of the climatology data to estimate the output power from renewables as in Figure 5 and Figure 6 for solar radiation and ambient temperature, respectively.

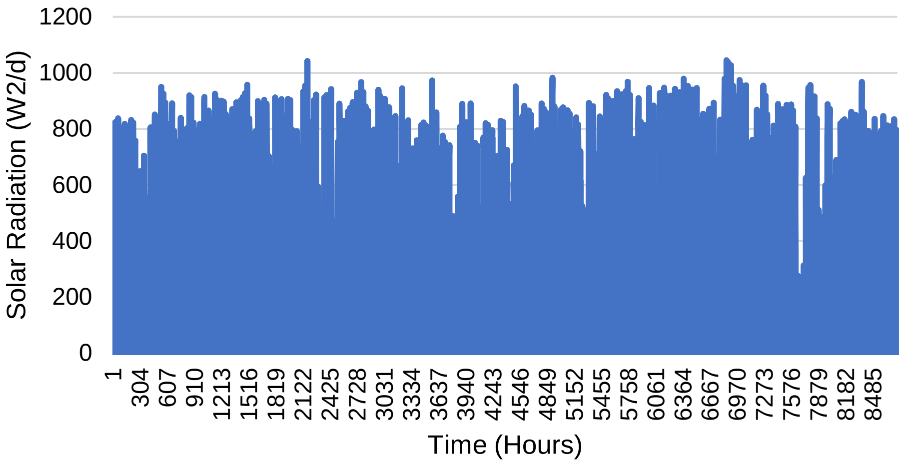

Figure 5. Solar radiation data.

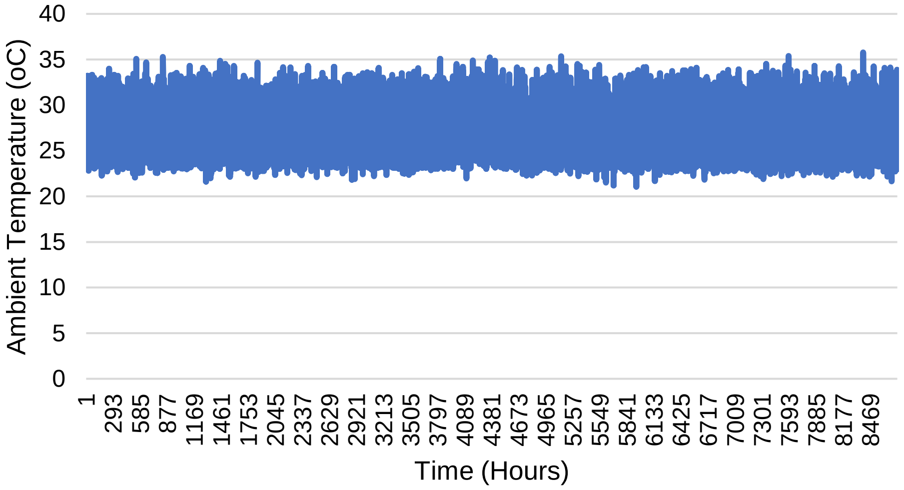

Figure 6. Temperature data.

3.2 WT analysis output power

The collected data on wind speed is demonstrated in Figure 7 shows the yearly analyzed data for 8760 hours of the case study.

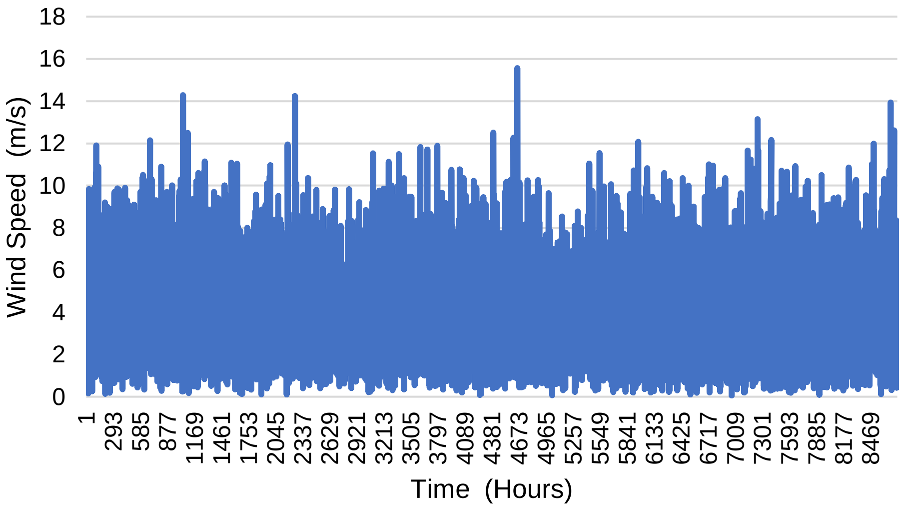

Figure 7. Wind speed data

The followed methodology in this study based on MATLAB software is demonstrated in Figure 8.

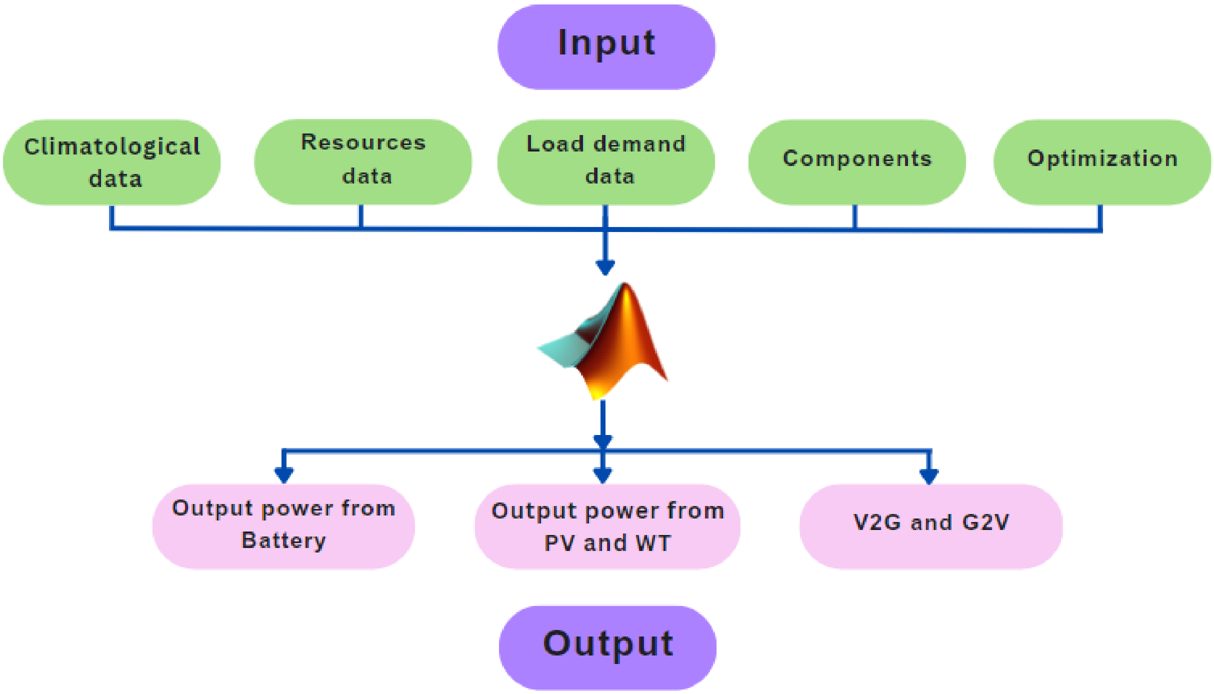

Figure 8. The architecture of the system operation

4. Results and discussion

The output power from BT is presented in Figure 9, the obtained result is shown in the case of 24 hours which illustrates the situation when charging case which refers to the sufficient moment of meeting the demand. On the contrary, the case of not sufficient case that is not able to meet the demand.

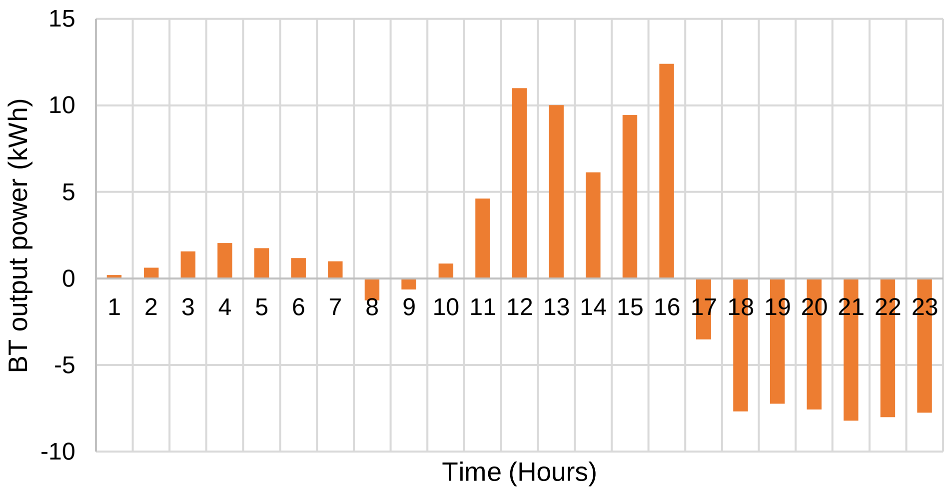

Figure 9. Battery output power.

The case of charging and discharge is demonstrated in Figure 10 (a and b), respectively. The output power from the utilized renewables (PV and WT) is Figure 11.

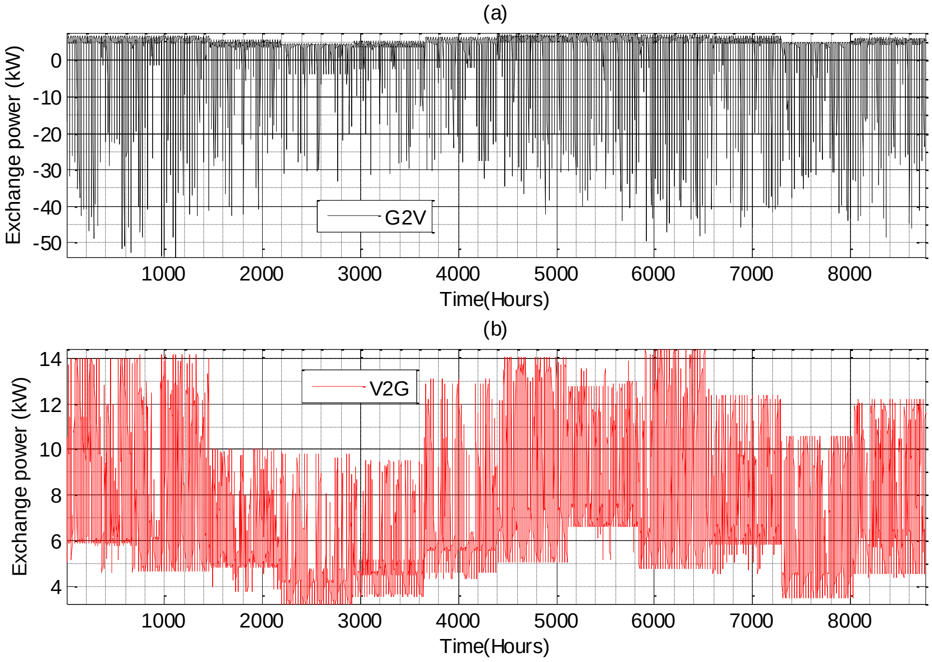

Figure 10. Output power for charge and discharge operations.

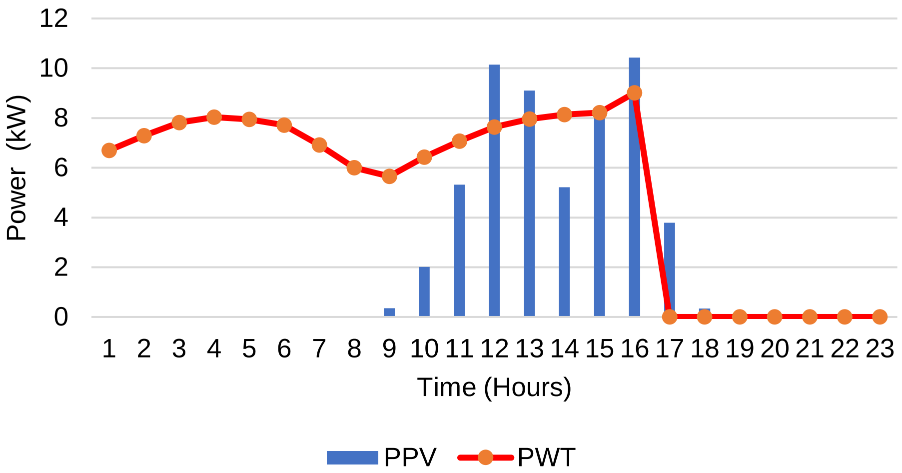

Figure 11. RESs output power.

5. Conclusion

Stand-alone hybrid systems are a promising option for reaching sustainable energy goals, according to the analysis of their energy sustainability. Several energy sources, including solar, wind, and battery storage, are combined by these systems to maximize energy production and consumption. Multiple significant advantages apply to standalone hybrid systems. By offering a steady power supply even when there is no grid connection, they improve energy reliability in the first place. For rural places or applications that operate off the grid, this is especially crucial. The second benefit of these systems is that they lessen reliance on fossil fuels, which helps to fight climate change and cut greenhouse gas emissions. In addition, by utilizing complementary energy sources, standalone hybrid systems enable optimal use of the resources that are already accessible. While wind turbines may produce electricity at night, solar panels can do so during the day. Users have easy access to knowledge, advice, and tools for regulating energy usage, increasing system performance, and maximizing energy output.

Through this connection, knowledge can be shared more easily, and users may make more educated choices to increase the sustainability of their energy use.

References

[1] A. Alsharif *et al.*, “Impact of Electric Vehicle on Residential Power Distribution Considering Energy Management Strategy and Stochastic Monte Carlo Algorithm,” *Energies (Basel)*, vol. 16, no. 3, p. 1358, Jan. 2023, doi: 10.3390/en16031358.

[2] A. Razmjoo, R. Shirmohammadi, A. Davarpanah, and F. Pourfayaz, “Stand-alone hybrid energy systems for remote area power generation,” *Energy Reports*, vol. 5, pp. 231–241, 2019, doi: 10.1016/j.egyr.2019.01.010.

[3] W. Pinthurat, B. Hredzak, G. Konstantinou, and J. Fletcher, “Techniques for compensation of unbalanced conditions in LV distribution networks with integrated renewable generation: An overview,” *Electric Power Systems Research*, vol. 214, no. PB, p. 108932, Jan. 2023, doi: 10.1016/j.epsr.2022.108932.

[4] S. Li, T. Zhang, L. Niu, and Q. Yue, “Analysis of the development scenarios and greenhouse gas (GHG) emissions in China’s aluminum industry till 2030,” *J Clean Prod*, vol. 290, p. 125859, 2021, doi: 10.1016/j.jclepro.2021.125859.

[5] O. M. Bătae, V. D. Dragomir, and L. Feleagă, “The relationship between environmental, social, and financial performance in the banking sector: A European study,” *J Clean Prod*, vol. 290, p. 125791, Mar. 2021, doi: 10.1016/j.jclepro.2021.125791.

[6] P. Ritala, L. Albareda, and N. Bocken, “Value creation and appropriation in economic, social, and environmental domains: Recognizing and resolving the institutionalized asymmetries,” *J Clean Prod*, vol. 290, p. 125796, 2021, doi: 10.1016/j.jclepro.2021.125796.

[7] S. M. Zahraee, N. Shiwakoti, and P. Stasinopoulos, “Biomass supply chain environmental and socio-economic analysis: 40-Years comprehensive review of methods, decision issues, sustainability challenges, and the way forward,” *Biomass Bioenergy*, vol. 142, p. 105777, 2020.

[8] B. Bacar, A. Almaktoof, A. M. Khalat, and M. K. Elmezughi, “Smart metering and energy access programs: An approach to energy poverty reduction in sub-Saharan Africa,” in *2022 IEEE 2nd International Maghreb Meeting of the Conference on Sciences and Techniques of Automatic Control and Computer Engineering, MI-STA 2022 - Proceeding*, 2022, pp. 127–132. doi: 10.1109/MI-STA54861.2022.9837661.

[9] N. AbouSeada and T. M. Hatem, “Climate action: Prospects of green hydrogen in Africa,” *Energy Reports*, vol. 8, pp. 3873–3890, 2022, doi: 10.1016/j.egyr.2022.02.225.

[10] N. M. Kumar, S. S. Chopra, A. A. Chand, R. M. Elavarasan, and G. M. Shafiullah, “Hybrid Renewable Energy Microgrid for a Residential Community: A Techno-Economic and Environmental Perspective in the Context of the SDG7,” *Sustainability*, vol. 12, no. 10, p. 3944, May 2020, doi: 10.3390/su12103944.

[11] W. Ji, M. Nicholas, and G. Tal, “Electric vehicle fast charger planning for metropolitan planning organizations: Adapting to changing markets and vehicle technology,” *Transp Res Rec*, vol. 2502, no. 1, pp. 134–143, Jan. 2015, doi: 10.3141/2502-16.

[12] M. M. Kamal, A. Mohammad, I. Ashraf, and E. Fernandez, “Rural electrification using renewable energy resources and its environmental impact assessment,” *Environmental Science and Pollution Research*, 2022, doi: 10.1007/s11356-022-22001-3.

[13] M. S. T. Hussain, D. N. Bin Sulaiman, M. S. T. Hussain, and M. Jabir, “Optimal Management strategies to solve issues of grid having Electric Vehicles (EV): A review,” *J Energy Storage*, vol. 33, no. October 2020, p. 102114, Jan. 2021, doi: 10.1016/j.est.2020.102114.

[14] D. Azuatalam, K. Paridari, Y. Ma, M. Förstl, A. C. Chapman, and G. Verbič, “Energy management of small-scale PV-battery systems: A systematic review considering practical implementation, computational requirements, quality of input data and battery degradation,” *Renewable and Sustainable Energy Reviews*, vol. 112, no. June, pp. 555–570, 2019, doi: 10.1016/j.rser.2019.06.007.

[15] S. Aghajan-Eshkevari, S. Azad, M. Nazari-Heris, M. T. Ameli, and S. Asadi, “Charging and Discharging of Electric Vehicles in Power Systems: An Updated and Detailed Review of Methods, Control Structures, Objectives, and Optimization Methodologies,” *Sustainability*, vol. 14, no. 4, p. 2137, Feb. 2022, doi: 10.3390/su14042137.

[16] K. Araújo, J. L. Boucher, and O. Aphale, “A clean energy assessment of early adopters in electric vehicle and solar photovoltaic technology: Geospatial, political and socio-demographic trends in New York,” *J Clean Prod*, vol. 216, pp. 99–116, Apr. 2019, doi: 10.1016/j.jclepro.2018.12.208.

[17] A. Alsharif, C. W. Tan, R. Ayop, A. Ali Ahmed, M. Mohamed Khaleel, and A. K. Abobaker, “Power Management and Sizing Optimization for Hybrid Grid-Dependent System Considering Photovoltaic Wind Battery Electric Vehicle,” in *2022 IEEE 2nd International Maghreb Meeting of the Conference on*

Sciences and Techniques of Automatic Control and Computer Engineering (MI-STA), IEEE, May 2022, pp. 645–649. doi: 10.1109/MI-STA54861.2022.9837749.

[18] M. Khaleel, A. A. Ahmed, and A. Alsharif, "Artificial Intelligence in Engineering," *Brilliance: Research of Artificial Intelligence*, vol. 3, no. 1, pp. 32–42, Mar. 2023, doi: 10.47709/brilliance.v3i1.2170.

[19] O. Ellabban, H. Abu-Rub, and F. Blaabjerg, "Renewable energy resources: Current status, future prospects and their enabling technology," *Renewable and Sustainable Energy Reviews*, vol. 39, pp. 748–764, 2014, doi: 10.1016/j.rser.2014.07.113.

[20] Z. Abdmouleh, A. Gastli, L. Ben-brahim, M. Haouari, and N. A. Al-emadi, "Review of optimization techniques applied for the integration of distributed generation from renewable energy sources," *Renew Energy*, vol. 113, pp. 266–280, 2017, doi: 10.1016/j.renene.2017.05.087.

[21] A. Alsharif, A. A. Ahmed, M. M. Khaleel, A. S. D. Alarga, Omer. S. M. Jomah, and A. B. E. Alrashed, "Stochastic Method and Sensitivity Analysis Assessments for Vehicle-to-Home Integration based on Renewable Energy Sources," in *2023 IEEE 3rd International Maghreb Meeting of the Conference on Sciences and Techniques of Automatic Control and Computer Engineering (MI-STA)*, IEEE, May 2023, pp. 783–787. doi: 10.1109/MI-STA57575.2023.10169210.

[22] N. Mithulananthan, D. Q. Hung, and K. Y. Lee, "Intelligent Network Integration of Distributed Renewable Generation," *Chapter 2:Distribution System Modelling*, no. January, pp. 21–29, 2017, doi: 10.1007/978-3-319-49271-1.

[23] E. Shahrabi, S. M. Hakimi, A. Hasankhani, G. Derakhshan, and B. Abdi, "Developing optimal energy management of energy hub in the presence of stochastic renewable energy resources," *Sustainable Energy, Grids and Networks*, vol. 26, p. 100428, 2021, doi: 10.1016/j.segan.2020.100428.

[24] L. La Picirelli de Souza *et al.*, "Life cycle assessment of prospective scenarios maximizing renewable resources in the Brazilian electricity matrix," *Renewable Energy Focus*, vol. 44, pp. 1–18, 2023, doi: 10.1016/j.ref.2022.11.002.

[25] Y. Sawle, S. C. Gupta, and A. K. Bohre, "Socio-techno-economic design of hybrid renewable energy system using optimization techniques," *Renew Energy*, vol. 119, pp. 459–472, Apr. 2018, doi: 10.1016/j.renene.2017.11.058.

[26] M. M. Khaleel, A. A. Ahmed, and A. Alsharif, "Energy Management System Strategies in Microgrids: A Review," *The North African Journal of Scientific Publishing (NAJSP)*, vol. 1, no. 1, pp. 1–8, 2023.

[27] M. T. I. Khan, Q. Ali, and M. Ashfaq, "The nexus between greenhouse gas emission, electricity production, renewable energy and agriculture in Pakistan," *Renew Energy*, vol. 118, pp. 437–451, Apr. 2018, doi: 10.1016/j.renene.2017.11.043.

[28] S. M. Shariff, D. Iqbal, M. Saad Alam, and F. Ahmad, "A State of the Art Review of Electric Vehicle to Grid (V2G) technology," *IOP Conf Ser Mater Sci Eng*, vol. 561, no. 1, p. 012103, Oct. 2019, doi: 10.1088/1757-899X/561/1/012103.

[29] T. F. Agajie *et al.*, "A Comprehensive Review on Techno-Economic Analysis and Optimal Sizing of Hybrid Renewable Energy Sources with Energy Storage Systems," *Energies (Basel)*, vol. 16, no. 2, p. 642, Jan. 2023, doi: 10.3390/en16020642.