Integrating Renewable Energy Sources with Electric Vehicle Infrastructure for Enhanced Renewability

Abdussalam Ali Ahmed[1], Abdulgader Alsharif[2], Mohammed Khaleel[3], Yassar F. Nassar[4], Adel Obelaid[5], Mohit Bajaj[6,7,8,9], Ankit Bhatt[6], Subhashree Choudhury[10]

[1] Mechanical Engineering Department, Faculty of Engineering, Bani Waleed University, Bani Walid, Libya
[2] Department of Electrical and Electronic Engineering, Faculty of Technical Sciences, Sebha-Sebha-Libya
[3] Research and Development Department, College of Civil Aviation, Misrata, Libya
[4] Mechanical & Renewable Energy, Engineering Department., Wadi Alshatti University, Brack-Libya
[5] Laboratoire de Technologie Industrielle et de l'Information, Faculté de Technologie, Université de Bejaia, 06000, Bejaia, Algeria
[6] Department of Electrical Engineering, Graphic Era (Deemed to be University), Dehradun-248002, India
[7] Hourani Center for Applied Scientific Research, Al-Ahliyya Amman University, Amman, Jordan
[8] Graphic Era Hill University, Dehradun, 248002, India
[9] Applied Science Research Center, Applied Science Private University, Amman-11937, Jordan
[10] Dept. of EEE, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, India

subhashreechoudhury@soa.ac.in

Abstract. This study proposes a model system that integrates utility grid integration, batteries, and renewable energy sources (RESs) with electric vehicles (EVs). The aforementioned hybrid microgrid system model was created with the goal of maximizing the Renewable Energy Fraction (REF) as the primary goal of this study. Based on the integration of the aforementioned components, green energy may be produced; nevertheless, the distribution system may be jeopardized if not correctly controlled. The climatology data and load demand data were collected from the PVWatt established by the International Renewable Energy Agency (IRENA). The paper presents the hybrid system development and implantation of the microgrid system integration for exchanging energy for the purpose of charging and discharging in a bidirectional way. These examination cases have been simulated, and results were analyzed using a sophisticated simulation tool, namely MATLAB R2021a. As a result, the objective function of renewability has been achieved with a maximum value of 50 %.

Keywords: RESs, EV, BT, REF, MATLAB

1. Introduction

It becomes imperative to seek an alternative energy source that is sustainable, environmentally friendly, and cost-effective [1]. The amount of energy that can be exchanged between the grid and an Electric Vehicle (EV) is governed by several factors [2]. Along with the vehicle and charging station's capabilities, local laws, and safety restrictions are also taken into consideration [3]. The maximum charging and discharging power of the vehicle and the charging station, in general, govern the quantity of energy that may be exchanged [4]. The

ICISML 2024, January 05-06, Pune, India

DOI 10.4108/eai.5-1-2024.2342575

maximum charging power for the majority of EVs is roughly 50 kW, while certain high-performance EVs can manage even faster charging rates [5]. To keep the system secure and stable, the charging station must be able to provide the car with the necessary power, and the power exchange between the vehicle and the grid must be controlled [6].

The maximum amount of energy that can be exchanged depends on a variety of factors, including technical capability, local legislation, and safety requirements. For example, some jurisdictions may have regulations that limit the maximum charging power to protect the electrical grid from overloading. Domestic and commercial EV charging refers to the types of charging stations available for electric vehicles (EVs) [3]. The basis of a manufacture description for the Tesla Model S and Nissan Leaf as examples that could store almost 80 -100 kWh of energy as electric fuel [7]. Additionally, an EV battery capacity of 60 kWh could offer enough energy to run essential home appliances for 1 or 2 days [8]. While 1 kWh could provide power to run a refrigerator for almost 5 hours [9]. According to the aforementioned statement, the amount of energy that an EV could provide is based on various factors, such as the capacity of the EV battery measured in kWh and charging pattern [10],

The most frequently exploited RESs are PV and WT, along with their advanced technologies [11]. The developing growth in PV among researchers is increasing due to the supper provided benefits and the requirements of meeting the electricity demand with clean energy [3]. Various methods were taken into consideration in order to control the operational mechanism in hybrid RESs, such as using nature-inspired metaheuristics to size the system components [12].

The article's contribution is the analysis of the share of renewable energy in the RES used in the proposed hybrid grid integration system that includes both EVs and RESs. The following sections are organized as follows: While Section 3 provides the mathematical formulae for the exploited combinations, Section 2 digs into the processes and materials. Section 4 provides a summary of the acquired results and a concise commentary. Final thoughts and references round out the piece.

2. Methods and materials

Various simulation tools and software were exploited in the literature to present the performance and analysis of RES systems [13]. Continuously to the aforementioned reference, in [14], the electric vehicle charging technology along with the RESs integration were deeply discussed as the EV globally become the forerunners in vehicle technology. The impact of EVs can be categorized into the economic, grid, and environment [15], [16]. Besides, the effect of EVs into the grid and RESs [17]. These are some of the ways in which the integration of EVs has an impact, as demonstrated in Figure 1. As the technology continues to evolve and become more widespread, it is likely that the impact will become even more pronounced [18].

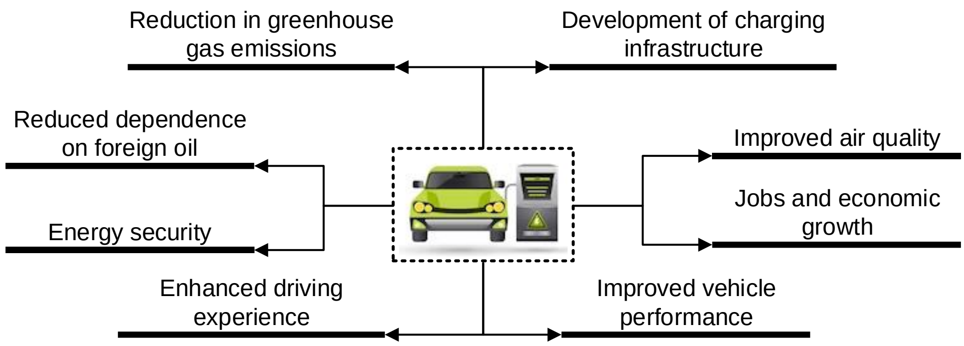

Figure 1. Samples of electric vehicle impacts

The Libyan Center for Solar Energy Research and Studies [19], PVWtt [20], the International Energy Agency (IEA) [21], and the International Renewable Energy Agency (IRENA) [22] serve as pivotal hubs for data collection and consultancy. Recognizing the global energy demand and heightened environmental awareness, the European Wind Energy Association (EWEA) set a target in 2030 to fulfill 23% of the European electricity demand [17]. Hence, choosing a proper site could improve the efficiency of electricity generation through wind energy [11]. The global comparison of the installation between the most widely used RESs (PV and WT) in Gigawatts is plotted in Figure 2. In addition, the various forms of RESs can be used in different locations such as (buildings, industry, and agriculture) as illustrated in Figure 3 for the Global comparison increase in renewable energy consumption by source and sector in the period of 2020-2025 is demonstrated in Exajoule (EJ), where 1 EJ = 1018 J [23]. Besides, as presented in Figure 3, with the increases of RESs in the building section, the WT is increasing among consumers globally, as shown in Figure 4.

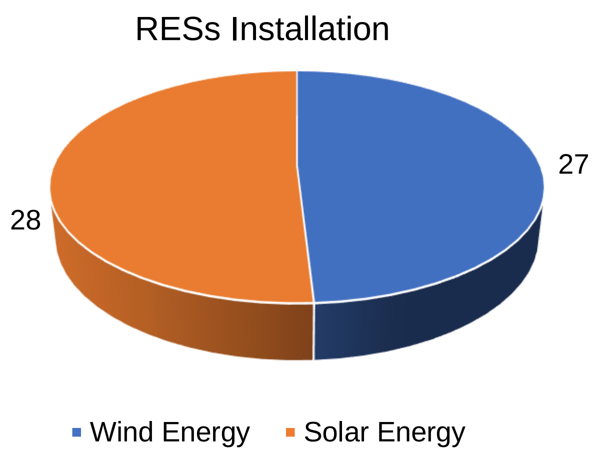

Figure 2. Global solar and wind energy installation in Gigawatts based on IRENA [24], [25].

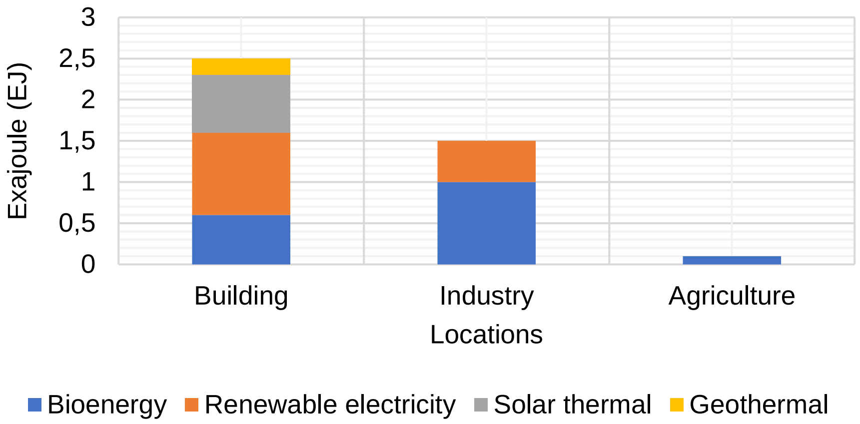

Figure 3. Increase in global renewable energy consumption by source and industry, based on IEA projections for 2020 to 2025 [23].

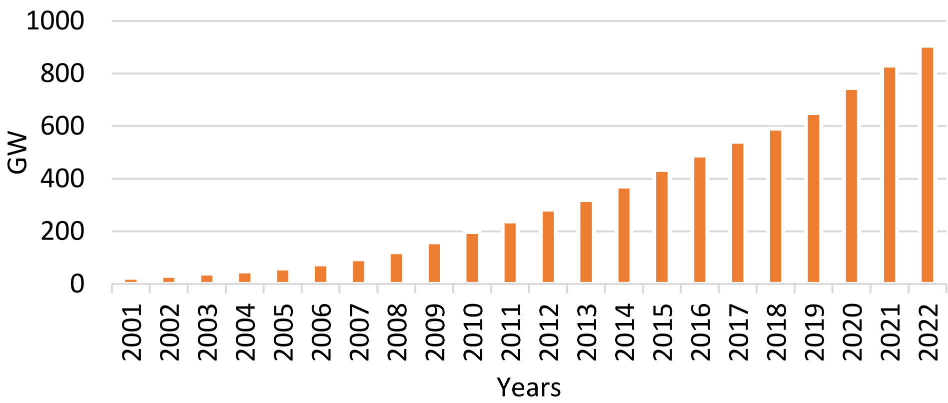

Figure 4. The total installed global wind power capacity from 2001 to 2022.

The climatology data plays an essential role in analyzing and is capable of estimating the output generation from the RESs with the help of mathematical equations, as will be presented in the next section [26]. Besides. To make it easy for customers to understand, along with the load demand data for the same case study,

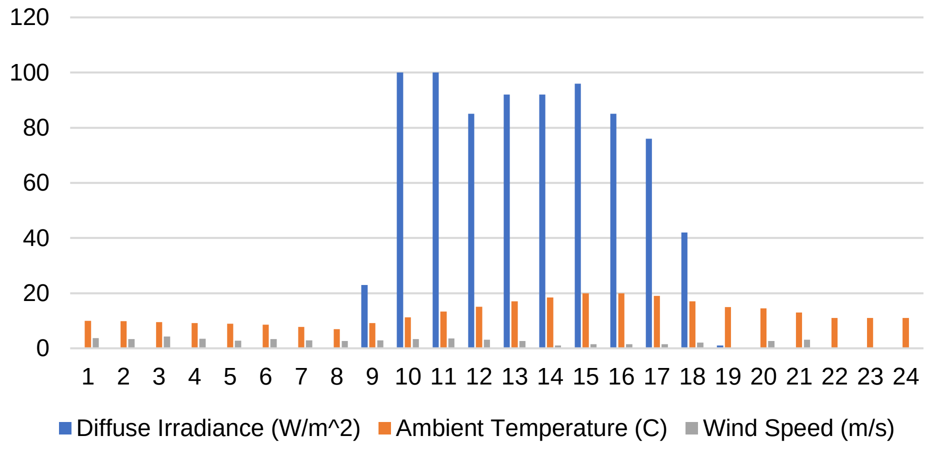

Figure 5. Weather data (irradiance, temperature, and wind speed) for the case study [26].

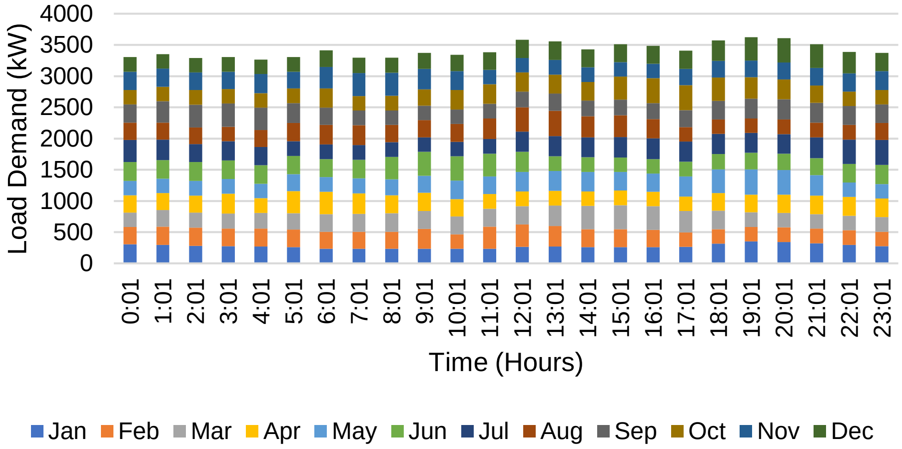

Figure 6. Annual average of Load demand data [26].

The utilization of EVs as another energy resource that has the ability to run home appliances, however, brings overloading into the utility grid [11]. The aforementioned limitation could be addressed by integrating an energy storage battery that is used as backup when the load cannot be met or the generated energy is low. The operation of the arrival and departure EV from and to the charge station is demonstrated in Figure [24].

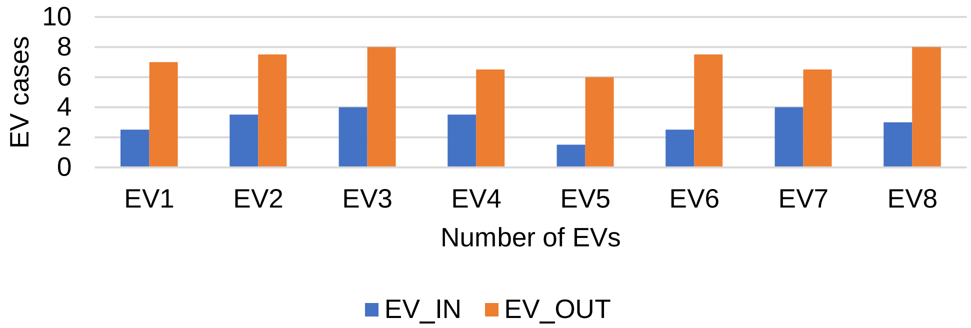

Figure 7. Arrival and Departure of EVs into the charge station [27].

3. Mathematical equation of the hybrid proposed system and objective

Due to a number of power system limitations, RESs were integrated with the utility grid and EVs. This section [28] discusses the suggested system's mathematical equation. In the proposed hybrid system, multiple sources are integrated, and the PV and WT could generate electricity based on the climatological conditions at the moment of generation, which refers to random behavior. Furthermore, on sunny days, the PV gives abundant power. On the other hand, on cloudy or unwindy days, the WT could generate power; nonetheless, it won't be enough to satisfy the demand. Hence, to solve the aforesaid weather limitation, energy storage must be integrated into the hybrid system. Moreover, the mathematical behavior that represents each component action is expressed in the subsection.

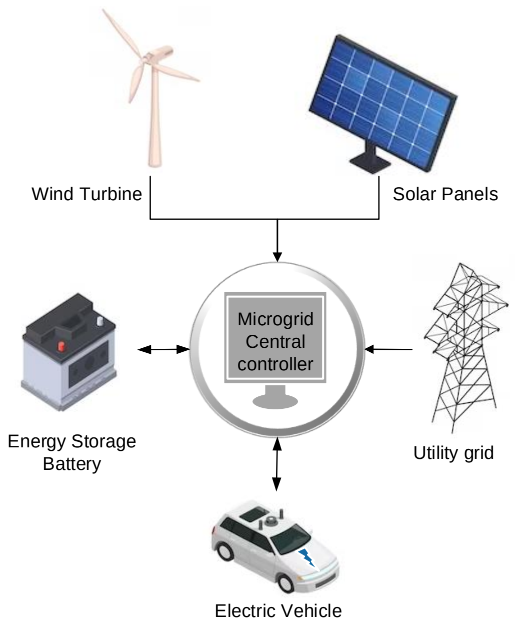

Figure 8. Microgrid proposed architecture.

3.1 WT Farm

In nature, the wind can generate electricity through a wind turbine, a sophisticated tool with three blades known as kinetic energy [15], [16]. The manipulated wind turbine in this study is NPS 100C-24 with the provided description from the manufacturer as a rated power (P_r) is 59.9 kW with 3 and 25 m/s as cut in (v_{cut-in}) and cut out ($v_{cut-out}$) wind speed, respectively. The assessed output generated power (P_{WT}) from the aforementioned wind turbine can be statistically stated in Eq. (1). The rated wind speed of the utilized WT is 11m/s.

$$P_{WT}(t) = \begin{cases} 0 & v(t) \leq v_{cut-in} \\ P_r \dfrac{v(t) - v_{cut-in}}{v_r - v_{cut-out}} & v_{cut-in} < v_r \\ P_r & v_r < v(t) < v_{cut-out} \end{cases} \quad (1)$$

3.2 PV Farm

The PV is an essential tool that converts the sunlight into electricity. This study's exploited type of PV panel is SHARP ND-240QCJ (Polycrystalline), which produces 240 W, NOCT is the nominal operation cell temperature that equals 47.5 ℃ [29]. The estimated output power ($P_{pv_{out}}$) from the considered PV can be mathematically expressed in Eq. (2) with the help of the value of $T_{C(STC)}$ that refers to cell temperature of standard test of the cell that presented in Eq. (3).

$$P_{pv_{out}}(t) = P_{(PV_{rated})*} \frac{G_{(t)}}{1000} * \left[1 + \alpha_t \left(T_{amb} + \left(\left(\frac{NOCT - 20}{800}\right) * G_t\right)\right) - T_{C_{STC}}\right] \quad (2)$$

$$T_{C(STC)} = T_{Amb} + G_{(t)} * 0.0256 \quad (3)$$

3.3 Utility grid

The utility grid may face some energy crises as a primary available source. The operation integration of the utility grid within the system components for purchasing and selling operations is mathematically presented in Eq. (4) and Eq. (5), respectively. Besides, for V2G operation, the bidirectional function has been considered in the following equation [30].

$$P_P^{grid}(t) = P_{EV_{Dem}}(t) - \left[P_{PV}(t) + \left[\left(SOC_{BT}(t) - SOC_{BT}^{min}(t)\right) \times \eta_{inv}\right]\right] \quad (4)$$

$$P_S^{grid}(t) = \left[P_{PV}(t) + \left[\left(SOC_{BT}(t) - SOC_{BT}^{max}(t)\right) \times \eta_{inv}\right]\right] - P_{EV_{Dem}}(t) \quad (5)$$

3.4 BT

The operation of charging and discharging of the conducted deep cycle battery as a chemical reaction can be mathematically expressed in Eq. (6) and Eq. (7). The integrated type of the battery is lithium-ion [31].

$$SoC(t) = SoC(t-1).(1-\sigma) + \left(\left(P_{PV}(t) + P_{WT}(t)\right) - \frac{P_L(t) + P_{EV_{Dem}}}{\eta_{inv}}\right) \times \eta_b \quad (6)$$

$$SoC(t) = SoC(t-1).(1-\sigma) + \left(\frac{P_L(t) + P_{EV_{Dem}}}{\eta_{inv}} - (P_{PV}(t) + P_{WT}(t))\right) \times \eta_b \quad (7)$$

3.5 Inverter

In a microgrid hybrid system, the process of transforming power involves utilizing an inverter. This device converts the direct current (DC) power produced by renewable sources like solar panels or wind turbines into alternating current (AC) power, which is suitable for consumption by electrical loads within the microgrid. It also allows for the conversion of AC power from the utility grid to DC power for battery storage to run home appliances and charge electric vehicles. The generated power from the inverter (P_{inv}) at time (t) can be mathematically estimated by Eq. (8) [15], [16].

$$P_{inv}(t) = \frac{P_l^m(t)}{\eta_{inv}} \quad (8)$$

3.6 EV

An area where electric cars may be charged is referred to as an electric vehicle charging station, often known as an EV charging station or an EV charger. These stations provide electricity to charge the batteries of electric vehicles, allowing them to travel longer distances. The type of EV considered is PHEV, while the power demand of EV and period time of charging are presented in Eq. (9) and Eq. (10), respectively [15].

$$P_{EV_{Dem}} = \frac{C_{\text{bat}}^{\text{EV}} \times \left(\text{SOC}_{max}^{\text{EV}} - SOC_{\text{min}}^{\text{EV}}\right)}{\text{T}} \quad (9)$$

$$\text{T} = Time_{Arr}^{EV} - Time_{Dep}^{EV} \quad (10)$$

3.7 Renewable energy fraction

The objective of renewability refers to the amount of energy generated from renewables [32]. This study's main considered renewable sources are PV and WT, while the REF can be mathematically expressed as in Eq. (11).

$$REF = \frac{\sum_1^{8760}(P_{PV} + P_{WT}) * \Delta t}{\sum_1^{8760}\left(P_{PV} + P_{WT} + P_{grid_{purchased}}\right) * \Delta t} \quad (11)$$

4. Results and discussion

According to the presented model in Figure 8, the results have been plotted and discussed. To show the higher ability to generate electricity from the RESs to run the home appliance and charge EVs, the output power from the two sources is shown in Figure 9. Furthermore, the summation value between the two sources is presented in gray, and the peak of the generated power is shown at 16 pm due to the higher amount of power produced from the wind and solar, respectively. The sunset hours presented in Figure 9 started at 18 pm, generating less power. The random state of charge of the EV battery could show the allowability of SOC, which is between 0 and 1 and has been created randomly, as demonstrated in Figure 10 as the weekly data for the first 24 hours of each day. Due to the proposed objective function of this study, increasing the dependency on renewable sources rather than the conventional, known as renewable energy fraction, is presented in Figure 11.

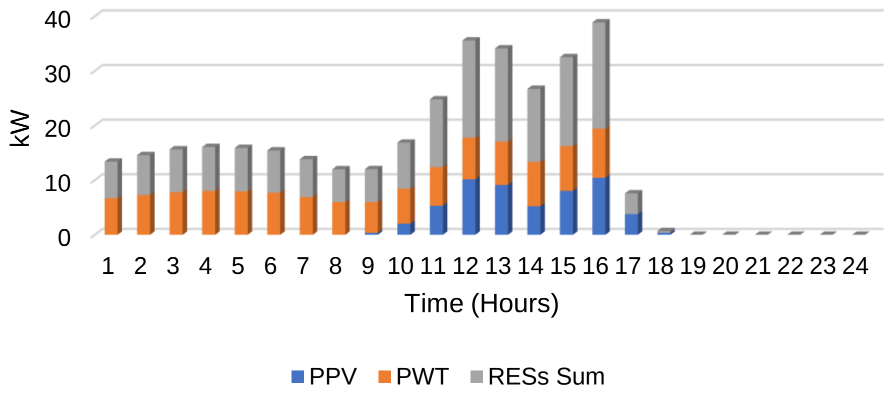

Figure 9. Comparison breakdown of output power from renewable sources.

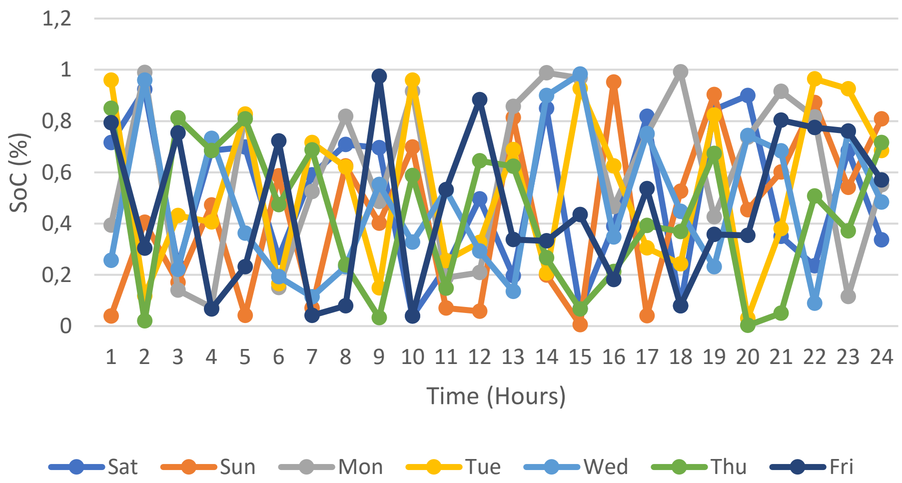

Figure 10. Weekly SoC of EV.

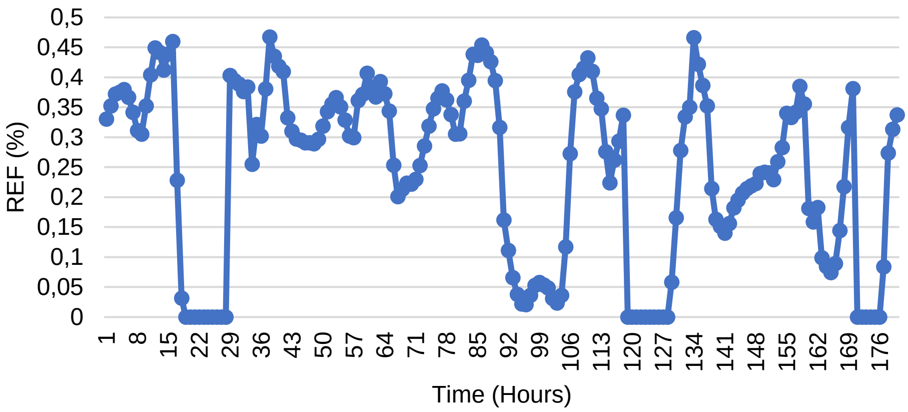

Figure 11. Renewable energy fraction output for 180 hours (a week).

5. Conclusion

In conclusion, the allowable amount of energy for exchange between the grid and an EV is determined by a combination of technical and regulatory factors. To ensure the safe and efficient exchange of energy, it is important to consider these factors when designing and operating the charging infrastructure. For future direction, other researchers depend on other RESs to be integrated, such as biomass and solar thermal energy, and integrated alternative storages, such as fuel cells with the electrolyzer due to its environmentally friendly products.

References

[1] Khosravi, Nima, Rasoul Baghbanzadeh, Adel Oubelaid, Marcos Tostado-Véliz, Mohit Bajaj, Zineb Hekss, Salwa Echalih, Youcef Belkhier, Mohamad Abou Houran, and Kareem M. Aboras. "A novel control approach to improve the stability of hybrid AC/DC microgrids." Applied Energy 344 (2023): 121261.

[2] Oubelaid, Adel, Nabil Taib, and Toufik Rekioua. "Performance Assessment of a Direct Torque Controlled Electric Vehicle considering Driving Cycles and Real Load Conditions." In 2019 International Conference on Advanced Electrical Engineering (ICAEE), pp. 1-6. IEEE, 2019.

[3] Oubelaid, Adel, Nima Khosravi, Youcef Belkhier, Nabil Taib, and Toufik Rekioua. "Health-conscious energy management strategy for battery/fuel cell electric vehicles considering power sources dynamics." Journal of Energy Storage 68 (2023): 107676.

[4] Mohamed, Nachaat, Saif Khameis Almazrouei, Adel Oubelaid, Mahmoud Elsisi, Basem M. ElHalawany, and Sherif SM Ghoneim. "Air-gapped networks: exfiltration without privilege escalation for military and police units." Wireless Communications and Mobile Computing 2022 (2022).

[5] Shanmugam, Y., Narayanamoorthi, R., Vishnuram, P., Savio, D., Yadav, A., Bajaj, M., Nauman, A., Khurshaid, T. and Kamel, S., 2023. Solar-powered five-leg inverter-driven quasi-dynamic charging for a slow-moving vehicle. Frontiers in Energy Research, 11. https://doi.org/10.3389/fenrg.2023.1115262.

[6] Hamed, S.B., Abid, A., Hamed, M.B., Sbita, L., Bajaj, M., Ghoneim, S.S., Zawbaa, H.M. and Kamel, S., 2023. A robust MPPT approach based on first-order sliding mode for triple-junction photovoltaic power system supplying electric vehicle. Energy Reports, 9, pp.4275-4297. https://doi.org/10.1016/j.egyr.2023.02.086.

[7] Muhammad Zeshan Afzal, Muhammad Aurangzeb, Sheeraz Iqbal, Mukesh Pushkarna, Anis Ur

Rehman, Hossam Kotb, Kareem M. AboRas, Nahar F. Alshammari, Mohit Bajaj, Viktoriia Bereznychenko, "A Novel Electric Vehicle Battery Management System Using an Artificial Neural Network-Based Adaptive Droop Control Theory", International Journal of Energy Research, vol. 2023, Article ID 2581729, 15 pages, 2023. https://doi.org/10.1155/2023/2581729.

[8] Kumar BA, Jyothi B, Rathore RS, Singh AR, Kumar BH, Bajaj M. A novel framework for enhancing the power quality of electrical vehicle battery charging based on a modified Ferdowsi Converter. Energy Reports. 2023 Nov 1; 10:2394-416.

[9] Mohammed Abdullah Ravindran, Kalaiarasi Nallathambi, Pradeep Vishnuram, Rajkumar Singh Rathore, Mohit Bajaj, Imad Rida, Ahmed Alkhayyat, "A Novel Technological Review on Fast Charging Infrastructure for Electrical Vehicles: Challenges, Solutions, and Future Research Directions", Alexandria Engineering Journal, Volume 82, 2023, Pages 260-290, ISSN 1110-0168, https://doi.org/10.1016/j.aej.2023.10.009.

[10] Khoudir Kakouche, Toufik Rekioua, Smail Mezani, Adel Oubelaid, Djamila Rekioua, Vojtech Blazek, Lukas Prokop, Stanislav Misak, Mohit Bajaj, and Sherif S. M. Ghoneim, "Model Predictive Direct Torque Control and Fuzzy Logic Energy Management for Multi Power Source Electric Vehicles" Sensors 22, no. 15: 5669, 2022. https://doi.org/10.3390/s22155669.

[11] Adel Oubelaid, Nabil Taib, Toufik Rekioua, Mohit Bajaj, Arvind Yadav, Mokhtar Shouran, Salah Kamel, "Secure Power Management Strategy for Direct Torque Controlled Fuel cell/ Supercapacitor Electric Vehicles" Frontiers in Energy Research, 2022. DOI: 10.3389/fenrg.2022.971357.

[12] Salah Beni Hamed, Mouna Ben Hamed, Lassaad Sbita, Mohit Bajaj, Vojtech Blazek, Lukas Prokop, Stanislav Misak, and Sherif S. M. Ghoneim, "Robust Optimization and Power Management of a Triple Junction Photovoltaic Electric Vehicle with Battery Storage" Sensors 22, no. 16: 6123, 2022. https://doi.org/10.3390/s22166123.

[13] Sarthak Mohanty, Subhasis Panda, Shubhranshu Mohan Parida, Pravat Kumar Rout, Binod Kumar Sahu, Mohit Bajaj, Hossam M. Zawbaa, Nallapaneni Manoj Kumar, Salah Kamel, "Demand side management of electric vehicles in smart grids: A survey on strategies, challenges, modeling, and optimization" Energy Reports, Volume 8, 2022, Pages 12466-12490, ISSN 2352-4847, https://doi.org/10.1016/j.egyr.2022.09.023.

[14] Panchanathan, Suresh, Pradeep Vishnuram, Narayanamoorthi Rajamanickam, Mohit Bajaj, Vojtech Blazek, Lukas Prokop, and Stanislav Misak. "A Comprehensive Review of the Bidirectional Converter Topologies for the Vehicle-to-Grid System." Energies 16, no. 5 (2023): 2503.

[15] E. Parimalasundar, R. Senthilkumar, B. Hemanth Kumar, K. Janardhan, Arvind R. Singh, Mohit Bajaj, Viktoriia Bereznychenko, "Artificial Neural Network-Based Experimental Investigations for Sliding Mode Control of an Induction Motor in Power Steering Applications", International Journal of Intelligent Systems, vol. 2023, Article ID 9381915, 14 pages, 2023. https://doi.org/10.1155/2023/9381915.

[16] Belkhier, Y., Abdelyazid, A., Oubelaid, A., Khosravi, N., Bajaj, M., Vishnuram, P., Zaitsev, I.: Experimental analysis of passivity-based control theory for permanent magnet synchronous motor drive fed by grid power. IET Control Theory Appl. 00, 1–16 (2023). https://doi.org/10.1049/cth2.12574.

[17] N. Kalaiarasi, A. Sivapriya, Pradeep Vishnuram, Mukesh Pushkarna, Mohit Bajaj, Hossam Kotb, Sadam Alphonse, "Performance Evaluation of Various Z-Source Inverter Topologies for PV Applications Using AI-Based MPPT Techniques", International Transactions on Electrical Energy Systems, vol. 2023, Article ID 1134633, 16 pages, 2023. https://doi.org/10.1155/2023/1134633.

[18] Srikanth Goud B, Naga Sai Kalyan C, Krishna D, Nagi Reddy B, Bajaj M, Choudhury S, Shukla S., "Power Quality Enhancement in PV integrated System Using GSA-FOPID CC-VSI Controller", EAI Endorsed Transactions on Scalable Information Systems, 2023. DOI: https://doi.org/10.4108/eetsis.3974.

[19] Panda, Subhasis, Sarthak Mohanty, Pravat Kumar Rout, Binod Kumar Sahu, Shubhranshu Mohan Parida, Indu Sekhar Samanta, Mohit Bajaj, Marian Piecha, Vojtech Blazek, and Lukas Prokop. "A comprehensive review on demand side management and market design for renewable energy support and integration." Energy Reports 10 (2023): 2228-2250.

[20] NREL, "PVWatts®," 2020. https://pvwatts.nrel.gov/pvwatts.php (accessed Oct. 19, 2020).

[21] Sahoo, Gagan Kumar, Subhashree Choudhury, Rajkumar Singh Rathore, Mohit Bajaj, and Ashit Kumar Dutta. "Scaled Conjugate-Artificial Neural Network-Based novel framework for enhancing the power quality of Grid-Tied Microgrid systems." Alexandria Engineering Journal 80 (2023): 520-541.

[22] IEA ETSAP and IRENA, "Renewable Energy Integration in Power Grids. Technology Brief," no. April, pp. 1–36, 2015.

[23] International Energy Agency (IEA), "Global increase in renewable energy consumption by source and sector, 2020-2025," 2023. https://www.iea.org/data-and-statistics/charts/global-increase-in-renewable-energy-consumption-by-source-and-sector-2020-2025 (accessed Aug. 30, 2023).

[24] Jena, Narendra Kumar, Subhadra Sahoo, Binod Kumar Sahu, Amiya Kumar Naik, Mohit Bajaj, Stanislav Misak, Vojtech Blazek, and Lukas Prokop. 2023. "Impact of a Redox Flow Battery on the Frequency Stability of a Five-Area System Integrated with Renewable Sources" Energies 16, no. 14: 5540. https://doi.org/10.3390/en16145540.

[25] Dominic Dudley, "Solar Overtakes Wind Energy For First Time In Global Rush For Renewables," 2022. https://www.forbes.com/sites/dominicdudley/2022/04/12/solar-overtakes-wind-energy-for-first-time-in-global-rush-for-renewables/?sh=6491633169a9 (accessed Aug. 24, 2023).

[26] Sahoo, G.K.; Choudhury, S.; Rathore, R.S.; Bajaj, M. A Novel Prairie Dog-Based Meta-Heuristic Optimization Algorithm for Improved Control, Better Transient Response, and Power Quality Enhancement of Hybrid Microgrids. Sensors 2023, 23, 5973. https://doi.org/10.3390/s23135973

[27] M. Bajaj, S. Aggarwal and A. K. Singh, "Power Quality Concerns with Integration of RESs into the Smart Power Grid and Associated Mitigation Techniques," 2020 IEEE 9th Power India International Conference (PIICON), Sonepat, India, 2020, pp. 1-6, doi: 10.1109/PIICON49524.2020.9113008.

[28] Tamalouzt, S.; Belkhier, Y.; Sahri, Y.; Bajaj, M.; Ullah, N.; Chowdhury, M.S.; Titseesang, T.; Techato, K. Enhanced Direct Reactive Power Control-Based Multi-Level Inverter for DFIG Wind System under Variable Speeds. Sustainability 2021, 13, 9060. https://doi.org/10.3390/su13169060

[29] SHARP, "SHARP PV module ND- 240QCJ." www.civicsolar.com (accessed Aug. 26, 2023).

[30] M. Bajaj, A. Flah, M. Alowaidi, N. K. Sharma, S. Mishra and S. K. Sharma, "A Lyapunov-Function Based Controller for 3-Phase Shunt Active Power Filter and Performance Assessment Considering Different System Scenarios," in IEEE Access, vol. 9, pp. 66079-66102, 2021, doi: 10.1109/ACCESS.2021.3075274.

[31] F. Aymen, M. Alowaidi, M. Bajaj, N. K. Sharma, S. Mishra and S. K. Sharma, "Electric Vehicle Model Based on Multiple Recharge System and a Particular Traction Motor Conception," in IEEE Access, vol. 9, pp. 49308-49324, 2021, doi: 10.1109/ACCESS.2021.3068262.

[32] M. Gharibi and A. Askarzadeh, "Size and power exchange optimization of a grid-connected diesel generator-photovoltaic-fuel cell hybrid energy system considering reliability, cost and renewability," *Int. J. Hydrogen Energy*, vol. 44, no. 47, pp. 25428–25441, Oct. 2019, doi: 10.1016/j.ijhydene.2019.08.007.