A Comprehensive Review in Addressing Environmental Barriers Considering Renewable Sources Integration and Vehicle-to-Grid Technology

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مراجعة شاملة في معالجة العوائق البيئية مع الأخذ في الاعتبار تكامل مصادر الطاقة المتجددة وتكنولوجيا الاتصال بالشبكة

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Abstract:
There is no doubt that environmental restrictions are getting worse every day affecting the living pattern that inhabits it and the natural world. Environmental and sustainable challenges have significant impacts on the health of ecosystems and humans that cause a negative impact that needs to be taken into consideration. Electric Vehicles (EVs) are considered as a prominent solution for the environmental and sustainability challenges that require more attention like global warming, Greenhouse Gas (GHG) emissions, and depletion of Fossil Fuel (FF) reserves. In FF-based, countries are facing environmental crises from the exhaust pipe of the Internal Combustion Engine Vehicle (ICEV) and electricity generation that ordinary needs to be switched to automobility to meet sustainability. Overall, this article provides interactive guidelines for researchers in Renewable Energy Sources (RESs) and EV integration to assist them in deciding on their further studies.

Keywords: EV, FF, GHG, ICEV, RESs.

الملخص
تتمتع ليبيا بإمكانات كبيرة للطاقة المتجددة بسبب وفرة مواردها من أشعة الشمس والرياح. ومن مصادر الطاقة المتجددة التي يمكن لليبيا تسخيرها (الطاقة الشمسية وطاقة الرياح والطاقة الحرارية الأرضية). أدى النمو المتقدم في قطاع النقل لاستخدام السيارات الكهربائية إلى زيادة شعبية استخدام السيارات الكهربائية الهجينة بدلاً من السيارات التقليدية بين الناس. ومع ذلك، يصبح نظام النقل معقدًا بسبب المكونات المستخدمة مثل دمج مصادر الطاقة المتجددة (**RESs**) في الشبكة لشحن وتفريغ المركبات الكهربائية، مما يؤدي إلى العديد من التحديات. يمكن التغلب على تحديات تقسيم الطاقة بين الأنظمة الفرعية الحرارية والكهربائية من خلال طريقة تحكم المشرف المعروفة باسم استراتيجيات إدارة الطاقة (**EMS**)، والتي تؤدي إلى تعظيم الاقتصاد في استهلاك الوقود وتقليل التلوث. تتم مناقشة النتيجة المكتسبة في قسم النتائج والمناقشة. إن **RESs** قادرة على تشغيل الأنظمة من خلال تكامل المركبات الكهربائية.

الكلمات المفتاحية: الطاقات المتجددة، السيارات الكهربائية، استراتيجيات إدارة الطاقة.

1 Introduction

Due to the changes in nature, most of the Renewable Energy Sources (RESs) such as Photovoltaic (PV) and Wind Turbines (WT) are ambient environmental based and produce an unpredictable output [1]. Environmental problems are brought on by human actions including industrialization, deforestation, the burning of fossil fuels, and inappropriate garbage disposal. Sustainable Development Goal Seven (SDG7) is considered as one of the sustainable development goals for achieving green energy and gaining a clean environment that refers to (cleaner and affordable energy) [2]. The main objective of the aforementioned goal is to gain a higher renewable fraction and minimum emission [3], [4]. Charge and discharge coordination between EVs and the grid is gaining interest as a decarbonization tool that provides ancillary services [5]–[7]. Emissions, increasing temperature, melting polar ice, sea level rise, and depletion of conventional sources are global faced challenges [8]. These limitations give a wake-up call to all humans to seek alternative solutions [9]. In this regard, the EV is introduced as a solution to the aforementioned problems since the EV is emitting zero exhaust gas with no noise as reported in the state-of-the-art [10]–[12].

Numerous conducted studies found in the literature considering on RESs, widely utilized RESs are Solar and wind that could sufficiently generate power that can provide a continuous source of energy when properly designed and integrated into the power grid [13]–[15]. Energy storage systems, such as batteries or pumped hydro storage, can also be used to store excess energy for later use [16], [17]. While the availability of solar and wind power depends on weather conditions, advanced forecasting models and energy storage systems can help mitigate these challenges [18], [19]

Different types of EVs are exploited to share energy for charging and discharging purposes. The EV can be classified into three main groups, Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV), and Plug-in Hybrid Electric Vehicle (PHEV). However, the PHEV is the most widely used type that is a hybridization of the Internal Combustion Engine Vehicle (ICEV) and BEV [20]. Furthermore, it forms the ICEV when using Internal Combustion (IC) is the based and the purely EV when switching to the Electric Motor Engine (EME) based on the speed and the situation on the road [21]. The utilized technology for forming the power exchange between the grid and EV using the electrification of the transportation system is known as vehicle-to-everything (V2X). One of the variant technologies of V2X is known as Vehicle-to-Grid (V2G) which can be referred to as Mobile Energy (ME), Smart Energy (SE), Virtual Power Plant (VPP) [1], [9], [22].

Various conducted studies were presented in the literature that considered the environmental issues, however, there is a lack of consideration of the V2G integration with RESs to meet the SDGs in order to overcome environmental barriers. The aforementioned limitation is gaining consideration in this article. The rest of the article is organized as follows: Section 2 is presenting a general view of environmental barriers considering CO_2 and emission. While the benefits of exploiting EV and RESs integration are placed in Section 3. Additionally, Section 4 denoted the barriers to EVs from an environmental perspective. Finally, Section 5 discusses the impacts of EV integration on the environment. The article is closed with a concluded summary followed by a list of references.

2 General Overview of Environmental Barriers

Since we are living in an era with various environmental issues such as IC emissions which affect the atmosphere, Carbon dioxide (CO_2), increasing average temperature, and air pollution that has influenced the lifestyle. Switching to EV could overcome the aforesaid challenges [23]. Environment barriers refer to obstacles or limitations that prevent individuals or groups from accessing or participating fully in various environments, such as schools, workplaces, public spaces, and social settings [24]. These barriers can take various forms, such as physical, social, cultural, economic, and political as tabulated in Table 1 along with their explanations. Environmental barriers have the potential to exclude individuals or groups from participating fully in society, and it is important to recognize and address these barriers to promote equal access and inclusion for all.

Table 1 Environmental barriers [25]–[27].

List of Barriers	Features
Physical barriers	Include the lack of accommodations for people with disabilities, such as wheelchair ramps or accessible restrooms
Social barriers	Include discrimination or prejudice based on factors such as race, religion, gender, sexual orientation, or age
Cultural barriers	Include language or cultural differences that prevent individuals from fully engaging in a particular environment
Economic barriers	Include financial constraints that limit a person's ability to access certain resources or participate in certain activities
Political barriers	Include legal or policy restrictions that limit access to certain environments or opportunities

3 Benefits of EV and RESs Integration

The technology of power exchange in a bidirectional way that refers to V2G is proving various advantages when integrated with RESs. Besides, all the provided benefits can be called as auxiliary services or ancillary services as figured out in Figure 1 and further descriptions are formulated in Table 2.

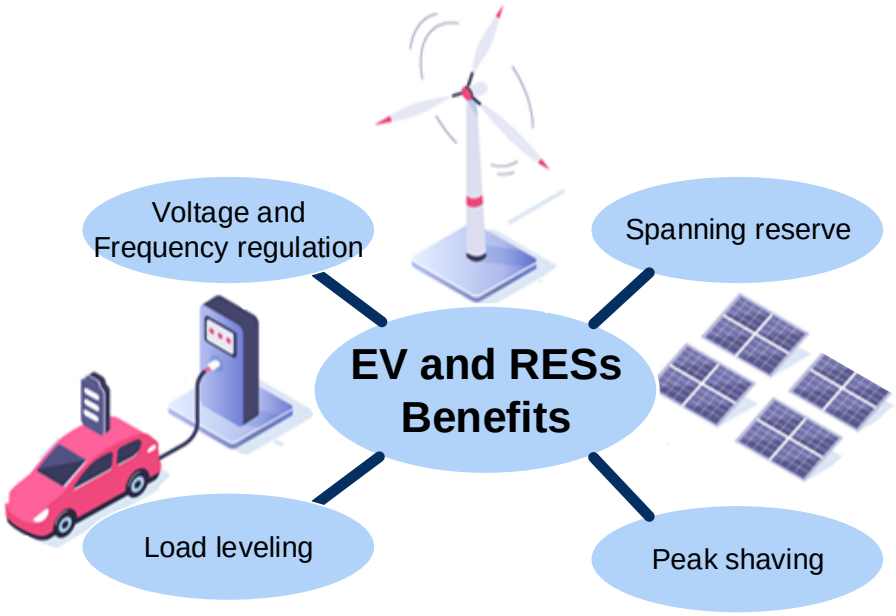

Figure 1: EV and RESs benefits [28]–[30]

Table 2 EV and RESs benefits [30]–[32]

EV and RESs benefits list	definitions
Voltage regulation	Helping to maintain the proper voltage levels on the grid.
Frequency regulation	• Providing power to the grid during periods of high demand • Helping to stabilize the grid's frequency.
Spinning reserve	• EVs can act as a reserve power source. • Quickly providing power to the grid when there is a sudden drop in supply
Load levelling	• Balancing the supply and demand of electricity on the grid • Storing excess energy in EVs during periods of low demand and releasing it during periods of high demand.
Peak shaving	• Helping to reduce peak demand by charging during periods of low demand. • Discharging during periods of high demand.

4 EVs with Environmental Barriers

The goal of V2G technology is to overcome environmental obstacles (Global warming, GHG emission, and Depletion of fossil fuel reserve) by allowing two-way electrical power transmission between the EV battery and the power grid as shown in Figure 2. By expanding the penetration of renewable energy sources, supplying voltage support, and obviating the need for costly grid infrastructure changes, V2G technology has the potential to lower carbon emissions and enhance air quality [33]. Examining V2G technology reveals that it has a lot of promise to solve environmental constraints in a variety of ways as listed below.

- Can assist in the grid integration of more RESs (wind and solar) by storing excess energy generated during periods of low demand and releasing it during times of high demand. As a result, there may be a lessening of dependency on fossil fuels and a decrease in carbon emissions. [34].
- Ensure that the grid receives crucial voltage support, especially when there is a lot of demand. V2G technology can stabilize the grid, avert blackouts, and lessen the need for costly infrastructure upgrades by supplying extra power during peak hours [35].

Reduce the need for costly grid infrastructure upgrades like new power plants, transmission lines, and transformers. Instead, V2G technology may take advantage of the current EV battery infrastructure to supply electricity to the grid during periods of peak demand [36].

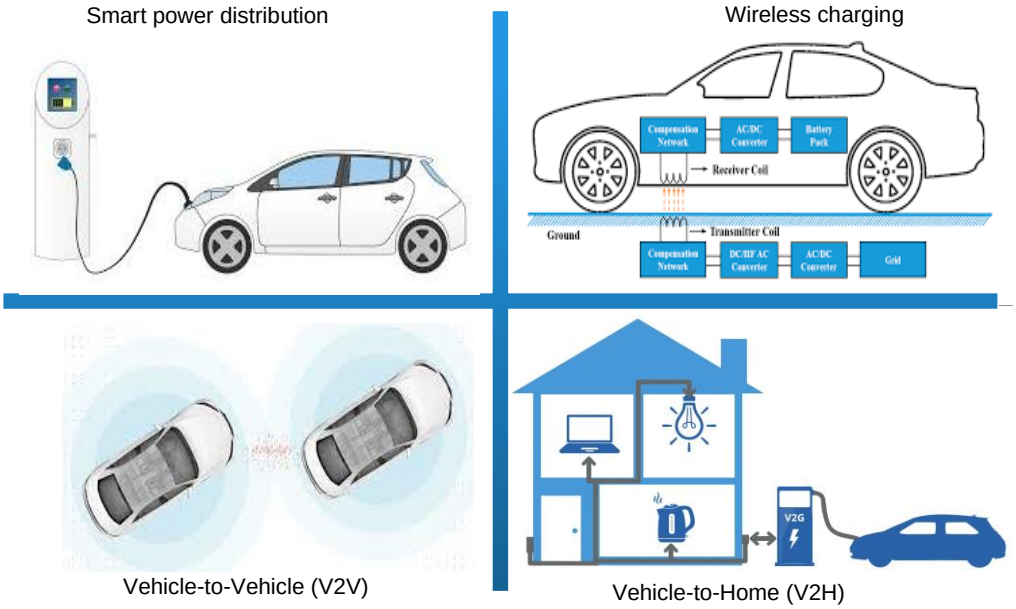

Figure 2: Trades and emerging technology of Electric Vehicle developments [32], [37], [38]

5 Discussion

The integration of EVs into the power system with renewable energy sources can have both positive and negative impacts. EVs can help to integrate renewable energy sources into the grid by storing excess energy and releasing it when needed. Besides, EVs can potentially serve as energy backup sources, but they are not necessarily more stable, safer, or more continuous compared to other renewable energy sources. The suitability of each technology depends on various factors, including the specific application, location, and energy demand requirements.

6 Conclusion

To sum up, V2G technology offers the ability to overcome a number of environmental obstacles, such as lowering carbon emissions and improving air quality, supporting the grid's voltage, and avoiding the need for costly infrastructure modifications. The requirement for standardization and interoperability between various EV models and grid systems, as well as for efficient market mechanisms to encourage EV owners to take part in V2G programs, are still issues that must be resolved. For further studies, integrating RESs in all their forms is recommended to be utilized in order to gain a green, sustainable, and safe environment.

References

[1] B. Bibak and H. Tekiner-Moğulkoç, "A comprehensive analysis of Vehicle to Grid (V2G) systems and scholarly literature on the application of such systems," *Renewable Energy Focus*, vol. 36, no. March, pp. 1–20, Mar. 2021, doi: 10.1016/j.ref.2020.10.001.

[2] A. Alsharif, C. W. Tan, R. Ayop, K. Y. Lau, and A. M. Dobi, "A rule-based power management strategy for Vehicle-to-Grid system using antlion sizing optimization," *J Energy Storage*, vol. 41, p. 102913, Sep. 2021, doi: 10.1016/j.est.2021.102913.

[3] N. S. M. N. Izam, Z. Itam, W. L. Sing, and A. Syamsir, "Sustainable Development Perspectives of Solar Energy Technologies with Focus on Solar Photovoltaic—A Review," *Energies (Basel)*, vol. 15, no. 8, p. 2790, Apr. 2022, doi: 10.3390/en15082790.

[4] 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.

[5] T. U. Solanke, V. K. Ramachandaramurthy, J. Y. Yong, J. Pasupuleti, P. Kasinathan, and A. Rajagopalan, "A review of strategic charging–discharging control of grid-connected electric vehicles," *J Energy Storage*, vol. 28, no. September 2019, p. 101193, Apr. 2020, doi: 10.1016/j.est.2020.101193.

[6] G. Saldaña, J. I. San Martin, I. Zamora, F. J. Asensio, and O. Oñederra, "Electric Vehicle into the Grid: Charging Methodologies Aimed at Providing Ancillary Services Considering Battery Degradation," *Energies (Basel)*, vol. 12, no. 12, p. 2443, Jun. 2019, doi: 10.3390/en12122443.

[7] A. A. A. A. M. M. K. and M. A. Altayib. Alsharif, "Ancillary services and energy management for electric Vehicle: Mini-review," *North African Journal of Scientific Publishing (NAJSP)*, pp. 9–12, Apr. 2023.

[8] X. Li, Z. Wang, L. Zhang, F. Sun, and D. Cui, "Electric vehicle behavior modeling and applications in vehicle-grid integration : An overview ☆," *Energy*, vol. 268, no. 5, p. 126647, 2023, doi: 10.1016/j.energy.2023.126647.

[9] 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.

[10] Y. Noorollahi, A. Golshanfard, A. Aligholian, B. Mohammadi-ivatloo, S. Nielsen, and A. Hajinezhad, "Sustainable Energy System Planning for an Industrial Zone by Integrating Electric Vehicles as Energy Storage," *J Energy Storage*, vol. 30, no. May, p. 101553, Aug. 2020, doi: 10.1016/j.est.2020.101553.

[11] D. Ribó-Pérez, L. Larrosa-López, D. Pecondón-Tricas, and M. Alcázar-Ortega, "A Critical Review of Demand Response Products as Resource for Ancillary Services: International Experience and Policy Recommendations," *Energies (Basel)*, vol. 14, no. 4, p. 846, Feb. 2021, doi: 10.3390/en14040846.

[12] A. Kumar *et al.*, "Strategic integration of battery energy storage systems with the provision of distributed ancillary services in active distribution systems," *Appl Energy*, vol. 253, Nov. 2019, doi: 10.1016/j.apenergy.2019.113503.

[13] 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 2022 - Proceeding*, IEEE, May 2022, pp. 645–649. doi: 10.1109/MI-STA54861.2022.9837749.

[14] M. Y. Khan, M. Ali, S. Qaisar, M. Naeem, C. Chrysostomou, and M. Iqbal, "Placement Optimization for Renewable Energy Sources: Ontology, Tools, and Wake Models," *IEEE Access*, vol. 8, pp. 72781–72800, 2020, doi: 10.1109/ACCESS.2020.2984901.

[15] A. Q. Al-Shetwi, M. A. A. Hannan, K. P. Jern, M. Mansur, and T. M. I. M. I. Mahlia, "Grid-connected renewable energy sources: Review of the recent integration requirements and control methods," *J Clean Prod*, vol. 253, p. 119831, Apr. 2020, doi: 10.1016/j.jclepro.2019.119831.

[16] A. A. Ahmed, A. Sami, A. Alsharif, A. S. D. Alarga, J. Santhosh, and A. Albagul, "Evaluation of Electric Vehicle Stability Using Fractional PID and Fuzzy PID Based Controllers," 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. 116–120. doi: 10.1109/MI-STA54861.2022.9837532.

[17] M. S. Javed *et al.*, "Economic analysis and optimization of a renewable energy based power supply system with different energy storages for a remote island," *Renew Energy*, vol. 164, pp. 1376–1394, 2021, doi: 10.1016/j.renene.2020.10.063.

[18] M. M. Khaleel, T. Mohamed Ghandoori, A. Ali Ahmed, A. Alsharif, A. J. Ahmed Alnagrat, and A. Ali Abulifa, "Impact of Mechanical Storage System Technologies: A Powerful Combination to Empowered the Electrical Grids Application," 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. 628–636. doi: 10.1109/MI-STA54861.2022.9837670.

[19] E. Hossain, H. Faruque, Md. Sunny, N. Mohammad, and N. Nawar, "A Comprehensive Review on Energy Storage Systems: Types, Comparison, Current Scenario, Applications, Barriers, and Potential Solutions, Policies, and Future Prospects," *Energies (Basel)*, vol. 13, no. 14, p. 3651, Jul. 2020, doi: 10.3390/en13143651.

[20] A. W. Thompson and Y. Perez, "Vehicle-to-Everything (V2X) energy services, value streams, and regulatory policy implications," *Energy Policy*, vol. 137, no. December 2019, p. 111136, Feb. 2020, doi: 10.1016/j.enpol.2019.111136.

[21] A. A. Ahmed, A. Alsharif, T. Triwiyanto, M. Khaleel, C. W. Tan, and R. Ayop, "Using of Neural Network-Based Controller to Obtain the Effect of Hub Motors Weight on Electric Vehicle Ride Comfort," *2022 IEEE 2nd International Maghreb Meeting of the Conference on Sciences and Techniques of Automatic Control and Computer Engineering, MI-STA 2022 - Proceeding*, pp. 189–192, 2022, doi: 10.1109/MI-STA54861.2022.9837608.

[22] 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.

[23] A. Alsharif, C. Wei, R. Ayop, K. Yiew, and A. Moh, "A rule-based power management strategy for Vehicle-to-Grid system using antlion sizing optimization," *J Energy Storage*, vol. 41, no. April, p. 102913, 2021, doi: 10.1016/j.est.2021.102913.

[24] A. Demirci, S. M. Tercan, U. Cali, and I. Nakir, "A Comprehensive Data Analysis of Electric Vehicle User Behaviors Toward Unlocking Vehicle-to-Grid Potential," *IEEE Access*, vol. 11, pp. 9149–9165, 2023, doi: 10.1109/ACCESS.2023.3240102.

[25] M. H. K. Tushar, A. W. Zeineddine, and C. Assi, "Demand-Side Management by Regulating Charging and Discharging of the EV, ESS, and Utilizing Renewable Energy," *IEEE Trans Industr Inform*, vol. 14, no. 1, pp. 117–126, Jan. 2018, doi: 10.1109/TII.2017.2755465.

[26] R. C. Green, L. Wang, and M. Alam, "The impact of plug-in hybrid electric vehicles on distribution networks: A review and outlook," *Renewable and Sustainable Energy Reviews*, vol. 15, no. 1, pp. 544–553, Jan. 2011, doi: 10.1016/j.rser.2010.08.015.

[27] H. Yu, S. Niu, Y. Shang, Z. Shao, Y. Jia, and L. Jian, "Electric vehicles integration and vehicle-to-grid operation in active distribution grids: A comprehensive review on power architectures, grid connection standards and typical applications," *Renewable and Sustainable Energy Reviews*, vol. 168, no. April, p. 112812, Oct. 2022, doi: 10.1016/j.rser.2022.112812.

[28] C. Mahmoudi, A. Flah, and L. Sbita, "An overview of electric Vehicle concept and power management strategies," in *2014 International Conference on Electrical Sciences and Technologies in Maghreb (CISTEM)*, IEEE, Nov. 2014, pp. 1–8. doi: 10.1109/CISTEM.2014.7077026.

[29] F. S. Gazijahani and J. Salehi, "Reliability constrained two-stage optimization of multiple renewable-based microgrids incorporating critical energy peak pricing demand response program using robust optimization approach," *Energy*, vol. 161, pp. 999–1015, Oct. 2018, doi: 10.1016/j.energy.2018.07.191.

[30] A. Banerji, K. Sharma, and R. R. Singh, "Integrating Renewable Energy and Electric Vehicle Systems into Power Grid: Benefits and Challenges," in *2021 Innovations in Power and Advanced Computing Technologies (i-PACT)*, IEEE, Nov. 2021, pp. 1–6. doi: 10.1109/i-PACT52855.2021.9696887.

[31] E. M. Strategy *et al.*, “Renewable Energy Focus Energy Management Strategy for Vehicle-to-Grid Technology Integration with Energy Sources : Mini review”.
[32] E. A. Soto, L. B. Bosman, E. Wollega, and W. D. Leon-Salas, “Peer-to-peer energy trading: A review of the literature,” *Appl Energy*, vol. 283, no. October 2020, p. 116268, 2021, doi: 10.1016/j.apenergy.2020.116268.
[33] A. Mohammad, R. Zamora, and T. T. Lie, “Integration of Electric Vehicles in the Distribution Network: A Review of PV Based Electric Vehicle Modelling,” *Energies (Basel)*, vol. 13, no. 17, p. 4541, Sep. 2020, doi: 10.3390/en13174541.
[34] M. Sufyan, N. A. Rahim, M. A. Muhammad, C. K. Tan, S. R. S. Raihan, and A. H. A. Bakar, “Charge coordination and battery lifecycle analysis of electric vehicles with V2G implementation,” *Electric Power Systems Research*, vol. 184, p. 106307, Jul. 2020, doi: 10.1016/j.epsr.2020.106307.
[35] G. Salvatti, E. Carati, R. Cardoso, J. da Costa, and C. Stein, “Electric Vehicles Energy Management with V2G/G2V Multifactor Optimization of Smart Grids,” *Energies (Basel)*, vol. 13, no. 5, p. 1191, Mar. 2020, doi: 10.3390/en13051191.
[36] A. Alsharif, C. W. Tan, R. Ayop, A. Dobi, and K. Y. Lau, “A comprehensive review of energy management strategy in Vehicle-to-Grid technology integrated with renewable energy sources,” *Sustainable Energy Technologies and Assessments*, vol. 47, no. xxxx, p. 101439, Oct. 2021, doi: 10.1016/j.seta.2021.101439.
[37] T. Mo, Y. Li, K. Lau, C. K. Poon, Y. Wu, and Y. Luo, “Trends and Emerging Technologies for the Development of Electric Vehicles,” *Energies (Basel)*, vol. 15, no. 17, p. 6271, Aug. 2022, doi: 10.3390/en15176271.
[38] A. Info *et al.*, “A Review of the Smart Grid Communication Technologies in Contactless Charging with Vehicle to Grid Integration Technology,” *Journal of Integrated and Advanced Engineering (JIAE)*, vol. 1, no. 1, pp. 11–20, Apr. 2021, doi: 10.51662/jiae.v1i1.8.