The North African Journal of Scientific Publishing (NAJSP)
مجلة شمال إفريقيا للنشر العلمي (NAJSP)
P-ISSN:0000-0000, EISSN: 0000-0000
Volume 1, Issue 1, January-March 2023, Page No: 9-12
Website: https://najsp.com/index.php/home/index

Ancillary Services and Energy Management for Electric Vehicle: Mini-Review

Abdulgader Alsharif [1,2 *], Abdussalam Ali Ahmed [3], Mohamed Mohamed Khaleel [4], Masoud Albasheer Altayib [2,5].

[1] Communication Engineering Department, College of Civil Aviation Technology and Meteorology, Espiaa, Libya
[2] Faculty of Engineering, Universiti Teknologi Malaysia, UTM, 81310, Skudai, Johor, Malaysia
[3] Mechanical Engineering Department, Bani Waleed University, Bani Walid, Libya.
[4] Aeronautical Engineering Department, College of Civil Aviation, Misurata, Libya
[5] Higher Institute of Science and Technology, Albrkat-Ghat, Libya

[*]*Corresponding author: abdulgaderalsharif@gmail.com*

Received: December 04, 2023	Accepted: December 28, 2022	Published: January 04, 2023

Abstract:
The Vehicle-To-Grid (V2G) technology refers to the use of Electric Vehicles (EVs) as a source of energy storage for the grid by providing several services. Ancillary services refer to the additional services that EVs connected to the grid can provide, such as frequency regulation and voltage control, and Renewable Energy (RE) exploitation. There are several different charging topologies that can be used for V2G, including bidirectional charging, where the EV can have dual functionality (charge and discharge energy), and unidirectional charging that presents the operation of the EV that can only charge from the grid. The most popular charging topologies for V2G are currently AC charging and DC fast charging.

Keywords: Electric Vehicle (EV), Renewable Energy (RE), Vehicle-to-grid (V2G)

Cite this article as: A. Alsharif, A. A Ahmed, M. k. Khaleel, M. A, Altayib, *"Ancillary Services and Energy Management for Electric Vehicle: Mini-Review," The North African Journal of Scientific Publishing (NAJSP), vol*. 1, no. 1, pp. 09–12, January-March 2023.

Introduction

Ancillary services are typically provided by conventional power plants such as coal, natural gas, and hydroelectric power plants, but with the integration of renewable energy sources, increasingly provided by wind, solar and storage. Energy management for Vehicle-to-Grid (V2G) and Vehicle-to-Home (V2H) systems in a smart grid environment can be enhanced by integrating Wind Turbine (WT) and Photovoltaic (PV) systems [1]. These renewable energy sources can provide a source of clean, sustainable energy for charging EVs and can also be used to feed excess energy back into the grid [2]. One strategy for energy management is to use the wind turbine and PV systems to charge the EVs during periods of high renewable energy generation and then use the stored energy in the EVs to feed back into the grid during periods of high demand or low renewable energy generation. This can help to balance the grid and improve overall energy efficiency [3].

Another strategy is to use the renewable energy to charge the EVs directly and use the excess energy to power the home or feed it back to the grid [4]. This can help to reduce the overall energy consumption and costs for the homeowner [5]. To make this possible, advanced energy management algorithms and control systems are needed to optimize the use of the renewable energy sources and the EV energy storage systems. Smart grid communication protocols such as Open Automated Demand Response (OpenADR), International Electro-Technical Commission (IEC) 61850, and IEC 61400-25 can be used for the integration and communication between the different components in the system [6].

Classification of ancillary services

The ancillary services can be defined as the support to the electricity transfer from the generator to the end-user. Additionally, ancillary services are a set of services that support the reliable and efficient operation of the electric power grid [7]. They mainly categorizes into many groups which provided by generators, transmission and distribution companies, and other market participants to maintain the balance between supply and demand on the electric grid [8]. Ancillary services are generally divided into two categories: balancing services and system support services as illustrated in Figure 1. The Balancing services are including the listed services:

1. Renewable energy integration: EVs can help to integrate renewable energy sources into the grid by storing excess energy and releasing it when needed.
2. Frequency regulation: EVs can provide power to the grid during periods of high demand, helping to stabilize the grid's frequency.
3. Reserve:

- Spinning Reserve: EVs can act as a reserve power source, quickly providing power to the grid when there is a sudden drop in supply.
- Supplementary Reserve
- Backup Reserve

While the system support services are including the presented services with their explanation:

1. Voltage control: maintaining the voltage level on the transmission and distribution system within acceptable limits.
2. Black start capability: the ability of a power plant to restart itself and restore power to the grid in the event of a complete blackout.
3. Reactive power support: maintaining the power factor on the transmission and distribution system within acceptable limits by adjusting the output of power plants.

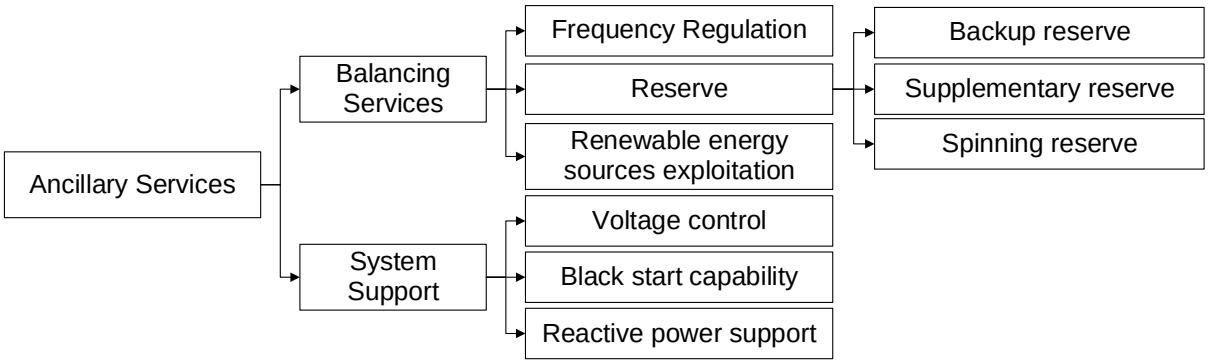

Figure 1: Classification of ancillary services [8].

Overall, the use of V2G technology can help to improve the efficiency and reliability of the power grid and make it more sustainable. By providing these ancillary services, EVs can help to make the power grid more efficient, reliable, and sustainable [9].

Energy management strategies

In Vehicle-to-Grid (V2G) technology the Power flow in a bidirectional way, the flowed power causes some additional loads on the grid. The issues in the burden that are caused during charging/discharging

while using V2G systems can be overcome by EMSs. It is reported in the literature for the classification of EMS which is two, rule-based and optimization-based [10]–[14]. Rules-based can be subcategorized into deterministic and fuzzy logic [15]. Whereas optimization-based can be sub-grouped into global optimization and local optimization. The four main EMS used to solve power flow issues are reported in the literature, also researchers paying attention toward them. Due to the aforementioned statements, the EMS objectives are tabulated in Table 1.

Table 1 Energy Management Strategy Objectives [16].

EMS objectives	Features
Improve fuel economy	Fuel consumption minimization Energy-optimal travel Reduce operational costs
Satisfy constraints	Required driving power Operating mode selections
Reduce emission	CO2 emission minimization Pollutant emission minimization
Use ESS efficiently	Prolonged lifetime of ESS Battery SoC regulation considering battery limitation
Improve Drivability & Comfort	Reduced driver tasks

Conclusion

In conclusion, Ancillary services play a crucial role in supporting the reliable and efficient operation of the electric power grid, especially in the context of Vehicle-to-Everything (V2X), V2G, and V2H systems. Ancillary services can be provided by a variety of market participants, including generators, transmission and distribution companies, and electric vehicle owners. V2X, V2G, and V2H systems can provide ancillary services such as frequency regulation, voltage control, spinning and non-spinning reserve, and black start capability. By using the energy storage capacity of electric vehicles, these systems can help to balance the grid, reduce demand on the grid during peak hours, and improve energy efficiency. Furthermore, the integration of renewable energy sources for charging EVs can also help to reduce dependence on fossil fuels and decrease the overall environmental impact of transportation. To fully realize the benefits of ancillary services provided by V2X, V2G, and V2H systems, it is important to have advanced energy management algorithms, communication protocols, and control systems in place to optimize the use of renewable energy sources and EV energy storage systems. With the increasing penetration of electric vehicles, and the integration of renewable energy sources, ancillary services will become more and more important in maintaining the reliability and stability of the grid.

References

[1] M. R. H. Mojumder, F. Ahmed Antara, M. Hasanuzzaman, B. Alamri, and M. Alsharef, “Electric Vehicle-to-Grid (V2G) Technologies: Impact on the Power Grid and Battery,” *Sustainability*, vol. 14, no. 21, p. 13856, Oct. 2022, doi: 10.3390/su142113856.

[2] Z. Li, A. Khajepour, and J. Song, “A comprehensive review of the key technologies for pure electric vehicles,” *Energy*, vol. 182. Elsevier Ltd, pp. 824–839, Sep. 01, 2019, doi: 10.1016/j.energy.2019.06.077.

[3] 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,” *Sustain. Energy Technol. Assessments*, vol. 47, no. xxxx, p. 101439, Oct. 2021, doi: 10.1016/j.seta.2021.101439.

[4] A. M. Pirbazari, “Ancillary services definitions, markets and practices in the world,” in *2010 IEEE/PES Transmission and Distribution Conference and Exposition: Latin America (T&D-LA)*, Nov. 2010, pp. 32–36, doi: 10.1109/TDC-LA.2010.5762857.

[5] 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.

[6] N. Shaukat *et al.*, “A survey on electric vehicle transportation within smart grid system,” *Renew.*

Sustain. Energy Rev., vol. 81, no. February 2016, pp. 1329–1349, 2018, doi: 10.1016/j.rser.2017.05.092.

[7] M. İnci, M. M. Savrun, and Ö. Çelik, “Integrating electric vehicles as virtual power plants: A comprehensive review on vehicle-to-grid (V2G) concepts, interface topologies, marketing and future prospects,” *J. Energy Storage*, vol. 55, no. September, p. 105579, Nov. 2022, doi: 10.1016/j.est.2022.105579.

[8] Alfonso Damiano, Gianluca Gatto, Ignazio Marongiu, Mario Porru, and Alessandro Serpi, “Vehicle-to-Grid Technology: State-of-the-Art and Future Scenarios,” *J. Energy Power Eng.*, vol. 8, no. 1, pp. 152–165, Jan. 2014, doi: 10.17265/1934-8975/2014.01.018.

[9] D. Wang, F. Locment, and M. Sechilariu, “Modelling, Simulation, and Management Strategy of an Electric Vehicle Charging Station Based on a DC Microgrid,” *Appl. Sci.*, vol. 10, no. 6, p. 2053, Mar. 2020, doi: 10.3390/app10062053.

[10] S. Xie, X. Hu, Z. Xin, and J. Brighton, “Pontryagin’s Minimum Principle based model predictive control of energy management for a plug-in hybrid electric bus,” *Appl. Energy*, vol. 236, no. December 2018, pp. 893–905, Feb. 2019, doi: 10.1016/j.apenergy.2018.12.032.

[11] S. Mumtaz, S. Ali, S. Ahmad, L. Khan, S. Z. Hassan, and T. Kamal, “Energy Management and Control of Plug-In Hybrid Electric Vehicle Charging Stations in a Grid-Connected Hybrid Power System,” *Energies*, vol. 10, no. 11, p. 1923, Nov. 2017, doi: 10.3390/en10111923.

[12] F. Zhang, H. Liu, Y. Hu, and J. Xi, “A Supervisory Control Algorithm of Hybrid Electric Vehicle Based on Adaptive Equivalent Consumption Minimization Strategy with Fuzzy PI,” *Energies*, vol. 9, no. 11, p. 919, Nov. 2016, doi: 10.3390/en9110919.

[13] S. Onori, L. Serrao, and G. Rizzoni, *Hybrid Electric Vehicles*, no. 9781447167792. London: Springer London, 2016.

[14] E. Taherzadeh, H. Radmanesh, and A. Mehrizi-sani, “A Comprehensive Study of the Parameters Impacting the Fuel Economy of Plug-in Hybrid Electric Vehicles,” *IEEE Trans. Intell. Veh.*, vol. 8858, no. c, pp. 1–1, 2020, doi: 10.1109/TIV.2020.2993520.

[15] F. Un-Noor, S. Padmanaban, L. Mihet-Popa, M. Mollah, and E. Hossain, “A Comprehensive Study of Key Electric Vehicle (EV) Components, Technologies, Challenges, Impacts, and Future Direction of Development,” *Energies*, vol. 10, no. 8, p. 1217, Aug. 2017, doi: 10.3390/en10081217.

[16] H. Liu and T. Li, “Energy Management Strategy Development for Fuel Cell Hybrid Loaders,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 189, no. 5, p. 052015, Nov. 2018, doi: 10.1088/1755-1315/189/5/052015.

[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," 2022 IEEE 2nd International Maghreb Meeting of the Conference on Sciences and Techniques of Automatic Control and Computer Engineering (MI-STA), Sabratha, Libya, 2022, pp. 645-649, doi: 10.1109/MI-STA54861.2022.9837749.