Chapter 7

Smart Mobility:
The Role of Vehicle-to-Grid Integration in Energy Management

Harpreet Kaur Channi
https://orcid.org/0000-0002-9059-8821
Eudoxia Research Centre, India

ABSTRACT

As urbanization intensifies and the demand for clean energy rises, Vehicle-to-Grid (V2G) integration has emerged as a vital element in advancing smart mobility and sustainable energy systems. V2G technology enables electric vehicles (EVs) to not only consume electricity but also discharge stored energy back to the grid during peak demand, effectively serving as mobile energy storage. This bidirectional flow enhances grid stability, supports renewable energy integration, reduces fossil fuel dependency, and lowers energy costs. This study examines key global case studies, demonstrating the environmental and economic advantages of V2G while addressing barriers such as regulatory limitations and technological constraints. Strategic solutions for effective adoption are proposed. Furthermore, analysis of average grid demand in Ludhiana from January to October 2024 reveals a stable consumption range (3.18–3.31 kWh), which supports predictable energy planning and efficient V2G implementation. These findings highlight V2G's potential as a cornerstone of future smart energy ecosystems.

INTRODUCTION

The transition to sustainable energy solutions has become a global imperative in addressing climate change and reducing dependency on fossil fuels. With the rising adoption of electric vehicles (EVs), Vehicle-to-Grid (V2G) integration emerges as

DOI: 10.4018/979-8-3373-3226-0.ch007

Copyright © 2026, IGI Global Scientific Publishing. Copying or distributing in print or electronic forms without written permission of IGI Global Scientific Publishing is prohibited.

a crucial innovation in enhancing energy management systems. V2G technology enables EVs not only to draw power from the grid but also to return surplus energy during peak demand, effectively transforming these vehicles into distributed energy resources. As urban areas face increasing energy consumption and the integration of renewable energy sources, V2G provides a promising solution to enhance grid stability and resilience. By allowing bidirectional energy flow, V2G contributes to balancing supply and demand, thereby mitigating the variability inherent in renewable energy generation (Hira and Hira, 2024). This capability is particularly vital in densely populated urban environments, where energy usage patterns can fluctuate significantly. The significance of V2G extends beyond energy management; it offers economic benefits for both consumers and utility providers. It fosters greater incorporation of renewables, thereby reducing greenhouse gas emissions and supporting energy transition goals (Kumar and Channi, 2023). This paper aims to explore the multifaceted role of V2G integration in energy management and its implications for smart mobility. Key objectives include providing an overview of V2G technology, analyzing its benefits, presenting successful case studies, identifying barriers to adoption, and discussing the future of V2G within the context of smart cities. Ultimately, this research seeks to underscore V2G as a cornerstone of sustainable energy practices. The transition towards sustainable energy solutions has become a critical focus globally, driven by the need to mitigate climate change and reduce reliance on fossil fuels (Du et al., 2025). As electric vehicles (EVs) gain popularity due to their environmental benefits, the concept of Vehicle-to-Grid (V2G) integration emerges as a transformative approach to enhance energy management systems. V2G allows EVs to not only draw power from the grid but also feed surplus energy back during peak demand periods, effectively turning vehicles into distributed energy resources (Bogdanov & Breyer, 2024).

Background

The increasing adoption of electric vehicles (EVs) is reshaping global transportation systems, representing a pivotal shift toward cleaner and more sustainable mobility. While EVs offer significant environmental benefits by reducing greenhouse gas emissions and dependence on fossil fuels, their large-scale integration poses new challenges for existing electricity grid infrastructures. As more EVs connect to the grid, especially in densely populated urban areas, the cumulative demand for electricity during peak hours may stress the grid, leading to voltage instability, transformer overloading, and increased operating costs for utilities. These issues are compounded by the fact that EV charging is often uncoordinated, with users

28 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage: www.igi-global.com/chapter/smart-mobility/389033

Related Content

Evaluation of the Criteria Used in the Selection of Renewable Energy Sources With the Plithogenic PIPRECIA Method

Alptekin Ulutaand Aye Topal (2022). *Optimization and Decision-Making in the Renewable Energy Industry (pp. 109-125).*

www.irma-international.org/chapter/evaluation-of-the-criteria-used-in-the-selection-of-renewable-energy-sources-with-the-plithogenic-piprecia-method/300657

Design of an Expert System for Distribution Planning System using Soft Computing Techniques

Shabbir Uddin, Amitava Ray, Karma Sonam Sherpaand Sandeep Chakravorty (2016). *International Journal of Energy Optimization and Engineering (pp. 45-63).*

www.irma-international.org/article/design-of-an-expert-system-for-distribution-planning-system-using-soft-computing-techniques/151520

Identification of Most Significant Parameter of Impact of Climate Change and Urbanization on Operational Efficiency of Hydropower Plant

Priyanka Majumderand Apu Kumar Saha (2019). *International Journal of Energy Optimization and Engineering (pp. 43-68).*

www.irma-international.org/article/identification-of-most-significant-parameter-of-impact-of-climate-change-and-urbanization-on-operational-efficiency-of-hydropower-plant/228165

Empowering Industry 5.0: Nurturing STEM Tertiary Education and Careers Through Additional Mathematics

Chuan Zun Liang, Abraham Lim Bing Sern, Tan Chek Cheng, David Lau King Luen, Nursultan Japashovand Tan Ee Hiae (2024). *Utilizing Renewable Energy, Technology, and Education for Industry 5.0 (pp. 124-155).*

www.irma-international.org/chapter/empowering-industry-50/352697

Business Development in the Renewable Energy Industry

Adrian Dumitru Tantauand Laureniu Ctlin Fril (2021). *Research Anthology on Clean Energy Management and Solutions (pp. 1439-1474).*

www.irma-international.org/chapter/business-development-in-the-renewable-energy-industry/286525