

Final Project 1

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Project Template

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To

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Project title

**Integration of Electric Vehicles for Grid Support in Urban
Environments: A Case Study of Amman**

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1. Chapter 1: Introduction

1.1. Research Background

The increase in GHG emission is an important global concern. High costs and substantial energy waste from voltage regulation, daily load demand fluctuations and frequency adjustments are the main reasons why operational efficiency of power grids is still unsatisfactory. In times where the amount of energy required surpasses that which can be supplied by base load power plants, peak load plants come into operation. Conversely, on days with minimal electricity needs, unwanted energy from base load generators ends up as waste. Also, Voltage/frequency control of this nature has high operating costs.

This issue can be solved through Vehicle to Grid (V2G) technology that uses electric vehicle's (EVs) extensive energy storage capacity as a buffer for both power grid and renewable sources of electricity. EVs can be attached to the smart grid either in V2G or G2V modes. The vehicle-to-grid involves flow of energy from EV to grid while grid-to-vehicle mode involves movement of electric charges from the grid to the EVs.

Smart grids and V2G systems are interconnected and have a symbiotic relationship between them. An important function is played by AC to DC (and vice versa) conversions during energy exchange processes. Energy storage systems in electric vehicles become very useful when exchanging electrical power with a grid system. as an example, when grid demand goes down sharply, the cars can take on extra energy overloads which in turn help to reduce power plant strains.

is during low periods of network load demand that electric vehicles can be used as storage for excess electricity to avoid wastage. When prices drop, purchasers of EVs may prefer to import power from the distribution companies only to sell them back during peak periods at high costs, thus providing a chance for gains.

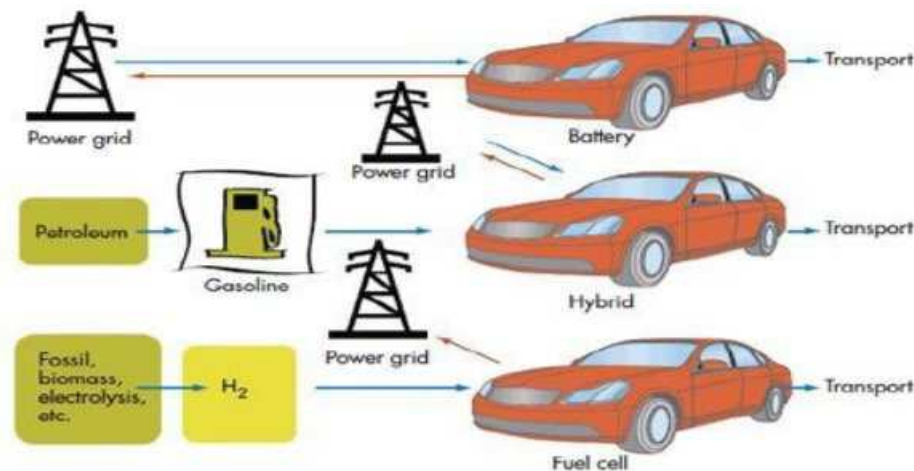


Fig. 1: The schematic diagram of V2G (Harighi et al., 2018).

1.2. Research Problem

The main research problem addressed in this project is:

1.2.1. Theoretical Gaps

- Existing literature primarily focuses on technical aspects of EV integration for grid support, such as:
 - Modeling EV charging behavior
 - Optimizing charging schedules
 - Analyzing impact on grid stability and power quality?
- Lack of research addressing business and management implications of EV integration, including:

- Development of viable business models
- Assessment of economic feasibility
- Analysis of policy and regulatory frameworks needed to incentivize EV adoption and V2G participation
- Existing theories and frameworks fail to consider unique challenges and opportunities presented by urban environments, such as:
 - High population density
 - Presence of diverse stakeholders
 - Need for coordinated planning and decision-making

1.2.2. Practical Gaps

- Rapid growth of EV adoption in urban areas can strain existing power grid infrastructure, leading to challenges in:
 - Grid stability
 - Peak demand management
 - Energy distribution
- Uncontrolled EV charging can cause:
 - Voltage deviations
 - Overloading of distribution transformers
 - Increased energy losses
- Practical implementation of EV integration for grid support in urban environments is hindered by:
 - Lack of coordination among stakeholders (utility companies, EV manufacturers, policymakers, end-users)
 - Need for investment in infrastructure upgrades (smart charging infrastructure, V2G-enabled vehicles)
- Practical application of EV integration for grid support is limited by lack of clear policy and regulatory frameworks that incentivize EV adoption and V2G participation

1.3. Research Significance

The findings of this study will contribute to the following:

1.3.1. At the theoretical level

At the theoretical level, this research project contributes to the existing body of knowledge on electric vehicle (EV) integration for grid support in urban environments by addressing the gaps in the current literature. The study provides a comprehensive analysis of the business and management implications of EV integration, including the development of viable business models, the assessment of economic feasibility, and the analysis of policy and regulatory frameworks needed to incentivize EV adoption and V2G participation.

Moreover, the research extends the existing theories and frameworks used to analyze the integration of EVs for grid support by considering the unique challenges and opportunities presented by urban environments, such as the high population density, the presence of diverse stakeholders, and the need for coordinated planning and decision-making. By incorporating these factors into the analysis, the study offers a more nuanced and context-specific understanding of the potential benefits and challenges of EV integration for grid support in urban settings.

1.3.2. At the practical level

- **Grid Optimization:** The study will provide empirical insights into the impact of EV integration on grid stability, peak demand, and energy distribution in Amman, enabling utility companies to develop effective strategies for optimizing grid performance and supporting renewable energy integration.
- **Economic Benefits:** The research will analyze the feasibility and benefits of V2G technology for grid support, energy trading, and peak shaving in Amman, potentially leading to cost savings for both EV owners and utility companies.
- **Sustainability:** By proposing empirically grounded strategies for transitioning to a Smart Grid model in Amman, the study will contribute to enhancing energy efficiency, grid

resilience, and sustainability in urban settings, ultimately promoting a greener and more sustainable future.

- **Policy Implications:** The research findings will inform policymakers and regulatory authorities in Amman about the necessary policy and regulatory changes needed to incentivize EV adoption and V2G participation, thereby facilitating the large-scale integration of EVs for grid support.

By addressing both the theoretical and empirical significance of the study, this section highlights the importance of the research project in advancing academic knowledge and informing practical decision-making in the context of EV integration for grid support in Amman.

1.4. Research Questions

1. In what ways can the urban power grid be updated to embrace Electric Vehicles (EVs) to improve its stability and efficiency while in Amman?
2. What are the managerial and business consequences of utilizing EVs for power supply in city environments?
3. In what way does economic viability of integrating vehicles-to-grid technology affect economics of EV integration for grid support purposes?
4. Which policy and regulatory frameworks should be put in place to encourage the adoption of electric vehicles and V2G participation within Amman?
5. What challenges exist for integrating electrical vehicles into urban areas where they will operate?

1.5. Research Objectives

- To evaluate how EV integration affects a grid's stability, peak demand, and energy distribution within Amman.
- To come up with feasible corporate models on which electrical vehicle integration for power supply in towns can be based.
- To ascertain if V2G technology is financially feasible regarding smart grids, electricity trading, and load leveling.

- To offer policies as well as regulatory frameworks that incentivize adoption of electric cars together with their accompanying V2G issues.
- To identify unique obstacles and opportunities related to incorporating EVs into cities' transport systems.

1.6. Research Hypotheses

- **H1:** Grid stability and efficiency in urban environments can be significantly improved through EV integration.
- **H2:** Viable business models to sustain the grid's stability and economic feasibility with respect to EV integration are possible.
- **H3:** The utility companies can earn significant economic benefits from both their customers who own electric vehicles and vehicle-to-grid technology.
- **H4:** Policy and regulatory frameworks that are efficient can induce a major increase of EV adoption and V2G participation.
- **H5:** Urban contexts have different risks and opportunities for integrating electric vehicles, which may require taking up custom-made approaches

1.7. Research Model

The research model will investigate how dependent variables (grid stability, economic viability, EV adoption, urban challenges) are related to independent ones (integration of EVs, business scenarios, V2G technology, policies).

1.8. Research Methodology

The power utility sector in Amman is recommended as the industry for empirical research on integrating electric vehicles into the grid in order to provide support. The study will include stakeholders such as Amman utility companies, end-users, policy makers as well as manufacturers of electrical cars.

1.9. Scope of The Study

Geographical Focus:

- Analyzing the urban power grid and investigating the potential of electric vehicle integration in Amman, Jordan.

Technological Integration:

- Exploring EV and V2G technology for supporting grid.

Marketability Assessment:

- Appraising feasibility of integrating EVs, and creation of an enabling business framework.

Policy and Regulatory Framework:

- Current policy review with recommendations on new guidelines to encourage adoption, participation, and use EVs.

Stakeholder Engagement:

- Collection of data through surveys, interviews, and case studies from utility companies, electric vehicle manufacturers as well as suppliers to such industries.

Environmental Impact:

- Evaluation Of Environmental Impacts and Challenges Associated With The Integration Of Electric Vehicles On The Urban Grid

Implementation Roadmap:

- Developing a roadmap that outlines how to incorporate EVs into the power grid thereby indicating key milestones and resource needs.

This research aims at offering comprehensive analysis which will guide stakeholders in promoting sustainable urban development through integrating electric vehicles thereby improving stability within the grid.

1.10. The Suggested Project Structure

Chapter 1: Introduction includes sections on Research Background, Research Problem, Research Significance, Research Questions, Research Objectives, Research Hypotheses, Research Model, Research Methodology, Scope of the Study, and Project Structure.

Chapter 2: Literature Review covers an Introduction, details on the Independent Variable (EV integration), the Dependent Variable (Grid stability, economic feasibility), the Relationship between Independent and Dependent Variables, and a Conclusion.

Chapter 3: Research Methodology discusses Research Design, Data Collection Methods, Sampling Techniques, Data Analysis Methods, and Ethical Considerations.

Chapter 4: Data Analysis and Results presents Descriptive Statistics, Hypothesis Testing, and Case Study Analysis.

Chapter 5: Discussion interprets the Results and explores Implications for Theory and Practice.

Chapter 6: Conclusion and Recommendations summarizes the Findings, offers Recommendations for Stakeholders, and suggests Future Research Directions.

2.Chapter 2: Literature Review

2.1. Introduction

Brief introduction for the chapter

2.2. The independent variable

2.3. The dependent variable

2.4. The relationship between the independent and the dependent variables

2.5. Conclusion

References

Harighi, O., Bayindir, R., Padmanaban, S., Mihet-Popa, L., & Hossain, E. (2018). An Overview of Energy Scenarios, Storage Systems and the Infrastructure for Vehicle-to-Grid Technology. *Energies*, 2(8).