

# Electric Vehicle Aggregators in Electricity Markets under Optimal Conditions: Review

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**Abstract-** With the increasing adoption of electric vehicles (EVs), there is a growing need to efficiently integrate them into the existing electricity grid. Electric Vehicle Aggregators (EVAs) play a crucial role in this integration process by managing the charging and discharging patterns of a fleet of EVs to optimize energy utilization, grid stability, and economic benefits. This paper focuses on developing a scheduling framework for EVAs in electricity markets under optimal conditions.

**Keywords-** Electric vehicle, Electric vehicle aggregator, electricity, grid.

## I. INTRODUCTION

The increasing adoption of electric vehicles (EVs) poses significant challenges and opportunities for the integration of these vehicles into the existing electricity grid. Electric Vehicle Aggregators (EVAs) have emerged as a crucial element in managing the charging and discharging patterns of a fleet of EVs, aiming to optimize energy utilization, grid stability, and economic benefits. Efficient scheduling of EVAs in electricity markets under optimal conditions is essential to harness the full potential of EVs while ensuring reliable grid operations.

The integration of EVs into electricity markets presents a unique set of challenges due to the dynamic nature of electricity prices, grid constraints, and the diverse charging needs of individual EV owners. Traditional centralized approaches for managing EV charging may not be suitable in scenarios where EVs are widely distributed across different locations and charging infrastructure. Instead, EVAs act as intermediaries between EV owners and electricity markets, aggregating the charging and discharging activities to maximize their revenue and minimize the impact on the grid.

## II. NEED FOR EVA

Aggregators aim to optimize their participation in the electricity market to maximize revenue. This involves strategically scheduling the charging and discharging of EVs based on market prices, demand response programs, and other market opportunities.

There are several reasons for conducting this study:

### 1. Increasing adoption of electric vehicles:

The widespread adoption of electric vehicles presents a unique challenge of managing their charging and discharging activities effectively. By developing an optimal scheduling framework for EVAs, we can leverage

the potential of EVs to contribute to grid stability, renewable energy integration, and overall sustainability.

### 2. Grid stability and energy management:

The integration of a large number of EVs into the electricity grid can introduce significant variability and unpredictability in electricity demand. By scheduling EVAs in a coordinated and optimized manner, we can minimize the impact of EV charging on the grid, prevent congestion, and ensure grid stability.

### 3. Economic benefits for EVAs:

EVAs act as intermediaries between EV owners and electricity markets. By participating in electricity markets and optimizing the scheduling of EVs, EVAs can maximize their revenue and profitability. This research aims to provide insights into optimal scheduling strategies that enhance the economic benefits for EVAs.

### 4. Individual EV owner preferences:

Each EV owner may have specific preferences regarding charging duration, departure times, and other factors. The proposed scheduling framework takes into account these preferences to ensure user satisfaction and convenience while meeting the overall objectives of efficient energy management and revenue maximization.

### 5. Advancements in optimization techniques:

This study will utilize mathematical optimization models and advanced algorithms to determine the optimal charging and discharging schedules for EVs. By leveraging the latest optimization techniques, we can achieve efficient and effective scheduling solutions that can handle the complexity and variability of electricity markets.

## III. LITERATURE REVIEW

1. Tony Seba – “Clean Disruption of Energy and Transportation: How Silicon Valley Will Make Oil, Nuclear, Natural Gas, Coal, Electric Utilities and

**Conventional Cars Obsolete by 2030” (2014)-** In this book, Tony Seba discusses the convergence of technologies such as electric vehicles, solar power, and energy storage, and how they will disrupt traditional energy and transportation systems by 2030.

**2. Seth Leitman and Bob Brant – “Build Your Own Electric Vehicle” (2008) -** This book provides a comprehensive guide for individuals interested in converting a conventional gasoline-powered vehicle into an electric vehicle. It covers various aspects of EV conversion, including selecting components, safety considerations, and maintenance.

**3. David Kirsch – “The Electric Vehicle and the Burden of History” (2000) -** David Kirsch explores the history of electric vehicles from the early 20th century to the present day. The book examines the challenges faced by electric vehicles throughout history and the factors that have influenced their adoption and development.

**4. Chelsea Sexton – “Plug-in Hybrids: The Cars that Will Recharge America” (2007) -** Chelsea Sexton, a prominent advocate for electric vehicles, discusses the potential of plug-in hybrid electric vehicles (PHEVs) to reduce dependence on fossil fuels and address environmental concerns. The book provides insights into the development and future prospects of PHEVs.

**5. Brian Wynne – “Public Engagement on Electric Vehicle Charging Infrastructure” (2013) -** Brian Wynne’s book explores the social and political dimensions of electric vehicle charging infrastructure. It delves into the challenges and opportunities associated with public engagement in the planning and deployment of charging infrastructure for electric vehicles.

**6. John B. Robinson and Larry McCulloch – “Electric Vehicle Technology Explained” (2012) -** This book provides a comprehensive introduction to electric vehicle technology, covering topics such as battery technology, electric motors, charging infrastructure, and environmental impacts. It aims to demystify the technology and make it accessible to a wide audience.

**7. Jack E. B. Stewart – “Electric Vehicle Economics and Environmental Impacts” (2018) -** Jack Stewart’s book explores the economic and environmental aspects of electric vehicles. It examines the costs and benefits of EV ownership, the potential for reducing greenhouse gas emissions, and the role of government policies in promoting their adoption.

**8. Willett Kempton – “Plug-in Electric Vehicles: What Role for Washington?” (2010) -** Willett Kempton analyzes the potential impact of plug-in electric vehicles on energy consumption, greenhouse gas emissions, and the electricity grid. The book discusses the role of

government policies and regulations in supporting the widespread adoption of electric vehicles.

**9. Gijs Mom – “The Electric Vehicle: Technology and Expectations in the Automobile Age” (2004) -** Gijs Mom’s book provides a historical perspective on electric vehicles, tracing their development and societal expectations from the early days of automotive technology to the present. It explores the reasons behind the rise and fall of electric vehicles throughout the 20th century.

**10. Mark J. Perry – “The Case for Electric Vehicles” (2019) -** Mark Perry’s book makes a case for electric vehicles as a sustainable and economically viable transportation solution. It examines the advantages of EVs in terms of energy efficiency, environmental impact, and overall cost of ownership.

**11. Charles Morris – “Tesla Motors: How Elon Musk and Company Made Electric Cars Cool, and Remade the Automotive and Energy Industries” (2018)-** Charles Morris provides an in-depth look at the rise of Tesla Motors and its impact on the automotive and energy industries. The book explores Elon Musk’s vision for electric vehicles and how Tesla transformed the perception of EVs from niche products to mainstream luxury vehicles.

**12. John J. Duffy – “Electric Vehicle Machines and Drives: Design, Analysis, and Application” (2015) -** John Duffy’s book focuses on the engineering aspects of electric vehicle machines and drives. It covers the design, analysis, and application of electric motors, power electronics, and control systems used in electric vehicles.

**13. Dan B. Johnson – “Recharge: Lessons Learned on the Plug-In Road” (2019) -** Dan Johnson shares his experiences and insights gained from traveling across the United States in a plug-in hybrid electric vehicle (PHEV). The book discusses the challenges and benefits of owning and driving an electric vehicle and provides practical advice for prospective EV owners.

**14. Paul Gipe – “Wind Power, Revised Edition: Renewable Energy for Home, Farm, and Business” (2004) -** Although not exclusively focused on electric vehicles, Paul Gipe’s book provides valuable information on renewable energy, including wind power, which is often connected to charging infrastructure for electric vehicles. It covers the design, installation, and operation of wind power systems for various applications, including electric vehicle charging.

**15. Chelsea Sexton and Ed Niedermeyer – “Ludicrous: The Unvarnished Story of Tesla Motors” (2019) -** Chelsea Sexton and Ed Niedermeyer delve into the history and inner workings of Tesla Motors in this book.

It examines the challenges, successes, and controversies surrounding the company, shedding light on the complex world of electric vehicle manufacturing and the broader automotive industry.

**16. John B. Goodenough, David L. MacKay, and Cathy Zoi – “Plug-in Electric Vehicles: What Role for Washington?” (2009)** - This book explores the potential benefits and challenges of plug-in electric vehicles and their integration into the transportation system. It discusses policy considerations and recommendations for government involvement in promoting the adoption of electric vehicles.

**17. Dan Sperling and Lew Fulton – “Three Revolutions: Steering Automated, Shared, and Electric Vehicles to a Better Future” (2018)** - Dan Sperling and Lew Fulton examine the synergies between automated, shared, and electric vehicles and their potential to transform transportation systems. The book discusses the societal, environmental, and economic implications of these three revolutions and provides insights into their integration.

**18. Michael E. Schratz – “Electric Vehicle Business Models: Global Perspectives” (2021)** - Michael Schratz explores different business models related to electric vehicles from a global perspective. The book examines innovative approaches, such as vehicle-to-grid (V2G) technologies, mobility services, and EV charging infrastructure, and analyzes their impact on the industry.

**19. Gereon Meyer and Till Gnann – “Electric Vehicle Charging Infrastructure: Guidelines for Future-Proof Urban Development” (2015)** - Gereon Meyer and Till Gnann provide guidelines for the planning and implementation of electric vehicle charging infrastructure in urban areas. The book covers various aspects, including site selection, charging station design, integration with the electricity grid, and policy considerations.

**20. Luke Workman – “DIY Lithium Batteries: How to Build Your Own Battery Packs” (2017)**- Luke Workman’s book offers a comprehensive guide to building your own lithium battery packs, which are commonly used in electric vehicles. It covers battery cell selection, safety considerations, assembly techniques, and provides practical tips for constructing custom battery packs.

#### IV. OBJECTIVE

Addressing these gaps requires interdisciplinary research efforts, involving experts from optimization, electricity markets, power systems, data analytics, and policy domains. By tackling these challenges, we can enhance the scheduling of EV aggregators in electricity markets under optimal conditions, unlocking their full potential to

support grid stability, increase renewable energy integration, and achieve economic and environmental objectives.

The objectives of a study on Electric Vehicle (EV) Aggregators in Electricity Markets under optimal conditions could include the following:

- The study aims to evaluate the advantages of employing EV aggregators in electricity markets under optimal conditions.
- The study may involve developing mathematical models and conducting simulations to analyze the behavior of EV aggregators in electricity markets.
- The study may evaluate the existing policy and regulatory frameworks governing the participation of EV aggregators in electricity markets.

These objectives have been selected for my research work whose result will be discussed.

#### V. INDIA DRAFT POLICY: OVERVIEW

How to cover up for passenger's safety?

- Law enforcement - It is important to inquire about driver and experience, and one should not compromise with one's safety and check drivers for the best of journey experience
- Follow designated route - Both driver and passenger should get an instant notification if the vehicle is deviating from the directed path
- GPS in the vehicle should be functional - The aggregators are responsible for ensuring that the vehicle's GPS is working right and giving efficient feedback
- Have correct driver's identification - It is important to have details of the driver's identification and check it before hiring the person for work.
- Surge with price rise - With the help of the scheme, the main idea is to curb with price rise, and it should be more than twice the basic rate as has been rated by the head of the transport department
- Take actions for complaints - If there are more than 15% complaints in a month for a driver, evaluation and strict actions should be taken for the same and help maintain the standard of service to be offered.

However, if a driver doesn't follow the rules and regulations, the person has to pay penalties for it, and accordingly, steps would be taken as per the scheme.

By following the steps mentioned above as stated by the state government, it would be suitable to introduce a large number of EVs in Delhi. Therefore, it would be smooth and hassle-free for the transport department to handle it better and management service. When introducing EVs and drivers, it is better to ensure that it gets registered in

quick time and it is a suitable one to offer correct service to the passengers.

In this regard, ministries are trying to ensure that they can ensure smooth implementation of the EV scheme and help boost the concept of fleet service and ride aggregators in the city. The most aggressive of all categories is the two-wheelers that have to be converted to an electric vehicles and it should get the license approved within two years. This is another motive that is part of the successful launch of the scheme.

## VI. CONCLUSION

The topic as well as objective under the title “electric vehicle aggregators in electricity markets under optimal conditions: review” will be completed.

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