
Smart Vehicles, Smart Energy :

Strategic approaches to product creation in energy markets

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This proposal outlines the initial research design of my PhD project, which officially begins in March 2026. The objective at this stage is to present the research question, theoretical positioning, and methodological roadmap.

1 Development of the research PhD thesis project

The electrification of transport represents a profound shift in economic value. A large share of the USD 2 trillion global market currently focused on supplying gasoline for internal combustion engine (ICE) vehicles will gradually transition toward electricity services for electric vehicles (EVs). Unlike gasoline, electricity is a fundamentally different commodity : its price fluctuates throughout the day (intraday variability), and its supply relies on electric networks that must continuously balance demand and supply in real time.

These characteristics of electricity systems create the potential to multiply the value of the EV electricity market compared to the market for supplying gasoline. Two dynamics drive this opportunity. First, renewable sources such as wind and solar are intermittent, making energy storage essential to ensure clean electricity is available when needed. Second, EVs can enable bidirectional energy flows at roughly one-tenth of the capital cost of stationary battery storage (Kempton and Tomic, 2005)—currently the most scalable solution for decarbonizing electricity systems.

At the same time, these same characteristics also pose challenges. Capturing the opportunities of EV energy services is complex because multiple types of services can be provided, each with different requirements and value depending on the electricity system and jurisdiction. For example, Thompson and Perez (2020) estimate the value of ten different EV-related services. These range from bill management and energy arbitrage, which reduce the total cost of ownership by leveraging intraday price variability, to frequency regulation and spinning reserves, which help system operators maintain grid balance. Their analysis (Figure 1) highlights the significant variation in the annual market value of these services across the United States, Australia, and the United Kingdom. Some services, such as arbitrage or peak-shaving, are particularly relevant in markets with strong price volatility. Others, such as frequency regulation or capacity reserves, are more valuable in systems with high penetration of renewables. Importantly, the economic value of these services depends not only on system conditions but also on geographical and regulatory factors. However, other services such as replacement reserves and imbalances correction for the Transmission System Operator (TSO) perspective have remained underexplored; and thus, require exploring the potential of EVs to provide new types of services, and the current rules for their participation.

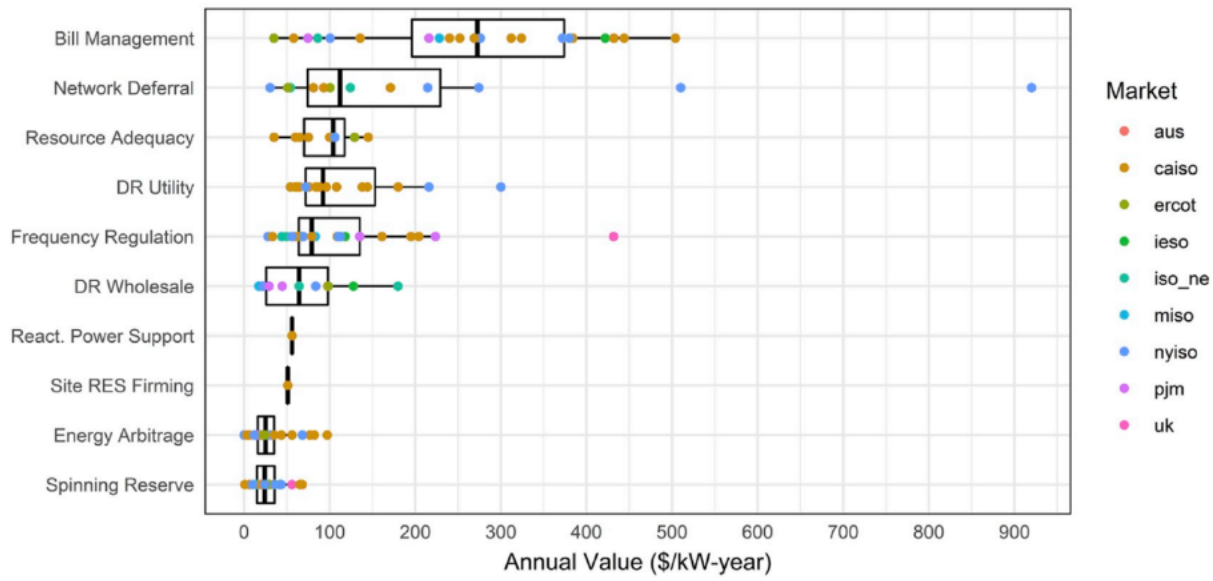


FIGURE 1 – Potential value of EV energy services

While the framework provided by Thompson and Perez (2020) has been crucial for structuring the discussion on EV energy services, it presents limitations when considering the perspective of global automakers such as Stellantis. Their value estimates are based on services provided by traditional electricity assets, such as thermal generators or stationary batteries, which are typically connected at high-voltage networks. EVs, by contrast, connect at low-voltage distribution networks and must comply with different technical requirements, standards, and procedures. The evaluation requires to consider that, EVs are highly distributed assets, and their availability is determined by the behavior and preferences of individual owners, which means the value of services is constrained by time, location, use-mode and aggregation. Such type of evaluation lacks for many types of the services that potentially can be performed by EVs; particularly for those that require TSO and DSO cooperation.

For automakers, these considerations are far from neutral. The capability of EVs to provide energy services comes with costs and risks, particularly related to battery degradation, warranty exposure, and the need for investment in advanced control systems and certification processes. Therefore, the key question is not only the size of the theoretical market for EV energy services, but rather : Which services deliver real value for EVs, and which are the most adapted in terms of technical readiness, market potential, and strategic fit for automakers? Answering this type of question requires considering the strategic alignment between product development and the cost-benefit analysis of the investments needed for an EV to comply with specific energy services. This is particularly relevant for TSO services, where compliance can be burdensome. At the same time, one must weigh the market value of each service, considering market depth and the type of driver behavior that maximizes revenue under the given service rules. Understanding this

alignment is essential, since the future role of EVs in electricity markets will depend as much on manufacturers' willingness to support specific functionalities as on the economic or technical potential of the services themselves.

2 Deliverables

To address this question, the research proceeds through five interrelated analytical steps.

The first step consists in systematically identifying and classifying the range of electricity services that electric vehicles may provide. Drawing on academic literature, market documentation, and selected expert interviews, the objective is to distinguish between user-oriented services (such as bill management or self-consumption optimization) and system-oriented services (such as balancing, reserves, or congestion management), while also examining less-studied functions such as replacement reserves or imbalance correction from the perspective of Transmission System Operators. This mapping establishes the analytical perimeter of the study.

The second step examines how the institutional configuration of electricity systems shapes the feasibility and valuation of these services. Particular attention is given to differences in market design, regulatory frameworks, renewable penetration, grid architecture, and the coordination mechanisms between Transmission System Operators and Distribution System Operators. Rather than assuming a uniform market for EV services, this comparative approach highlights how opportunity structures are institutionally contingent and vary across jurisdictions.

The third step develops a formal evaluation framework to assess the capacity of EVs to provide different categories of services. Because EVs are distributed, low-voltage assets whose availability depends on user behavior and aggregation mechanisms, their performance cannot be inferred from models designed for centralized generation or stationary storage. The framework therefore models availability constraints, network integration at the distribution level, and service-specific performance requirements such as response time for frequency regulation or duration capacity for peak shaving. This allows a systematic comparison between EVs and alternative flexibility assets, clarifying their relative advantages and limitations.

The fourth step analyzes the economic and organizational implications for automakers. Providing grid services may generate revenue, but it also entails costs related to battery degradation, warranty exposure, certification requirements, and investment in digital control systems. This part of the research therefore examines how electricity-market participation translates into manufacturer-level incentives and risk allocation, and how these considerations affect strategic decision-making.

Finally, the project integrates these elements into a comparative assessment of which services are likely to be both economically meaningful and institutionally feasible for automakers. The objective is not to produce a managerial ranking, but to identify the conditions under which particular services become viable, and those under which they remain constrained by regulatory design, technical requirements, or misaligned incentives.

The expected contribution of the thesis is threefold. Conceptually, it integrates electricity market economics, distributed energy systems, and industrial strategy. Methodologically, it introduces a service-specific simulation approach adapted to low-voltage distributed assets. Institutionally, it highlights how regulatory design and TSO–DSO coordination affect the strategic incentives of automakers.

3 Bibliography

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