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D6.1: Cost-Benefit Balance of Providing Bulk Energy

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V1.1	31.01.2026	Alexandra Ciuriuc	Added new and refined existing T6.1 experimental inputs
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1. Executive Summary

This deliverable, D6.1: Cost-Benefit Balance of Providing Bulk Energy, presents the preliminary economic and technical assessment of utilizing Electric Vehicles (EVs) as flexible assets for grid support within the XL-Connect project. As part of Work Package 6, this report evaluates the trade-offs between the investment costs associated with advanced bidirectional charging infrastructure and the monetised benefits derived from grid services, such as peak shaving, congestion management, and infrastructure deferral.

Methodological Framework

Given the pre-commercial status of Vehicle-to-Grid (V2G) technology and the stochastic nature of user behaviour, this analysis employs a probabilistic simulation framework. By integrating the "MYC grid model" with Monte Carlo simulations, the project has modelled massive EV penetration scenarios to quantify energy and power adequacy under varying conditions.

The Cost-Benefit Analysis (CBA) adopts a multi-stakeholder perspective to address critical economic barriers, specifically the "Split Incentive" dilemma and the regulatory "CAPEX Bias." It recognizes that under current regulations, Distribution System Operators (DSOs) earn returns on their Regulated Asset Base (RAB), meaning infrastructure deferral reduces their financial return while generating system-wide savings. Consequently, the economic calculations utilize a 10-year time horizon (2026–2035) and a social discount rate of 3.5% to assess the societal value of these technologies.

Preliminary Findings

The simulation results indicate that the economic viability of V2G is highly sensitive to operational strategies and the regulatory environment:

- **Grid Impact:** Unmanaged charging in high-penetration scenarios leads to significant thermal overloading and voltage violations. Conversely, smart charging (V1G) and V2G strategies successfully shift loads, reducing grid stress and enabling the integration of renewable energy.
- **Economic Performance:** Under a Conservative Scenario (high hardware costs, unmitigated battery degradation), the business case yields a negative Net Present Value (NPV). However, Central and Optimistic Scenarios demonstrate a positive Benefit-Cost Ratio (BCR > 1.0) from a societal perspective. This profitability is driven by advanced energy management algorithms that minimize battery ageing. Crucially, realizing this value for grid operators requires a transition to TOTEX-based regulations, which would allow DSOs to retain a share of the system savings generated by deferring physical grid reinforcement, thereby overcoming the current financial disincentive to reduce their asset base.

Demonstration Status and Future Validation

This report relies primarily on high-fidelity "Digital Twin" simulations and pre-installation baseline measurements collected from the project's physical demonstration clusters in Portugal (Coimbra), Germany (Aachen), and Italy (Florence). While baseline monitoring is fully active, the complete commissioning of bidirectional hardware is scheduled for the first quarter of 2026. Consequently, the findings presented herein are preliminary. The final operational validation, incorporating real-world efficiency data and user acceptance rates, will be reported in Deliverable D6.5 (Final Impact Assessment) following the Spring 2026 data collection campaign.

Consequently, this deliverable relies primarily on a combination of:

1. **High-fidelity Simulation Data:** Utilising the "Digital Twin" models developed in Work Package 4 and 5 [4], which allow for the extrapolation of energy flows, battery ageing, and grid impacts under various theoretical scenarios.
2. **Baseline Measurements:** Utilising preliminary data collected via the project's Data Management System (DMS), including baseline load profiles, PV generation data, and initial EV usage patterns from the operational sites in Aachen and the pre-installation monitoring in Portugal and Italy [6].

This approach ensures that a robust preliminary cost-benefit analysis can be performed at Month 36, providing necessary inputs for the final operational validation and business model refinement that will conclude the project.