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D4.2: Subcomponent Models

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1. Executive Summary

Deliverable D4.2 presents the development, implementation, and integration of subcomponent models essential for simulating advanced electric vehicle (EV) charging scenarios within the XL-Connect project. These models are designed to support intelligent, efficient, and scalable charging strategies by representing the physical and behavioural dynamics of key system components: electric vehicles, batteries, charging infrastructure, user behavior, and the electrical grid. The subcomponent models were developed in alignment with the simulation architecture defined in Task 4.1 and are integrated into the xMOD cloud-based simulation platform. This approach facilitates coordinated control strategies and optimal energy management.

The key contributions of this report can be summarised as follows:

- **EV and Battery Models**: High-fidelity 1D electro-thermal models incorporating Heating, Ventilation and Air Conditioning (HVAC) systems, battery aging, and bidirectional charging (V2G), developed in Dymola and validated through long-term testing of NMC (nickel manganese cobalt oxides) and LFP (lithium ferrophosphate) cells.
- **User Behavior Models**: Agent-based and statistical models simulating user charging behavior across home, residential, and public parking scenarios. These models are informed by real-world data, including surveys, expert interviews, and mobility simulations using MATSim (Multi-Agent Transport Simulation).
- **Charging Infrastructure Models**: Representations of charging points, including fast chargers and microgrid-connected systems, integration of PV and battery energy storage systems (BESS) for peak shaving and self-consumption scenarios.
- **Grid Interaction Models**: Low-voltage grid simulations (MYC model) assess the impact of EV and PV integration on voltage stability, thermal loading, and infrastructure planning.

The developed models support demand response strategies and V2X functionalities, which are further explored in Task 4.3.

This deliverable addresses regulatory considerations, ensuring compliance with evolving EU and national frameworks.

Challenges encountered include data privacy limitations, uncertainties in long-term battery degradation under V2X use, and the need for regulatory clarity. Despite these, the developed subcomponent models are reliable for the development of smart charging strategies.

Keywords: vehicle and battery model, 1D electro-thermal battery, Battery Management System, model behaviour, smart charging, grid integration, EVSE model, PV model, Battery Energy Storage System, regulatory framework, xMOD simulation platform.