WeForming

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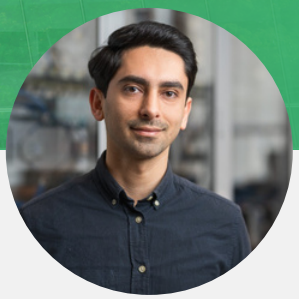

Electric Vehicles as a Core Flexibility Resource in Smart Buildings and Districts

Role of EVs in Grid Flexibility Practices

Across Europe, the electrification of transport is accelerating. Electric vehicles are becoming a central element of electricity demand in residential and commercial buildings. At the same time, the power system is undergoing a structural transition. Renewable generation is replacing conventional plants, increasing the need for electrical loads to adapt to the variable generation.

In this context, electric vehicles represent one of the most promising sources of flexibility in smart buildings and districts. Unlike most traditional loads, electric vehicle charging is inherently time-shiftable. Vehicles are typically parked for long periods, while the actual charging time is relatively short. This creates an opportunity to align charging processes with renewable generation, grid conditions, and market signals.

Within the WeForming vision, buildings are no longer passive consumers. They are active participants who can adjust their demand, store energy, and interact with the grid. Electric vehiclechargers are therefore treated as key controllable loads alongside photovoltaics, batteries, and building systems.

Why Electric Vehicles Offer Unique Flexibility

Many building loads follow occupant behaviour and offer limited flexibility. Heating and cooling systems can be shifted to some extent, but they remain constrained by comfort requirements and building physics.

Electric vehicles differ in three important ways. They provide relatively large battery capacities, they remain connected to the grid for extended periods, and their charging can usually be shifted without affecting user comfort. As long as the required state of charge is reached before departure, the exact charging time is often irrelevant to the user.

This makes electric vehicles particularly suitable for demand response. Demand response refers to the ability of consumers to adjust their electricity consumption in response to system signals or price incentives. As renewable energy shares increase, flexible demand becomes essential for balancing the grid.

The Challenge of Uncontrolled Charging

Flexibility does not arise automatically. If electric vehicle charging is uncontrolled, it can create significant new peak loads.

In office environments, many vehicles may start charging simultaneously when employees arrive. In residential areas, similar peaks often occur in the evening. Without coordination, these effects can overload local grid infrastructure and increase system costs.

Intelligent charging strategies are therefore required. By shifting charging schedules, limiting peak power demand, or prioritising local renewable energy, electric vehicle fleets can reduce grid stress and operating costs.

From Smart Charging to District Flexibility

Smart charging is the first step. It refers to coordinated charging control based on signals such as electricity prices, building load, or grid constraints. At the building level, electric vehicle chargers can already increase photovoltaic self-consumption and reduce peak demand.
However, the full system value emerges at the district scale. Buildings are interconnected through the local grid, and their combined behaviour determines whether grid limits are respected.

If each building optimises independently, conflicts may occur. One building may shift charging to a time when neighbouring buildings already experience peaks. From the grid perspective, this uncoordinated behaviour can still create critical load situations.

District-level coordination addresses this issue. By aggregating electric vehicle chargers across multiple buildings, the system gains a larger and more diverse flexibility pool. Charging processes can then be scheduled not only according to building needs, but also according to grid conditions and market opportunities. This aligns with the WeForming concept of coordinated flexibility across buildings, assets, and stakeholders.

Aggregated Electric Vehicle Fleets as System Resources

At the district scale, electric vehicle charging infrastructure can act as a virtual power plant. Individual vehicles may only offer a few kilowatts of flexible demand. When aggregated across dozens or hundreds of vehicles, the combined capacity becomes relevant for grid services and flexibility markets.

Aggregators or district energy management systems can pool this flexibility and offer it to system operators. In explicit demand response schemes, aggregated resources receive financial incentives for adjusting consumption patterns in real time.

This creates new business opportunities. Building operators can reduce peak demand charges, increase the value of local renewable generation, and participate in flexibility markets. At the same time, grid operators benefit from additional controllable resources.

The Importance of Interoperability

Large-scale electric vehicle flexibility requires more than smart chargers. It depends on interoperable data platforms, secure communication, and intelligent control systems.

Today, many buildings and charging systems operate in isolated digital environments. Proprietary protocols and fragmented data structures limit cross-system coordination. This lack of interoperability remains one of the main barriers to large-scale flexibility services.

WeForming addresses this challenge through interoperable platforms, AI-enabled energy management systems, and digital twins for forecasting and control. These technologies enable coordinated operation across buildings and districts, allowing electric vehicle charging to respond dynamically to grid conditions and market signals.

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Outlook

The number of electric vehicles in Europe will continue to grow rapidly. Each vehicle increases electricity demand but also adds potential flexibility.

If integrated intelligently, electric vehicles can absorb surplus renewable energy, reduce peak loads, and provide services to the grid. The key challenge lies in coordination across devices, buildings, and districts, supported by interoperable digital platforms.

By combining smart buildings, interoperable data infrastructures, and coordinated control strategies, electric vehicles can evolve from a potential grid challenge into a central component of a resilient and decentralised energy system.

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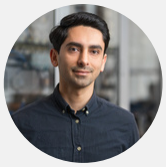
Johannes Galenzowski is a researcher at the Karlsruhe Institute of Technology (KIT), Institute of Applied Informatics (IAI), where he works on energy-technical districts, electric vehicle integration, and coordinated operation of distributed energy resources in real-world demonstrators.



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Both authors contribute to European research projects on smart buildings, interoperability, and district-scale energy management.

POWERED BY

Funded by the European Union

The WeForming project has received funding from the European Union's Horizon Europe Programme under the Grant Agreement No. 101123556.

UK Research and Innovation

The UK participant is co-funded by UKRI.