Bidirectional charging

A functional component of the energy transition

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Bidirectional charging describes the technology of not only charging an electric vehicle from the grid, but also feeding electricity back into the grid or to consumers. This is often referred to as Vehicle-2-Grid (V2G) or Vehicle-2-Home (V2H).

Bidirectional charging opens up immense storage potential

The mobile storage units in electric vehicles, even if they are individually very small from an energy system perspective, have immense storage potential due to their very large number, which can be leveraged >through bidirectional charging. Even today, with around 1 million electric vehicles in Germany, the pure storage capacity of vehicle batteries (approx. 50 GWh) is greater than the sum of all German pumped storage power plants (approx. 40 GWh). By 2030, when around 15 million electric vehicles are expected according to forecasts, the storage capacity will increase to 750 GWh. Of course, this storage potential is only available when the vehicles are not on the road but are stationary (approx. 95 percent of the time) and plugged into a charging point. The additional use of this storage capacity for bidirectional charging could reduce the need for large-scale battery storage beyond the scope of the Electricity Network Development Plan (NEP) and the associated costs and resource consumption.

Bidirectional charging is economical for customers

The flexibility of electric vehicles can be used by means of bidirectional charging in numerous applications to promote self-sufficiency, save costs and support the energy sector via grid and system services. The analyses in the BDL project show a positive economic perspective of the overall ecosystem, while significant savings or revenues can be generated. The exact savings or revenues are highly dependent on the use cases, vehicle and charging point parameters, application locations and cost components. The basic prerequisite for a successful and lucrative implementation of V2G applications for all parties involved is the adaptation of the regulatory framework. Under the current regulatory framework, charging electric vehicles from the public grid incurs taxes, levies and surcharges (TLS) in addition to the price of the energy. These TLS are not reimbursed when feeding energy back into the electricity grid, meaning that feeding energy back from the electric vehicles into the public electricity grid is not economical for the customer.[1]

Bidirectional charging makes sense from an energy system perspective

In addition to the stakeholder perspective, bidirectional charging also makes sense and is cost-optimized from a system perspective. The bidirectional development of the existing storage capacity in electric vehicles for the energy system reduces the energy supply costs in Europe compared to a scenario without bidirectional electric vehicles. The use as daily storage improves the system integration of renewable energies and PV energy in particular. In addition, the capacities of necessary stationary battery storage systems that exceed the NEP and the necessary capacities of thermal power plants could be reduced, thereby reducing CO2 emissions. Simulations have shown that, from a system perspective, around 30 % of electric vehicles should ideally be bidirectional.[2]

Grid integration of electromobility

The electricity grids must be further strengthened as part of the energy transition (e.g. for the connection of PV and wind power plants) and through the electrification of the mobility and heating sectors. The targeted use of decentralized flexibility can lead to different simultaneity factors depending on the application. Simulations with realistic participation rates for V2H and V2G (30 % of buildings in total) show that the grid expansion needs in the distribution grid are

[1] In the BDL project, 255 kWh were charged and fed back at a customer in pilot operation (in April 2022), whereby € 21 could be generated through energy trading, but € 49 TLS were incurred in the same period.

[2] BDL – Bidirectional charging management – Final report of FfE. Munich: Forschungsstelle für Energiewirtschaft (FfE), 2023.

similar to those for uncontrolled charging. Grid-friendly use can further reduce grid stress and thus offer the opportunity to turn a supposed problem into a solution.[2]

Decentralization ensures geographical balance / distribution

Generation and consumption structures are changing in the European energy system: a large proportion of the grid connections of generators are shifting from extra-high voltage to lower voltage levels, while increasing electrification is simultaneously changing the consumption structure and increasing the demand for electrical energy. Electric vehicles are distributed decentrally and, if bidirectional, can be used as both generators and consumers in the end consumer system (e.g. in single or multi-family homes) in an optimized manner. They can also mitigate and cushion disruptive developments in the distribution grid, for example by counteracting voltage drops in low-voltage grids. At the same time, they can have a stabilizing effect on the overall system: in aggregated form, they can contribute to congestion management, frequency stability or reactive power management.

Necessary standards exist and promote the use of bidirectional charging and the market launch and ramp-up

The large number of new technological interfaces in the bidirectional charging ecosystem requires standardization of the various interfaces in order to ensure functionality and interoperability and thus to be able to define dedicated discharging functions as a cross-industry functional scope of the CCS charging system. Key prerequisites in this context already exist and are conducive to a market ramp-up - the following is an excerpt: (1) for efficient communication between electric vehicles and charging stations - ISO 15118-20 (DIN Spec 70121), (2) for the targeted exchange of information between the CLS end point, controllable consumers/generators and control devices in properties - VDE-AR-2829-6 (EEBUS), (3) for the management of charging points, in particular for bidirectional charging - OCPP 2. 0.1 as a valuable further development of the communication standard, with a view to OCPP 2.1. and IEC 63110, (4) for demand-response control or control of decentralized resources by energy supply companies and grid operators - OpenADR 2.0 and IEC 62746-10. Networking and harmonization with the BigPicture charging ecosystem from the funding project "Wirkkette Laden" should be aimed for.

Intersectoral research projects are working to make this possible

In order to leverage the identified potential, cooperation is required between the various players along the entire value chain, from energy supply to the automotive industry. Projects such as BDL, unIT-e^2, Wirkkette Laden and BDL Next are working across sectors with the various stakeholders on the identified challenges and are important for bundling individual research activities and jointly achieving the goals: Contributing to the decarbonization of the energy system and attractive charging solutions for customers. Further overarching research projects are recommended in order to (further) develop the technology and the associated new processes for different stakeholders and to accelerate the availability of CCS charging and discharging functions.

For Germany as a domestic market, there is an opportunity to be an innovation leader

In summary, it can be said that the use of bidirectional electric vehicles in the energy system offers several advantages and synergies. Bidirectional electric vehicles promote the integration of renewable energies by using the vehicle batteries as flexible buffer storage to cushion the volatile feed-in and at the same time reduce the load on the grid through intelligent charging management. The continuous promotion of the market ramp-up of e-mobility should therefore be seen as an opportunity for innovation and economic growth across all sectors in the German energy and automotive industries. The bottom line is that bidirectionality will not only be an attractive but also a necessary feature of future generations of electric vehicles, which will be a cornerstone of the sustainable energy future in line with global sustainability goals.

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