VDE Fact Check

Bidirectional Energy Flows

Within the framework of the mobility and energy sector, there is an increasing focus on bidirectional energy flows as a flexibility option. The potential of this technology makes it possible to sensibly utilize the typically long downtimes of electrical vehicles to control loads. This fact check includes, among other things, definitions and existing regulations and explains the role of the VDE in this area.

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What does “bidirectional energy flow” mean?

It may sound strange, though it makes sense: the bidirectional energy flow of electrical vehicles. But what is it? Charging, in one direction, is completely normal for electrical vehicle drivers. The current flows out of the power grid into the electrical vehicle via the charging station. “Bidirectional charging”, meaning in two directions, is part of the near future. Here, the current can also flow back from a vehicle battery and into the power grid or house via the charging station when needed. What is clear is that everything must be regulated because intelligent load management offers many options to flexibly provide electricity, both for the washing machine at night and for the power grid in certain situations.

The German power grid is the backbone of electromobility. In addition, it is one of the safest, most reliable power grids in the world, from which electrical vehicle drivers here in Germany will initially profit. But remaining at the current status quo is not an option. Power grid operators must expect a significant increase in the number of electrical vehicles and each vehicle on a charging station constitutes a new, powerful consumer on the power grid. In the short term, no problems are expected, but in the medium and long term, the grid must be adapted to the growing need and flexibly integrate electrical vehicles into the power grid.

This results from the fundamental objective of supplying them with renewable energy. The charging process should therefore preferably take place when the offers for electricity from renewable energy sources is as high as possible.

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To avoid negative consequences, the grid must be continuously expanded, and an intelligent charging control system is needed. This would allow for not only the grid load to be optimized, but also the need for expansion to be reduced. The challenge is familiar: As soon as most electrical vehicle owners want to charge the battery at night during the “charging peak time”, there can be shortages and overloads on the grid and, under certain circumstances, damage, and power failures. To prevent this, one solution is a so-called energy management system (EMS) which considers the vehicle as well as, for instance, photovoltaic systems and home storage batteries. The basic functionality consists of monitoring, controlling, and optimizing connected generation and consumption units.

The potential of this system results from the downtime of the electrical vehicle at the workplace or residence, which is comparatively significantly higher than the charging period, which results in temporal flexibility with respect to the optimum charging and feed time. This flexibility potential increases even more if bidirectional energy flow can be enabled.

Instead of immediately charging the electrical vehicle after connecting it to the charging station, the user first transmits the time of their next trip and the necessary distance to the vehicle or EMS. This provides information about the electrical supply (price development, available output, etc.). Thus, all factors, like household electricity needs, the amount of self-produced electricity, the price for using the grid, etc. can be considered and the (price-related) benefits of locally or regeneratively generated power can be used. The increasing number of electrical vehicles also allows for increased flexibility: the charging time can be freely selected because shorter downtimes of individual cars can be compensated by others with longer services lives.

Why is VDE addressing this topic?

With respect to climate protection and air pollution control in cities, electrical driving plays a key role. Integrating public and private electrical vehicles and their charging infrastructure into energy systems is not only a major challenge for our power grids today, it will also be a major challenge in the next few years. This must be carefully planned early on. VDE therefore unites science, standardization, the development of regulations and product inspection under one roof.

The norms, rules and standards developed in the specific cases in the mobility sector not only ensure safety and quality, but also promote user trust which creates investment security and supports economic efficiency. All the participants, from grid operators to vehicle and charging infrastructure and measurement technology manufacturers through to certifiers and scientists, work together to design the necessary bases for the successful integration of modern mobility into the power grid.

To this end, at VDE committees or rather work groups and project groups develop practical solutions and provide balanced, technically founded guidelines. To avoid subsequent, expensive adjustments, they always work in a forward-looking manner. Norms, rules, and standards are indispensable for a global, successful market ramp-up.

Definitions

- Vehicle-to-Grid (V2G): This concept plans for the feed of power from the vehicle battery into the grid and thus corresponds to the function of a storage power plant, whereby, an adequate amount of (connected) electrical vehicles is required for efficient utilization. This allows for load control tasks to be fulfilled.
- Vehicle-to-Home (V2H): This concept is like the concept above, but here, excess energy, for instance from a home photovoltaic system, is stored in the vehicle battery and, when needed, is merely fed back into the house and not into the public grid. This would, for instance, cover the house’s power needs in the event of a power failure.
- Vehicle-to-Device (V2D): This concept allows for the vehicle battery (even while traveling) to be used as a power source, or emergency power generator, for electrical devices (for instance smart phones, laptops, or kitchen appliances).
- Vehicle-to-Vehicle (V2V): This concept provides for two electrical vehicles to be connected by a cable to, for instance, charge a broken-down vehicle or use parked vehicles as charging stations.

Flexibility in the system

Currently, conventional power plants still provide most of our power. Due to the increasing integration of renewable energy plants and photovoltaic and wind energy plants, which produce power depending on the weather, more and more flexibility in the power grid is required since consumption and generation always must be balanced.

Electrical vehicles can help by either halting the charging of their battery when consumption is too high, starting to charge later or, feeding power into the power grid when they are fully charged. In the event there is a surplus of renewable energy on the generation side, batteries can be charged in a targeted manner using this excess power. Experts refer to this charging behavior as “grid-beneficial use”.

“Short and sweet” regulations

- Standards:

Using the Electromobility Act and the Charging Station Directive as the legal framework for electromobility, standardization focuses on various aspects, from vehicle technology to the charging infrastructure through to urban planning, taking energy and environmental aspects into account. With respect to bidirectional energy flows, a variety of standards or series of standards must be considered. With respect to wired charging, general safety requirements for the charging infrastructure are described in the IEC 61851-1 standard which pertains to all the components used. There are also additional standards.

With respect to wired charging, the base standard has been finalized which establishes interoperability and set the foundation stone for the creation of a mass market.

- Application rules:

VDE application rules have been developed for the connection of charging equipment (charging station, wall box) that ensure proper implementation. Whether in public spaces or on private property, charging equipment for electrical vehicles must be registered with the local grid operator. To this end, all operators of charging equipment are obligated to register since the VDE application rule “Technical Connection Rules for Low Voltage” took effect on March 8, 2018. The commissioned electrical installer registers the equipment before installation. In addition to the grid connection, the operation of charging equipment for electrical vehicles is governed in various documents.

For electrical vehicles which can feed energy from the vehicle back into the customer system connected to the public grid, the VDE application rule VDE-AR-N 4105 is also relevant.

- VDE instructions:

Implementation aids in the form of VDE instructions are also available. These include, for instance, the instruction for integrating electromobility into the grid with preparatory requirements for the charging infrastructure, information about controlling charging processes and the impacts on the grids (version: September 2019). The connection and operation of accumulators to/on the low-voltage grid also offer a practical added value with the various accumulator connection variants because they also include mobile storage devices like electrical vehicles.

To control power consumption or for load management, there is also a concept to ensure the safe connection and deactivation of, for instance, electrical storage heaters or vehicles (Note: VDE Instruction "Control box specifications: Functional and structural features control box"; version: March 2021).

Forecast

In the future, the use of bidirectional energy flows is expected in Germany. Negative impacts on the vehicle battery due to the provision of energy are considered non-critical from many sides if, for instance, protective functions are sensibly applied. However, it is still important to continue researching and applying findings from pilot projects to make breakthroughs in this technology. To this end, charging standards that apply to all vehicle and charging infrastructure manufacturers are indispensable. To achieve this, manufacturers, among others, must ensure that the necessary equipment is comprehensively networked and can communicate with each other. This must be done in cooperation with the grid operators so corresponding equipment like smart meter gateways (SMG) or control boxes can be used for communication and control. However, this requires the provision of data, for instance regarding the charging status of the downtimes and driving times, etc. The focus should not be on collecting as much data as possible, but rather on collecting only the amount of data required. In principle, the close cooperation of all the involved parties must be further expanded and data protection matters must be clarified early on.

The potential of bidirectional energy flows can make a major contribution toward the mobility revolution and thus the energy revolution. VDEs contributions help achieve this.