V2G: The electric car as an energy supplier for the local energy network

The Interreg project DeeldeZon is pioneering a new approach to car sharing and energy use.

We are using smart charging to supply shared electric cars with solar energy. Where feasible we go further by installing a Vehicle to Grid (V2G) system that enables each car to supply energy from the battery to the grid.

Thanks to the involvement of municipalities and other local organisations we now have nearly 20 active project sites. At each location we connect solar panels sited on a neighbourhood building to either a smart charger or a V2G charging station, and in turn link this to one or more shared cars available to residents. Our goal is to have 80 project sites running in the south of the Netherlands and Flanders by November 2022, to demonstrate and monitor the impact of smart charging and V2G and to stimulate shared mobility.

V2G offers a way to store energy from intermittent renewable sources, making the energy network more resilient to power outages. At scale it can supplement or replace the flexible reserve which is usually generated in gas-fired power plants.

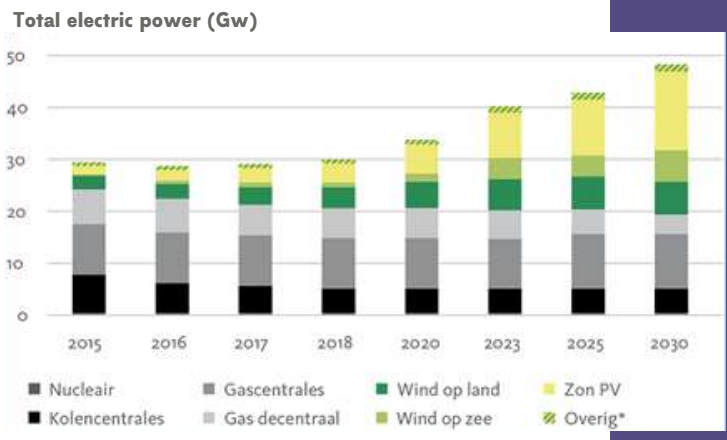
In this article we focus on this potential use of electric vehicles (EVs) to store and supply renewable energy and highlight some of the challenges involved in this aspect of the energy transition.

Smarter charging

European ambitions for electrification –especially for replacement of gas-fired central heating by electrically-driven heat pumps and for transport - mean that there will be enormous pressure on our energy supplies and grid capacity. For transport, the European Green Deal sets a target of 30 million electric cars by 2030. The Netherlands foresees an increase to 2, Belgium 1 million. Smarter solutions to manage these changes are urgently needed.

Unlike electric cars, most household appliances, such as refrigerators or televisions, make direct use of the energy they request. They do not need to be charged before you use them. You do have to charge an electric car, and this means that you can choose when to do it.

Recognising the scope for change that this provides, some European countries have begun to promote smart charging for EVs. An EV is not charged immediately it is plugged in, but at a 'smarter moment': when a lot of renewable energy is available and / or the electricity grid is only lightly loaded, such as at night. Smart charging is an important measure to counteract the disposal of sustainable energy (curtailment) and grid overload.



Explainer: curtailment

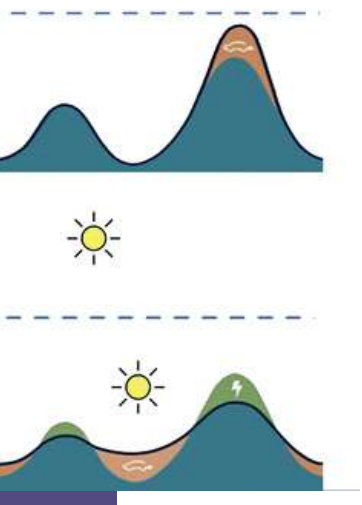
The grid operator uses algorithms to make a careful prediction of energy demand. However, it is impossible for the operator to calculate exactly how much electricity from renewable sources is generated or required. Surplus renewable energy is generally not used (ie it is thrown away) – a process termed "curtailment". Smart V2G charging makes it possible to use this grid surplus to charge EVs.

Next step: discharging power

Solar energy is a key solution, but the need to install a separate battery to store surplus energy makes this too expensive in many cases. Use of a car battery as an energy buffer via a V2G charging station provides an attractive alternative.

The battery of an electric car can often store 60 kWh – equivalent to the daily consumption (around 10 kw per day) of six households in one car. Generally, this stored energy is used only to power the car, and the same car is stationary on average 95 per cent of the time.

The V2G charging station makes it possible both to charge the electric car at a 'smart moment' and to discharge electricity to the network when there is too little sustainable energy available, for example because the sun is not shining, or because the grid operator has underestimated its availability.



The EV battery thus becomes multi-functional – powering both the car and the energy network. Typically, a single car connected to the charging station can feed 10 kW to 20 kW of power back into the grid - enough to power several households at the same time.

A calculation

With 2 million electric cars on the road by 2030 in the Netherlands it is expected that the electricity grid will have to carry a capacity of almost 50 GW in Belgium around 30.

In Deeldezon we estimate that enabling 1 in 8 cars in this country to charge and discharge bi-directionally via V2G would make 250,000 x 10kW, or 2.5 GW, of direct power available for energy supply. This is substantial when compared with the 100 MW of primary reserve capacity needed in the Netherlands to stabilize the electricity grid. If all EVs were V2G they could carry as much as 40 percent of the power.

This represents a gigantic storage and delivery capacity – potentially almost free of charge through the purchase and use of EVs by private individuals and companies. Locally, in districts and neighbourhoods, such storage capacity is of direct importance.

The battery becomes multi-functional, powering both the car and the energy network

An interactive simulation model for our pilot neighbourhoods developed on behalf of DeeldeZon by ZenMo (the research institute affiliated to Eindhoven University of Technology), shows that simultaneous charging of 40 electric car overloads the grid. Factoring in extra load – for example from heat pumps – adds to the risk of congestion.

However, the model also demonstrates that an appropriate mix of smart and V2G charging stations can prevent overload without further modifications to the network. Correct charging techniques make the electric car a bonus for the neighbourhood rather than a burden.

For the car owner with their own solar energy supply, using V2G can enable them to make cost savings by storing surplus energy in the car battery and using it to meet the household's other energy needs. More radically, EV owners can become small energy suppliers, effectively using vehicles as a battery for the neighbourhood and getting paid to feed power back to the network.

AC or DC?

In most countries the entire electricity network is based on AC (alternating current), while batteries and solar panels work on DC (direct current). It is not possible just to add DC to the AC network, or vice versa.

Typically, a car battery is charged with DC power – so the power must first be converted from the regular AC network to DC. Conversely, when we start charging V2G we must convert DC current to AC. The conversion requires an inverter placed either in the charging station or in the car.

At local level there is an important choice to be made between AC and DC charging stations. In common with about 93 per cent of V2G projects worldwide we have chosen to use DC rather than AC charging technology within DeeldeZon. It enables use of the charging station by several types of car without the additional technology which must be built into vehicles connecting to an AC V2G charging station.

We can make direct use of DC charging technology at our project sites because suitable cars are already available. All Nissan and Mitsubishi EVs – with more than 500,000 already sold worldwide - can discharge via DC. The Volkswagen group has recently announced roll out in 2022 of their DC/V2G system which uses a CCS connector meeting new international standards.

The Netherlands has up to now taken a different direction, with more than 300 AC V2G charging stations already in place in Utrecht and elsewhere. Here the AC to DC conversion takes place within the car rather than in the charging pole.

Disappointingly, for the past 4 years only Renault Zoe prototypes prepared for this purpose – a total of 15 vehicles located in Western Europe, only three of which are in the Netherlands - have been able to utilise these V2G stations to discharge power. However, more models suitable for AC discharge may in future be available, for example from Renault, Sono Motors and Hyundai / Kia.

V2G-charging station DeeldeZon Bonheiden

Some non-technical challenges

There are other issues in this innovative field of work, not least liability, energy taxation and finance. For example, what are the consequences of V2G for the lifespan of, and therefore the warranty on, an EV battery? Who earns from the electricity fed back to the grid - the vehicle owner or the owner of the building whose rooftop solar panels generate the power? Can V2G impede grid reinforcement, and does this generate savings for the grid operator? Should society collectively ensure a stable grid or should individual EV owners, or groups functioning as an energy cooperative, secure their parts of the grid?

The Deeldezon partners are tackling these broader issues together as the project progresses.

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