

Vehicle-to-Grid and Vehicle-to-Home Power Exchange Project

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Summary

The objective of this project was to conduct testing in real-life conditions to analyze the technical feasibility of vehicle-to-grid (V2G) and vehicle-to-home (V2H) power exchanges, which use the energy stored in electric vehicle (EV) batteries as an extra power source for the Hydro-Québec grid or a home.

Keywords: V2G, case-study, smart grid, charging.

1. Introduction

From May to December 2014, a test platform was connected to the Hydro-Québec grid and the main circuit of the user's home so the battery of her electric vehicle could directly supply some devices during simulated power outages. The test platform consisted of an all-electric vehicle equipped with a bidirectional charger, a high-power battery and a battery management system designed to inject a specific quantity of energy into the grid at a given time. This configuration made it possible to study the technical feasibility of vehicle-to-home (V2H) power exchange, which would allow an EV battery to be used a backup power supply for the home, like a generator.

2. Project results

The project produced many findings and tested a number of hypotheses. A brief overview follows.

2.1 Technology

- Systems of this type are safe, robust and reliable.
- System response times can easily be under three seconds.

2.2 User

- The user very much appreciated these systems for their transparency and ease of use, in particular V2H, which, during power outages, can supply a portion of household loads with silent and clean energy.

- The user rarely refused power exchanges or charge limit requests.
- The user wanted the EV battery to have a sufficient charge for a range of about 40 km.
- The user's habits were similar to people who use their car to commute to work:
 - Leave between 6:30 a.m. and 8 a.m.
 - Return between 4 p.m. and 6 p.m.
 - Return trip to work and back of about 45 km
- The user left the vehicle parked at home or work 90% of the time.
- The user needed to know the duration of V2G or V1G (smart unidirectional power exchange) requests to set the battery's critical threshold (battery charge level she wanted to retain for upcoming trips).

2.3 V2G power exchanges

- During peak periods, approximately 75% of initiated V2G operations were interrupted because the vehicle was disconnected (in the morning) or because the battery charge was too low (late afternoon).
- On average, the vehicle injected 6 kW into the grid for an hour (or about 6 kWh).

2.4 Potential of these systems

- The V2G and V1G systems (with charge limits) have a number of uses, including:
 - Reducing peak power demand for Hydro-Québec or the customer
 - Frequency regulation
 - Contribution to normal 10-minute and 30-minute reserves

3. Hurdles to V2G adoption

- Small number of electric vehicles
- Absence of electric vehicles equipped with bidirectional charging on the market
- Requires an aggregator to manage a large number of vehicles to ensure sufficient power availability to contribute to the stability and normal reserves
- Higher cost of charging stations and on-board equipment
- Need to secure communication between the aggregator and charging stations
- Possibility of damaging the vehicle battery
- Technologies currently under development could offer the same services at lower cost (grid storage)
- Reliable and efficient hydroelectric power system that gives Hydro-Québec cost-effective regulation

4. Summary of project data

Table 1: Summary of project data

Measurement	Value
Number of user testing days	84 days
Total distance travelled	4,100 km
Average daily distance travelled	48 km
Changing station connection time, at home and at work	90%
V2G mode exchange requests	74
Charge limit requests	56
Simulated V2H mode exchanges	5
Real V2H mode exchanges (due to an outage)	1
Average critical threshold – weekday	40%
Average critical threshold – weekend	32%
Average charge level – weekday	60%
Average charge level – weekend	80%
V2G mode exchanges completed	77%
V2G mode exchanges not completed – vehicle not connected	17%
V2G mode exchanges not completed – insufficient battery charge	4%
V2G mode exchanges not completed – user refused	2%
State of charge below critical threshold at time of connection	25%
V2G mode exchanges halted because critical threshold reached	30%
Average V2G mode power exchange	5.7 kW
Average V2G mode power exchange duration	About 1 hour
Charge limits completed	41%
Charge limits not completed – vehicle not connected	49%
Charge limits not completed – insufficient battery charge	7%
Charge limits not completed – user refusal	2%
Average power in V2H mode	2 kW
Total energy reinjected	322 kWh
Connection time between 6:30 a.m. and 9 a.m.	50%
Connection time between 4:45 p.m. and 7 p.m.	50%

5. Conclusion

The project showed that an EV can be used as a backup power source for the grid or the home. However, other solutions currently being studied, such as interrupting power to hot water heaters during peak periods and battery-based grid storage, could provide the same services at lower cost.

Author



Mr. Dupré is a graduate of l'École d'ingénieurs SUPÉLEC in France. He launched his career with the Société nationale des chemins de fer français (SNCF) in the signalization research and railway electrification sectors. In Québec, since 2001, he was a public transit consultant and then joined Hydro-Québec in 2011.

In his current role with the company's Direction – Électrification des transports, he is involved in public transit electrification projects and in the development of the Electric Circuit, the most extensive public charging network in Québec. Moreover, he was also part of the team that spearheaded the V2G-V2H pilot project.