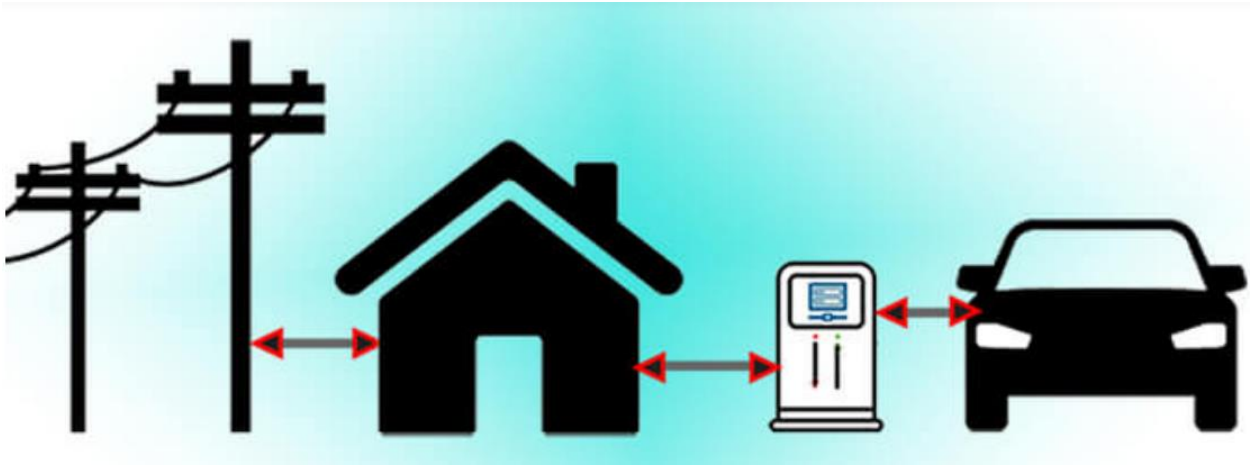
Vehicle-to-Grid: Status of Bidirectional Electric Vehicle Charging

The concept of Vehicle-to-Grid (V2G) has actually been around longer than the era of Electric Vehicles themselves. The concept – and some of the technology behind it – was developed by Willett Kempton at the University of Delaware back in 1996. The University of Delaware participated in one of the earliest field tests of the concept in Denmark back in 2013, working with Nissan.

Starting around that time there was a lot of discussion about V2G in the US. The idea behind it was presented as straightforward. Since most vehicles are parked for many hours a day, the power of the batteries could potentially be tapped to help power the grid. As the use of intermittent renewable energy sources - solar and wind – to power the grid increases the value of this back-up power source will increase as well. At the same time, the owners of the vehicles can earn cash from the participating utilities for providing the power – in much the same way as is currently done with solar PV systems via net-metering programs. Here's a 2013 article, for example, from the New York Times: In Two-Way Charging, Electric Cars Begin to Make Money from the Grid.



V2G is not the only use of bidirectional charging. Using an EV effectively as a back-up generator for a home is referred to as Vehicle-to-Home, or V2H. (A variant of that is referred to as Vehicle-to-Building (V2B), for use in a building that is not a house). V2H and V2B require an EV that supports bidirectional charging, a bidirectional charger, and additional equipment that supports the conversion of battery power to the home.

The other form of bidirectional charging – which you hear about much less frequently – is Vehicle-to-Load, or V2L. In this case, the vehicle is not being used to power an entire home or building but instead to power a few specific pieces of equipment that are plugged into the vehicle directly – with no need for a bidirectional charger at all.

There have been a handful of utility tests of V2G in the US – including projects in California undertaken by Pacific Gas and Electric and Southern California Edison - but these tests have for the most part been very short-term and involved few vehicles. There are some larger trials going on in England, including a

325-car project being run by OVO Energy (using the Nissan Leaf). OVO has reported that participants saw a reduction in their energy bills of about $850/year. Nuvve[1], a provider of 2-way charging stations, has been working on a V2G project in the UK with Cisco involving up to 200 cars and has formed a partnership with energy supplier EDF Energy to deploy up to 1,500 bidirectional chargers.

But these are the largest pilots anywhere, and much larger than anything in the US. Why has there been so little uptake on the V2G concept?

Issues Limiting the Promulgation of V2G

One obvious limitation has been the slow pace at which electric vehicles have rolled out. The rollout expanded rapidly in 2021 when almost 1 million electric cars were sold worldwide, up tenfold from just a few years earlier. But that still leaves very few EVs on the road compared to gas-powered vehicles - and this is only a small part of the story.

Of more significance is the fact that very few current electric cars are capable of bidirectional charging. Tesla, which was responsible for almost ¾ of EV sales in the US in 2021, does not currently support bidirectional charging. The only car models that have been supporting bidirectional charging are the Nissan Leaf and Nissan eNV200 and the Mitsubishi Outlander and Eclipse plug-in hybrids. So, there are very few EV's on the road that are even capable of V2G.

Secondly, there are also very few EV charging stations that support bidirectional charging. Bidirectional charging involves a complex power conversion process requiring a DC to AC inverter as opposed to a regular EV charger that charges using AC power. None of the most common EV chargers in the US, from ChargePoint, Tesla, EVGo, and others, support bidirectional charging. The only bidirectional chargers currently available in the US are from the afore-mentioned Nuvve, an American company, and a Spanish-based company called Wallbox which recently opened a manufacturing facility in Texas. Indra is a UK-based company whose bidirectional charger is currently in beta testing with the OVO Energy project mentioned earlier. Emporia Energy, a US supplier of EV chargers, has reported that they will release a bidirectional charger in the second half of 2023. As of yet, no one has announced the availability of 2-way Level 3 high speed chargers.

Moreover, bidirectional chargers are significantly more expensive than standard Level 2 EV chargers, which typically cost between $500 and $800. Wallbox's bidirectional Quasar chargers cost $4,500 - $8,000 vs. $650 for their standard Pulsar unit. Indra has reported that they have gotten their price down to about $6,000. Emporia has stated that their bidirectional charger will retail for less than $1,500, but that must be considered speculative at this time.

Making it even more complicated is the fact that that there is not a standard charging protocol shared by all electric vehicles and charging stations. The Nissan bidirectional EVs use the older Japanese-developed CHAdeMo protocol for DC chargers, which is what Indra uses as well. Wallbox's initial bidirectional charger also supports CHAdeMo, but the version that was just released is based on the more widely utilized Combined Charging System (CCS) protocol, which supports both AC and DC charging and is what is being supported by newer longer-range batteries. The Tesla Superchargers use yet a different protocol. Automobile manufacturers that support CCS include BMW, Daimler, Ford,

[1] Willett Kempton has been involved with Nuvve from its inception.

Jaguar, General Motors, Honda, Hyundai, Kia, Mazda, MG, Polestar, Renault, Rivian, and Volkswagen. Cars that support only 1 of these protocols cannot be charged with a charger that is based on a different standard without an appropriate adaptor.

There are also regulatory inconsistencies among the states that could get in the way of a smooth rollout of V2G. For example, there are still 9 states that do not allow for net-metering with respect to solar power, and the amount that utilities can offer their customers varies widely from state-to-state. That being said, regulatory issues are likely to be much less significant than the technology issues raised above in terms of limiting the rollout of V2G.

Tesla's Position on Bidirectional Charging

Given their market share, Tesla's position on V2G and bidirectional charging in general is key. Tesla has been openly tepid at best about bidirectional charging. They have pointed out that bidirectional charging has the potential to shorten the life of the batteries, although that issue has been becoming increasingly less important as Tesla continues to extend battery life. They have also noted that the current size of the EV fleet is too small to have any meaningful V2G impact and that any focus on bidirectionality can wait until the fleet grows significantly. Those with a cynical perspective have suggested that Tesla's real concern is the potential impact of bidirectional charging on the market for their Powerwall back-up battery systems, which retails for over $10,000. If the car's battery can be used there is no need for a separate battery back-up system; in fact, a Tesla car can generate about 5 times the 13.5 kW available from the Powerwall and so represents a much more powerful battery back-up option.

The *Electrek* website dedicated to electric transportation and sustainable energy news reported back in 2000 that Tesla had in fact already made the Tesla Model 3 (and by extension the Model Y) capable of bidirectional charging. (Tesla quietly adds bidirectional charging capability for game-changing new features). Given that the Model Y and Model 3 are the best-selling EVs this could have meaningful implications. However, aside from the fact that Tesla never confirmed this allegation, Electrek has since updated their position and now reports (in the link above) that the person who reported the bidirectionality had made a mistake. That being said, there are still reports that suggest that there is very little that Tesla would need to do to support bidirectionality.

Expanded Automotive Support for V2G

While bidirectional charging capabilities are severely limited with the generation of EVs currently on the road, that is about to change.

Most notably, Ford has orders for 200,000 Ford F-150 Lighting EVs which just began to ship. These will all have bidirectional charging capabilities. They will, however only work with Ford's own bidirectional charger (which uses the CCS protocol). The Ford charger is significantly less expensive than other bidirectional chargers, reportedly retailing for under $1,500. However, to make them work buyers will also need to obtain additional Ford equipment – specifically the Ford Home Integration System which purportedly is retailing for $3,900. There is also a cost for installation. (Solar company Sunrun is Ford's preferred installation partner).

The F-150 Lightning also has V2L capability in the form of four 2.4kW AC power outlets located on the truck bed. This simply allows you to plug an appliance into the car exactly as you would with a wall outlet. Other new vehicles that support V2L include the new Hyundai IONIQ 5 and the Kia EV6.

Volkswagen has announced that the ID-4 EV being released in the second half of 2022 will also support bidirectional charging. Other new cars that have just been released or scheduled to be released in the coming year and have been announced as supporting bidirectional charging include the Hyundai IONIC 5, Rivian R1T, Kia EV6, and Chevy Silverado EV.

So, What's the Bottom Line?

It would appear that there will be a lot more EVs that support bidirectional charging over the next couple of years, particularly if Tesla decides to offer support, and that there are likely to be many more bidirectional chargers available as well. Does that mean we are going to see a dramatic increase in V2G in the US?

While we should definitely see a meaningful increase, we are probably still many years away from a major rollout. Consider the following:

First, as noted earlier, bidirectional chargers are significantly more expensive than standard chargers. Even with the potential payments from sending power to the grid how many consumers will move quickly to make the additional investment? That may not happen until pricing comes down considerably.

Next, consider that most cars are not parked at home during energy peak periods when the grid has the greatest need for power (although that has certainly changed during this period of remote work). While V2G at night can be used as a substitute for solar power, most of the value of V2G occurs during daytime hours. Therefore, there will need to be a major increase in bidirectional chargers in the locations where the cars are parked during the day. And the question then is who is going to be paying for those units? Will the charger operators need to charge the EV owners more for the power they use when charging in order to pay for the extra cost of the bidirectional units? Will net-metering payments be shared between the drivers and the charger operators? These are issues that will need to be resolved before widespread adoption of V2G technologies can be accomplished.

Bidirectional charging at home in the form of V2H is something that will provide immediate value for consumers that purchase bidirectional EVs and will probably eliminate the market for battery back-up systems for EV owners. But widespread adoption of V2G in the US is likely to still take quite a few years to develop.