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Bidirectional Charging in the US

John Lindsey

Schneider Electric 201 Washington Street Boston MA 02111

john.lindsey@se.com

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Bi-directional electric vehicle (EV)

The transition to Electric Vehicles in the US is creating an opportunity to improve the utilization of renewable energy and help stabilize the national grid. Bi-directional electric vehicle (EV) charging is possible and scalable, and it's becoming more common as EV technology advances.

- *Bidirectional Charging*
- *Bi-directional electric vehicle (EV) charging*
- *vehicle-to-grid*
- *energy management*
- *sustainable EV infrastructure*

Bi-directional charging

Bi-directional charging, also known as vehicle-to-grid (V2G/V2H and V2x) charging, allows electric vehicles to not only draw power from the grid to recharge their batteries but also to send power back to the grid through demand management applications. EVs can potentially function as mobile energy storage units, which can help balance the grid during times of high demand or even supply emergency backup power to homes and businesses.

To enable bi-directional charging, EVs require specialized charging equipment and onboard vehicle technology that allows the bidirectional system to communicate with the grid. While this technology is still relatively new, EV manufacturers, charging station manufacturers, power distribution manufacturers and utilities are beginning to offer bi-directional charging solutions.

Overall, bi-directional charging has the potential to be a key part of a more flexible and resilient grid that can better integrate renewable energy sources and improve overall energy efficiency.

Through all the various parties involved in an overall solution, one of the factors is related to software integration. Without getting into significant detail, it needs to be understood there will have to be standardization of a minimally practical offer for charging station software, integrated DER software, facility energy management and utility demand management solutions.

The number of electric vehicles (EVs) needed to help stabilize the grid depends on numerous factors such as geography, grid capacity, EV adoption, and the charging patterns of EVs.

In general, EVs can supply a valuable grid stabilization source by serving as a distributed energy resource (DER). In a (V2G) applications EV's could be used to discharge power back to the grid during peak demand periods or to supply ancillary services to the grid. Bidirectional charging is the potential to charge the vehicle using renewable resources. Charge times can be managed when renewable energy generation is at its peak. This not only allows for better renewable energy generation use but helps use the vehicle battery as a storage container, reducing the concerns associated with the difficulty of storing electricity. Using EV's a storage medium also helps address the concerns associated with overall battery storage manufacturing capacity, instead of setting up the home to have extensive storage in times of need the car itself can be the storage medium, limiting the need for both stationary and mobile battery storage.

According to some studies, the penetration of EVs needed to supply a significant impact on the grid stability is estimated to be in the range of 10-20% [1]of the total number of vehicles on the road. Given that there are about 289 million vehicles on the road in the US , with an average age of 12.1 years. [2] With 14.9 new vehicles annually [3], 4% of which are currently EV's [4] it will take several years before we have the needed 58 million vehicles necessary. However, states like California and Texas are rapidly adopting EV's and they are likely to meet the stability threshold much sooner than the nation on average. It should be noted the 20% marker is subject to many uncertainties, including the charging behavior of EV owners, the capacity of the grid, and the availability of charging infrastructure.

While EVs can supply a valuable source of grid stabilization, the specific number of EVs needed to achieve this goal would depend on many factors and would require further analysis and modeling to decide the exact number.

To say the obvious, portions of the US electrical grid are unstable. California is the most talked about followed closely by Texas due to a February 2021 weather related outage. California Utilities repeatedly asks their customers to reduce electricity consumption to help avoid blackouts when the weather- and weather-related events create risks of outages causing the power system struggled to keep up. Texas uses more power that any state in the Union. In fairness, many areas of the US are not unstable, but most all do suffer outages for multiple reasons, most related to extreme weather events.

The need to move to from fossil fuel energy generation toward electric, both in the home and in automobiles, is going to create its own set of opportunities and frustrations. In the near term the challenges will be modest as we figure out ways to get more power to locations to allow for traditional lifestyles to be kept while taking advantage of new innovative technology which include electric vehicles.

Adding to the earlier two challenges and by no means a comprehensive list of all the concerns is the skyrocketing cost of energy in any form. U.S. residential price of electricity will average 14.9 cents per kilowatt-hour in 2022, up 8% from 2021.[5]

Not one of these issues are new, and whether the motivation for transition to a more sustainable infrastructure be activism, geopolitical, climate related, the viability of the planet, or simply a preference to advance our current technology, these challenges will continue to allow for concern related to an aging national grid that is and has been managed by several thousand different public and private entities for decades. All these factors, stability, outages, clean sources of power, innovation will have an impact on the grid. But we can not only transition, but we can also improve.

Set aside for the moment the fact that a grid that is more renewable and distributed allows for greater national security and a lower dependance on foreign fuel sources that are arguably cheaper than our own vast resources. Set aside considerable number of blue collar and white-collar jobs these improved technologies are creating. For the moment, lets even shelve the incredible situation that is being created by the eMobility transition that is allowing for manufacturing to return to US creating even more jobs and working from a core strength, innovation and improving technology.

The concept of a mandate to bidirectional charging would put more overall decision making in the hands of the homeowner and small business owners, related to how their money is used to consume and manage electricity. It's simply more democratic to allow a homeowner or small business owner to determine manage their energy.

The use of electricity in the US has remained relatively stable in the last twelve years [6] (Use has dropped in Europe) [7] as companies like Schneider Electric have helped focus on better use of energy at the base

level of machine management up to the level of a multi building campus using technologies like the Ecostruxure platform. Maintaining the infrastructure and generation necessary for the consumption of around 4000 terawatts [8] of energy has had its challenges and with the leading sector of energy consumption being residential [8] it doesn't look like energy management and generation will get much easier with the introduction of EV's. If all US cars were EVs, they would need a total of 1,106.6TWh, which is 27.6% of what the American grid [9] produced in 2020. Clearly that is a burden and opportunity that needs resourcefulness, ingenuity, and experience.

The first step is a reimagining of the home energy distribution system. It's worth noting that until recently the sector that consumes most of our electrical energy is the sector that has had the same basic infrastructure solution since the late 1950's. Yes, there have been advances from fuse to circuit breaker, and the average home has grown form a 30 amp service in the 1930's to a standard of 200 Amps in new homes during the 1980's, but the concept of protecting the circuit, which is still critical, remained the primary focus. It's only recently that new technologies such as the award winning Square D Energy Center has started to really change how we distribute power at home. Allowing the consumer, the actual homeowner, to have flexibility, insight and resilience into how their home not only uses power but also can use resources other than the grid as well as managing how and when the home (and homeowner) uses its power, is allowing for a shift of leverage in the residential energy sector.

Why is this discussion critically important today? Because the first step many will take into the new energy landscape will be with the purchase of an electric vehicle. Whether the individual consumer chooses the internal combustion engine (ICE) or electric power is no longer the issue. The demand for EV is leading the discussion with several manufactures sold out on pre orders of these new vehicles. The fact that these vehicles are safer, faster, more powerful, and significantly more feature laden than the current ICE vehicle is enough to have a sizable part of the US population noting their next car will be an EV. In choosing an EV, the next question becomes how to power it.

Because of the current pace of battery production in North America and the world there is a window for transition. We can follow the path of finding and installing the infrastructure to power our new EV or we can rethink our approach and make the situation better.

Bidirectional charging stations or Vehicle to Grid (V2G) technology uses stored energy from an EV's batteries and puts it back on the grid. A bidirectional charger can convert Direct Current (DC) to Alternating Current (AC) and transfer the power to the grid from the EV's lithium-ion cells. It can also simultaneously control the amount of power needed for the battery. If you're worried about utilities using your vehicles stored energy, you may want to think about this. The average home in the US has the capacity to use up to about 10KW of energy. Most home backup generators are between 5KW and 20 KW in potential, a residential solar array is about 10KW of potential and the batteries used to store the energy from a residential solar array store about 9.6KWh of stored power. The Chevy Bolt has approximately a 65KWH battery, that's six times greater than a typical residential storage system. Stepping up to a Chevy Silverado EV? The storage potential jumps to 200kWH in some specifications. It needs to be noted that not every vehicle is intended for use in bidirectional applications, (the Bolt is not) but many will be bidirectional as vehicle manufactures are starting to see V2G, V2H (home) and V2P (power for tools etc.) as a significant selling point.

In a recent Columbia News article Matthias Preindl, [10] an EV expert at Columbia Engineering was quoted as saying "Potentially, EVs could become the largest, distributed energy storage facility deployed," "Together, they could supply more electric power than all conventional power plants combined."

As the US government, States governments, local entities and Utilities start incentivizing, mandating, and regulating the needs of EV Charging requirements an emphasis should be placed on standards for bidirectional charging. Not only is this technology the most practical solution to stabilize the "national" grid it goes a step further and can strengthen the US grid. Combined with renewable power generation EV's acting as Distributed Energy Resources (DER's) with bidirectional capabilities, will help improve our traditional style of living, they will help create a safer, more stable, and more fair infrastructure for the US.

The potential is significant, for the homeowner starting down this road with an EV will allow for the first building block into the space of the consumer making the decision on the many ways to use the EV beyond just driving it. If they want to integrate on site energy storage, install a solar array, manage the energy use in their home at a finite level while having the ability to power their home off their grid. Stepping forward from

a starting point of installing a bidirectional charging station, into potentially obtaining favorable rates for energy time of use with the utilities, and in some instances sell power back to the utilities when they need it most is truly placing the control in the hands of the consumer at the same time helping Utilities find solutions to decades old issues.

Bidirectional charging should be the incentivized standard moving forward at a federal, state, and local level. A bidirectional charging station is expensive, but it allows for a more flexible consumer model, it add value to the challenges faced by utilities, it helps with the significant concern related to storing renewable energy and it has the potential to help significantly stabilize and create a more secure national electric grid. The primary reason bidirectional charging should be the standard moving forward is because it put the control of the charging solution and benefits in the hands of the consumer.

The challenges faced by EV Bid directional charging are the commonality of approach.

- Does DC to DC make sense as a standard
- IS AC to DC a better approach given the architecture that exists with today's standard architecture.
- Is it a mix of both

Added challenges have to do with scale and cost.

- Distributed energy design solutions or variations on microgrid technology also have bidirectional ability from a design standpoint and that could level overall costs models for fleet and depot applications where the charging stations could be primarily DC to DC.
- Bidirectional which likely offers grid stability is more expensive initially but would likely be a lower cost model as well as a near term as well as a near term relief valve for the potential grid capacity needs through demand response capabilities. (AutoGrid). A unidirectional device on a network would typically be several hundred dollars as opposed to a bidirectional solution that could several thousand per modest size charging capabilities.

Conclusion

With the challenges being noted, the benefits of bidirectional charging simply outweigh other near term and potentially long-term needs related to the national grid security and stability. Mandating the technology at a legislative level is not easily or comfortably recommended, but there is a significant need, and it appears there is a very viable solution to integrate bidirectional charging as we progress with the transition from fossil fuel vehicles to renewable energy vehicles.

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