# The Road Ahead:
## Planning for Electric Vehicles by Managing Grid Interactions

NATIONAL GOVERNORS ASSOCIATION

## Executive Summary

Transportation electrification is growing across the country and Governors are taking steps to advance electric vehicle (EV) adoption and prepare for the increasing interactions between EVs and the electric grid. Governors in 14 states have set electric vehicle goals and are planning a transition to EVs.[1] Additionally, 15 Governors recently signed a memorandum of understanding (MOU) to commit their states to eliminate medium and heavy-duty vehicle emissions by 2050.[2] A key challenge for states is how to meet EV charging needs and, as charging networks are built out, how to manage impacts to the electricity grid. This issue brief will explore the following topics:

- **Installing Charging Infrastructure.** Locating chargers in strategic locations, often referred to as siting, to provide convenient access to EV drivers can smooth demand impacts on the electric grid.
- **Vehicle Grid Integration (VGI) or Managed Charging**. EVs allow for flexible fueling, enabling them to be more responsive to grid demands and constraints. Appropriate vehicle-grid integration can enable cost savings and ensure a reliable electric grid. VGI strategies include integrating smart charging controls and designing responsive electric utility rate structures.
- **Vehicle-to-Grid (V2G)**. EVs have further capacity to feed electricity back to the grid, allowing for bidirectional energy flow, known as vehicle-to-grid (V2G). This technology is not fully implemented; there are pilot projects underway in parts of the U.S. V2G may provide additional benefits such as cost savings for utilities and customers, while improving grid resilience and reliability.

Impacts to the electric grid remain low as EV adoption remains close to 2 percent of all light-duty vehicles in the country. However, it is important for states to begin preparing for an increasing trend in transportation electrification. Many actions are available to Governors that can help smooth this transition as more EVs are on the road. Some potential steps include establishing an EV working group to plan for this transition; collaboration with other Governors to build out charging networks among interstate corridors; or instructing regulators to consider EV rate pilot programs. States can consider these actions as they move to an electrified transportation system.

## Introduction

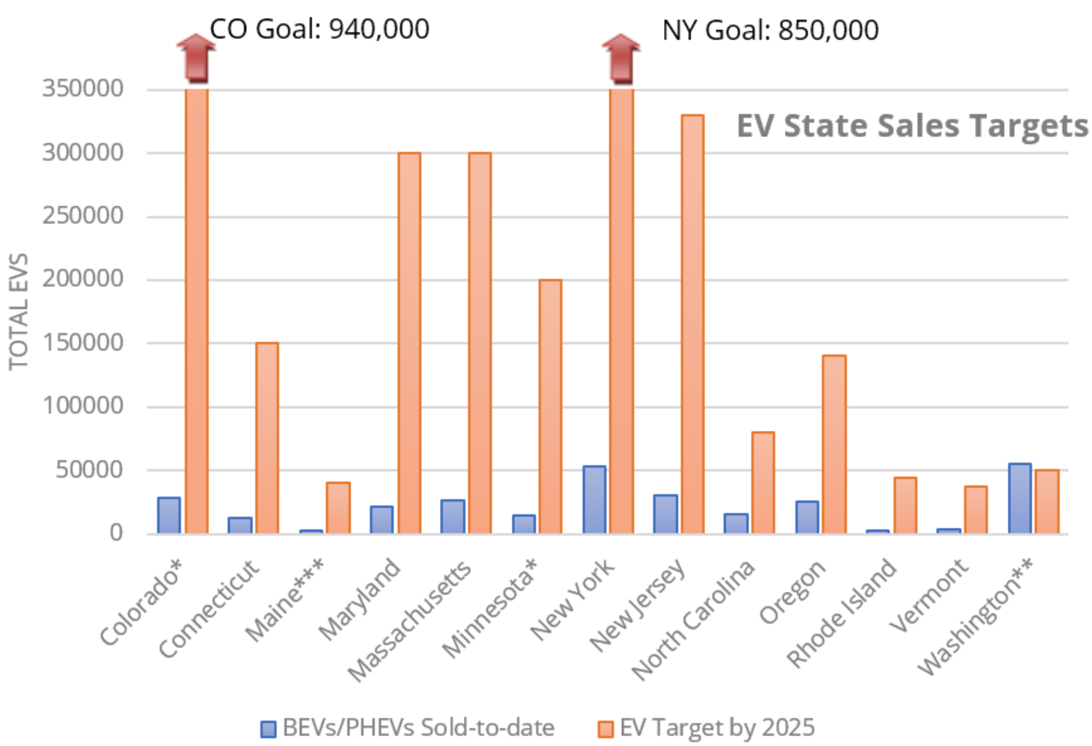
The transportation sector is rapidly evolving as electric vehicles, including both battery-electric vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs), grow in popularity, costs decline, and EV technology advances. While projections vary, and there may be a temporary slowing in growth due to the economic impacts from COVID-19, EVs are expected to make up 20 percent of annual vehicle sales by 2030 with more than 18.4 million total vehicles sold.[3] Governors have committed to reaching nearly 8.5 million EVs on the road by 2030 (See Figure 1 below). California and New Jersey have recently called for all vehicle sales to be zero emission vehicles by 2035.[4,5] At the beginning of 2020, there were nearly 1.5 million EVs in the U.S.[6] Battery costs have also fallen 87 percent since 2010 to an average market price of $156/kWh, with projections to fall to $100/kWh by 2023. These steady price decreases are edging EVs towards cost parity with internal combustion energy vehicles, which is estimated to be around $100/kWh.[7]

Through new executive actions and legislation, Governors' commitments are expected to further advance EV adoption. However, increasing numbers of EVs may have impacts on the electric grid. Installing charging infrastructure faces potential challenges including:

- Higher costs, particularly for DC fast chargers,
- Consumer awareness of both available chargers and rebate programs, and
- Exacerbated energy peaks by increased electricity demand from EVs

This paper includes recommendations to help Governors meet their EV goals and provides strategies that can improve the interplay between EVs and the electric grid.

**Figure 1: Which states have EV targets?[8]**




* = Target date is 2030
** = Target date is 2020 *Met Goal* - New goal is 300,000 EVs by 2025, all ZEV by 2050
*** = Vehicle sales goal is an estimate, true goal is 15.4% of vehicle sales in 2025
Due to scaling purposes, California is not included in the above graph. As of June 2020, the state had 726,000 EVs on roads, and a target of 5 million EVs by 2025.[9]

## Background: Why are Governors Supporting Grid Integration and Vehicle Electrification?

EVs can provide benefits to the electric grid and can provide environmental benefits if they are charged from electricity generated by renewable or zero-carbon emitting resources. Governors across the country are eager to capture these advantages. A significant electrification attribute is the ability to smooth electricity demand peaks through grid integration – by charging EVs during off-peak times and by using EVs to provide electricity back to the grid during demand peaks. VGI allows for managed charging, where electricity may be turned on or off, scaled up or down, or set to turn on at specific times of most benefit to the grid. One study of five northeast states, found potential electricity savings of $4 to $24 billion per state by 2050 from VGI.[10] These savings would be mostly realized by taking full advantage of off-peak charging, which allows utilities to save money from deferred infrastructure investments.

**Colorado Governor Jared Polis**

*"As we continue to move towards a cleaner electric grid, the public-health and environmental benefits of widespread transportation electrification will only increase."*

Strategically located smart chargers coupled with Time of Use (TOU) rates augment grid flexibility. Smart chargers allow for EVs to be plugged into the grid, yet only consume electricity based off energy loads. This allows for vehicles to limit stress on the grid, by charging during periods of low energy demand such as mid-afternoon or the middle of the night. TOU rates incentivize utility customers to use energy during lower demand periods by offering cheaper electricity prices. Combining TOU rates with smart chargers saves energy consumers on their utility bills while mitigating peak loads on stressed electricity feeders.[11] While savings will vary across utility programs, TOU rates can reduce costs by to an EV owner by $400 annually, whereas smart charging can further reduce costs up to $700 annually.[12] Further benefits can be captured by charging when electricity is supplied mainly by renewables. For certain regions, this means charging during periods of high solar capacity during the middle of the day, or in other areas to charge through wind energy generation, which peaks usually between 10 p.m. and 6 a.m.

## EV Grid Integration Recommendations for Governors

Governors can lead on advancing EVs in their state and mitigating electric grid impacts. The following section outlines recommendations for Governors to integrate EVs into the grid and is organized into three categories of policy strategies – *i) installing charging infrastructure; ii) VGI and managed charging; and iii) vehicle-to-grid (V2G).* These policy strategies can help ensure that the interactions between EVs and the grid are beneficial.

### i. Installing Charging Infrastructure

As Governors and states incentivize EV adoption and the development of charging infrastructure, it is important to avoid potential negative effects from increased electrification. The National Renewable Energy Laboratory (NREL) stresses that charging station installations need to be significantly expanded to meet future EV requirements for both long distance travel (assuming chargers spaced 70 miles apart), and city driving where many plugs are needed to supply daily commuter needs.[13] States are working to build out their charging networks with level 2 or direct current (DC) fast chargers. Level 2 chargers supply electricity faster than traditional household outlets. DC fast chargers are faster still, but much more expensive. (See Figure 2 for charging station characteristics.)

**Figure 2: Charging Infrastructure Levels**

| | Charger | Location | Miles of Range Added per hour Charged[14] | Average Installation Cost[15] |
|---|---|---|---|---|
| **Level 1** | 120V AC | Home | 15 miles | N/A |
| **Level 2** | 240V AC | Home | 30-90 miles | $1,000 |
| **Level 2** | 240V AC | Parking Garage | 30-90 miles | $3,500 - $7,500 |
| **Level 2** | 240V AC | Curbside | 30-90 miles | $5,000 - $13,000 |
| **DC Fast Charge** | 480V DC | Public Stations | 90-200 miles in 30 minutes | $30,000 – $70,000 |

Electric vehicle supply equipment (EVSE) can increase electricity peaks based on where chargers are installed, particularly if concentrated on specific electric feeders. Coincident vehicle charging could create new peaks in demand that would need to be mitigated, especially if vehicles are responding to price signals. Minimizing these peaks will require management, with modern controls, energy storage, potentially new generation, or a mix of such resources to accommodate increased demand. Effective placement of charging infrastructure, that considers available charging equipment and driving behaviors, will help alleviate many of these challenges.[16]

**Recommendation for Governors: Establish working groups and lead collaboration among EV stakeholders to optimize EV charging infrastructure buildout.**

As mentioned previously, Governors are setting various EV goals to help meet broader energy or decarbonization strategies. While this is positive, public charging stations remain limited. Siting charging infrastructure involves many key players beyond states to ensure range anxiety is mitigated for drivers. Electrify America and Chargepoint are planning to spend $2 billion and $1 billion, respectively, on EV charging rollout over the next several years.[17,18] Duke Energy is proposing new charging installations in North Carolina to meet Governor Roy Cooper's 2018 Executive Order, which set a state target of 80,000 EVs on the road by 2025.[19] The collaboration of states, private companies and utilities is integral to meeting state EV goals.

Organizing different interest groups to build out charging infrastructure requires strong centralized leadership. Governors can issue comprehensive Executive Orders that establish EV working groups. Maryland Governor Larry Hogan created the *Zero-Emissions Electric Vehicle Infrastructure Council* to develop strategies to both meet the state's aggressive EV targets while planning for charging expansion corridors.[20] Virginia has started a stakeholder group to study EV readiness and develop strategies to meet future needs. Rhode Island and New Jersey have similar working groups to ensure the comprehensive challenges are met. These working groups typically include utilities in discussions and identify critical sites for chargers and what potential challenges may occur. This coordination is essential as policymakers continue to address grid issues as they arise.

**Recommendation for Governors: Join regional collaborations to coordinate charging installations and reduce duplicated efforts.**

Regional state collaborations have been established to ensure long-distance trips are possible in EVs. These collaborations include the Northeast States for Coordinated Air Use Management, the West Coast Electric Highway and the Regional Electric Vehicle West initiative. The Regional Electric Vehicle West coordinates eight mountain west states by setting Voluntary Minimum Standards. These standards recommend locating charging infrastructure in strategic roadways with sufficient voltage, all while keeping an eye toward the future and considering potential impacts from expansion to direct current fast chargers (DCFC).[21]

**<u>Recommendation for Governors:</u> Direct state agencies to plan essential statewide charging networks and can encourage the consideration of charging infrastructure in equitable and accessible locations.**

New Jersey is building out an Essential Charging Network to install DCFC along convenient state corridors.[22] The goal is to make fast charging ubiquitous, while acknowledging that low utilization will limit private investment and project return on investments. The network mapped out 100 locations in frequent use roadways, as well as 200 locations in community centers. Florida Governor Ron DeSantis recently signed similar legislation to build electric vehicle charging stations on well-traveled roadways throughout the state.[23] The bill requires the state to plan for increasing charging accessibility and building in emergency contingencies in the case of hurricanes or other disasters.

Further considerations can be made to install charging stations in marginalized communities and ensure equitable access. NGA Chairman New York Governor Andrew Cuomo made equity a key consideration in New York's EV charging plan. The state issued a report directing utilities and regulators to plan make-ready EV infrastructure, which includes all charging equipment except for the plug itself, to enable accelerated charging installations. The plan has a specific call out to place chargers in "environmental justice communities – who have been disproportionately impacted by air pollution – and rural neighborhoods."[24] Focusing on these communities ensures that all populations benefit from transportation electrification.

## ii. Vehicle Grid Integration – Managed Charging

One common charging option that states and utilities are turning to is smart charging combined with TOU rates. Smart charging uses sensors as load control to turn on chargers during periods of low energy demand or when electricity prices are cheaper, potentially due to TOU rates. Load control can occur through the charging device, automaker telematics, or a smart circuit breaker. This allows for charging to cease even while vehicles remain connected.

Demand charges, typically based on the customer's highest 15-minutes of electricity use, can make up 93 percent of monthly electricity bills for EV owners.[25] For direct current fast chargers (DCFC), often known as level 3 chargers, demand charges are difficult to avoid due to their highly concentrated electricity draw. The Rocky Mountain Institute released a study finding that demand charges in DCFC can cost an equivalent of $20 per gallon of gas in extreme situations, largely eliminating the business case for prospective EVSE installers.[26] Innovative rate design such as TOU rates and smart devices can mitigate these charges by shifting EV charging to off-peak periods.

**Recommendation for Governors: Instruct regulators to design innovative rate-making frameworks and require utilities to develop transportation electrification programs.**

Smart charging combined with TOU rates can greatly increase utility savings for energy customers while smoothing peak demand for utilities. More than half of all investor-owned utilities have adopted time-of-use rates.[27] California required its investor-owned utilities to provide TOU rates by the end of 2019.[28] Pacific Gas and Electric replaced demand charges with fixed subscription rates to simplify customer bills and lock in specific rates. The utility is pairing subscription rates with TOU rates and estimates that it can reduce customer costs 30-50 percent.[29] Subscription rates also allow EV owners to monitor price differences between electricity and gasoline. While these rate-making processes seem promising, most states are in initial phases of identifying the most beneficial TOU rates.

Additionally, states need to explore whether to allow utilities to own and receive cost recovery on charging infrastructure investments. If charging infrastructure is seen as a public benefit, particularly if it is supporting disadvantaged communities, then there may be a case for receiving a rate of return. Virginia regulators are studying vehicle electrification in an open proceeding. Questions to address include allowable rates of return, whether cost recovery can be applied on non-EV owners, vehicle battery storage applications, and charging station ownership models.[30]

States can also offer incentives, but it is more typical for utilities to offer rebates as part of a transportation electrification program. Arizona, Minnesota and Oregon instructed utilities to submit transportation electrification plans, with potential considerations for charging stations rebates and new rate-making.[31] Missouri and Wisconsin are actively considering these questions in regulatory proceedings.[32] Utilities in Colorado and Nevada proposed incentive programs, with a particular focus on low-income customers, to expand charging access.[33] Furthermore, utilities in more than 35 states are offering charging incentives for customers, with many able to apply for a rate of return.[34] Governors can direct regulators to explore these issues further.

***Recommendation for Governors: Set energy storage goals, and guidance on the locational value of storage, to integrate with current EV charging stations.***

A strategy that Governors may consider is incorporating energy storage at EV charging facilities.[35] Governors in Massachusetts, New Jersey and New York among other states, have set aggressive energy storage goals, which when paired with EVSE can reduce demand charges and provide other grid benefits.[36] Energy storage systems can charge during off-peak periods, perhaps charging from excess renewable generation or renewables co-located with chargers and storage, and then supply electricity for EV charging or excess electricity back to the grid.

Further, demand issues are raised during fleet electrification charging. A fleet of cars charging simultaneously can create a spike in energy consumption as well as demand charges, which may negate the cost advantages of EVs. The spikes can also lead to shifting load curves or reliability concerns as energy feeders may already be congested. Usually fleets require a centralized charging depot, which in turn requires a series of high-powered chargers. Fleet administrators will have to plan for increased demand and collaborate with their electric utilities to lessen any concerns associated with additional fleet electrification. Co-locating energy storage at charging depots can help lessen these demand issues.

**Recommendation for Governors: Offer rebates to customers to install charging infrastructure.**

Smart charging requires level 2 chargers or DCFC meaning regular household outlet (Level 1) charging is excluded from the technology. Despite limited funding for rebates, one revenue source that states are turning to is the Volkswagen Settlement. States were able to spend up to 15 percent of their total VW allocation on charging stations and 34 states took advantage of this stipulation.[37] Additionally, many states offer their own rebates to install EVSE for individuals or businesses. New York offers rebates up to $4,000 for level 2 chargers, cutting between 30-80 percent of installation costs. The program, known as Charge Ready NY, lists qualified vendors, many of which offer network enabled devices.[38]

EVs provide valuable grid services like other distributed energy resources. This is particularly true when vehicle grid integration includes V2G technology. Traditionally, distributed energy resources are viewed as onsite or nearby generation for a facility and are typically renewable resources or combined heat and power applications. EVs with a 30-kWh battery (which is a typical minimum for most light duty EVs) can store as much energy as an average household consumes daily.[39] ZEV states have pledged more than eight million EVs on the road by 2025 and with this level of energy supply, EVs could greatly alter how electricity is used.[40]

## iii. Vehicle-to-Grid (V2G)

Taking grid integration a step further, V2G technology, which allows for bidirectional energy flow, can enable improved grid flexibility. V2G can allow EVs to charge when electricity is cheap and demand is low, as well as feed electricity back into the grid during times of peak demand. While concerns over battery degradation and vehicle warranty limit technology adoption, the benefits remain compelling. Utilities have filed pilot V2G proposals in California and New York to test the technology on heavy duty vehicles such as school buses. The buses will provide energy storage services to help mitigate demand peaks. Heavy-duty EV fleets are good candidates for V2G pilot programs with centralized charging, predictable schedules, and larger batteries.[41] Light-duty vehicles may be integrated down the road as the technology grows more mainstream. Additionally, EVs may be used as mobile batteries during power outages, improving grid resilience and emergency response services. Further research and pilot programs are required to realize this potential.

**Recommendation for Governors: Direct a study of how EVs can be used for their energy resilience attributes, including assessing how EVs can play a role at critical facilities during grid outages.**

States have been working on using energy storage to fill gaps in electricity supply from intermittent renewable resources. Utilizing electric vehicles as mobile energy storage provides more flexibility to accommodate grid demands. Additionally, EVs could provide rapid relief during power outages, especially if certain vehicles had high voltage power or larger battery packs. While pilots are only beginning to be implemented, the U.S. Army is testing V2G technology at Fort Carson. The project is part of a microgrid project to disconnect the base from the electricity grid and utilize EVs to supplement energy supply.[42] These benefits to resilience and reliability are paramount as EV adoption grows.

Heavy duty vehicles such as school buses may be especially useful to V2G efforts due to their large battery size, lengthy idle periods, and more predictable charge timing and load curves. A single school bus battery is large enough to supply average daily power for 10 homes.[43] Since school buses are not typically used during the summer or weekends they could be utilized more efficiently. For everyday transit purposes, electric buses are expanding swiftly, with commitments to electrify 33 percent of the transit bus fleet by 2045.[44]

**Recommendation for Governors: Encourage utilities and working groups to demonstrate V2G technology and develop pilot programs.**

California, New York, North Carolina and Virginia have experimented with V2G pilot programs, but have yet to be deployed broadly.[45] Utilities in these states including Dominion Energy, Duke Energy and Consolidated Edison have submitted proposals to utilize electric school buses as energy storage during summer months. The Southeastern Pennsylvania Transit Authority (SEPTA) that serves the Philadelphia area utilizes V2G technologies by storing energy as trains brake and then supplies energy back to the grid at opportune times.[46] These projects have shown increased payback periods due to lower maintenance costs and energy bills, while contributing essential grid moderation services.

More research is required to overcome barriers to technology adoption. The grid operator PJM identifies EVs as a potential for frequency regulation that balances short-term variations between load and supply, which is procured through the grid's Regulation Market.[47] Fully realizing this potential would enable states to balance energy loads as greater EV adoption begins to disrupt the grid.

## Conclusion

Electric vehicles may not have large impacts to the grid yet, but forecasts indicate this will change in the near-term as EV adoption increases. Governors need to prepare for the build out of VGI-managed charging, V2G and other related infrastructure through thoughtful policies and regulations to ensure that the potential advantages of vehicle and electric grid interactions are realized. With careful planning, EV benefits can be captured, leading to cost savings for stakeholders, enhancing grid reliability, and further modernizing both transportation and energy systems.

## Acknowledgements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The National Governors Association Center for Best Practices (NGA Center) and this report's authors thank the state officials and other experts who attended the virtual National Summit in September 2020 related to Grid Integration. For summit resources, please review the NGA website at https://www.nga.org/center/meetings/2020-electric-vehicle-grid-integration/. NGA also thanks the U.S. Department of Energy, Office of Electricity, for its support of the summit and publication of this issue brief.

### Recommended Citation Format

Rogotzke, M., & Rackley, J. (2020, November). *The Road Ahead: Planning for Electric Vehicles by Managing Grid Interactions* Washington, DC: National Governors Association Center for Best Practices.


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