CHARGING UP THE GRID

Preparing Utility Infrastructure for the Electrification of Transportation

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The Growing Challenge of Electrification

The transition to an electrified transportation future is underway and holds immense potential for reducing carbon emissions and achieving sustainable mobility. In order for the electric grid to fully enable this unprecedented change, utilities will need to invest in their transmission and distribution infrastructure to ensure their grids can handle the increased demand from electric vehicles (EVs) - including passenger cars, fleets, and buses.

To support the timeline of rapid electrification and to create the additional transmission capacity needed, utilities must expand their adoption of Grid Enhancing Technologies (GETs), such as Dynamic Line Rating (DLR), for seamless integration and support of EV charging into the grid. The deployment of GETs like DLR will enable utilities to more cost effectively and quickly increase transmission capacity to support the growing demand for EV charging infrastructure, in particular for fleets and large EV charging stations while planning and completing traditional transmission development.

The rapid growth of EVs and the planning process to accommodate this growth poses a new challenge for existing transmission and distribution systems that were primarily designed for traditional energy consumption patterns. Grid congestion, limited capacity, and reliability concerns have emerged as critical roadblocks to achieving widespread EV adoption and seamless integration into the grid. It is crucial for electric grid infrastructure to be able to handle the additional load in locations where charging infrastructure is anticipated to have significant system demand, whether due to the electrification of fleets or cumulative impacts from the build out of charging infrastructure for passenger EVs. Proactively addressing these planning needs will allow for faster adoption of EVs and more seamless, cost-effective achievement of decarbonization goals.

While most EV charging infrastructure build outs have targeted sites that happen to have enough capacity to serve them, a growing body of evidence, ranging from studies of infrastructure costs for charging along highways in the U.S. Northeast, to the direct experience of projects in and around California's busy coastal ports, indicates that meeting aggressive electrification targets will require much more grid capacity.[1] This is true for charging infrastructure to support all electric vehicle classes, from light-duty vehicles to fleets.

This need for grid capacity tied to transportation electrification comes at a time when various studies, including the draft study titled "National Transmission Needs Study" released from the U.S. Department of Energy ("DOE") in February 2023, suggest an unprecedented need for transmission build outs that effectively double or triple the capacity of the existing transmission grid over the next 10 to 20 years. This equates to, at a minimum, tripling today's level of transmission investment (estimated to be ~$25 billion a year) for the foreseeable future.[2]

Further, from an emissions perspective, focus on EVs is critical as transportation accounts for the largest portion of total U.S. GHG emissions.[3] Highlighting the need for grid expansion and GHG impact, the REPEAT Project says that if the transmission grid fails to expand by more than 1% yearly, U.S. greenhouse gas emissions will increase by 800 million tons annually by 2030.[4] In other words, if the grid doesn't grow to meet the needs of clean energy, the goal of the Inflation Reduction Act will go unrealized, losing more than 80% of the emissions gains.

Planning for this transmission buildout requires focused collaboration among business, technology, and energy leaders—as well as federal, state, and local government agencies and electric utility regulators— if we are to realize carbon-free transportation powered by carbon-free electricity. At the same time, utilities must transform both energy generation and their grid infrastructures to ensure the stability, availability, and quality of electricity for all consumers in the face of increased demand.

Utilization of GETs needs to be a part of the solution to add needed capacity to accommodate EV charging by more quickly and affordably addressing existing or emerging issues , including congestion, before new transmission projects are put in place. Addressing these developments, this white paper is designed to highlight the policy drivers enabling and accelerating the shift to transportation electrification, examine the key role of utilities in enabling this transition, and showcase how GETs like DLR are a "no-regrets" tool to help utilities ensure that the grid is ready for this unprecedented new source of electric demand.

Policy & Regulation are Driving EV Growth

A critical driver of the anticipated growth in EVs is federal and state policy that sets in-state EV sales goals, alongside federal and state tax incentives and rebates for their purchase and charging infrastructure, or directs GHG emission reductions from vehicles. These policies target both light-duty and medium-to-heavy duty EVs, as well as vehicle fleets.

An example of how these types of policy actions come together can be found at the federal government level. In April 2023 the Biden administration announced a goal of 50% of all new vehicle sales by 2030.[5] In addition, the Inflation Reduction Act (IRA) included new and expanded tax credits for the purchase of EVs alongside incentives for charging infrastructure and electrification of heavy duty vehicles.[6] Beyond these targets and incentives, the Environmental Protection Agency (EPA) recently proposed federal vehicle emissions standards to accelerate EV adoption for light, medium and heavy duty vehicles beginning in 2027.[7] Compliance with these proposed rules will require deployment of emission control technologies, and is largely expected to accelerate transition to EVs.[8] For heavy duty vehicles, the EPA is proposing a flexible structure to adopt performance based standards (these vehicles include utility trucks, transit, shuttles, buses).[9] In addition, the 2021 Infrastructure Investment and Jobs Act (IIJA), authorizes $1.2 trillion in infrastructure spending over the next five years. Through various programs, EVs and charging infrastructure are eligible for $30.7 billion of IIJA funding.[10]

States have also been paving the way for adoption of EVs, largely modeling efforts led by California. Under the federal Clean Air Act, California has the ability to seek a waiver of federal preemption from the EPA and enact its own emission standards for vehicles.[11] Once California has received EPA approval of a waiver, other states can adopt these standards.[12] For example, California has adopted:

- The Advanced Clean Cars II rule approved in 2022 with an updated standard that all new passenger cars, trucks and SUVs sold in CA be zero emissions by 2035.[13]
- The Advanced Clean Trucks (ACT) rule, approved in 2023, requires an increasing percentage of trucks sold in the state be zero emission vehicles, with percentage sold requirements varying by truck class.[14]

- The Advanced Clean Fleets rule that directs certain private and federal fleet owners to start transitioning fleets to zero emissions starting in 2024, drayage trucks to be zero emissions by 2035, and then optional percentages with varying deadlines for full zero emission adoptions for remaining fleets. The rule also includes ending combustion truck sales by 2036.[15]

Fast-moving states such as Massachusetts, New Jersey, New York, Oregon, Vermont, Washington, and others have followed California's lead.[16]

From a climate perspective, medium-and heavy-duty trucks are a critical area to address since, although medium- and heavy-duty trucks and other larger vehicles make up less than 5 percent of vehicles on the road in the U.S., they account for nearly 30 percent of the country's total transportation-sector greenhouse gas emissions.[17] Electric trucks, which largely operate as part of a fleet(s), stand to be adopted at a faster pace than passenger EVs as once fleet operators are convinced of their reliability and durability, they tend to be purchased at a faster scale.[18] This stands to have a massive impact on the grid given the fleet depot charging needs that will come with truck electrification. According to modeling done by the Rocky Mountain Institute (RMI), by 2035, as over half the heavy-duty trucks (HDT) electrify, electric trucks will consume the same amount of electricity per year as the states of Massachusetts, Nevada, and New Jersey combined.[19]

In addition to adopting the standards set by California, a number of other states have signed onto memorandums of understanding to spur ZEV adoption[20] and support build out of EV infrastructure, with a majority of states offering incentives for hybrid and electric vehicles.[21] There is also federal funding with the National Electric Vehicle Infrastructure (NEVI) Formula Program that has $5 billion to help every state build at least a skeleton of charging networks along major transportation routes.[22] In addition, a number of companies have signed onto the EV100 global initiative, committing to transitioning to electric fleets by 2030.[23]

School buses are another area of focus in the context of electrifying transportation. The growth in electric school buses is critically important from a health and equity perspective as over 90% of existing school buses run on diesel, the exhaust of which is a known carcinogen that has links to health issues, respiratory diseases like asthma, and cognitive development impacts. Students from low-income families are particularly exposed to the dangers of diesel exhaust pollution: 60% ride the bus to school, compared to 45% of students from families with higher incomes.[24] Electrifying entire fleets of school buses can help address these health concerns and inequalities.

The primary driver of this growth has been the 2021 IIJA, which directed the EPA to award $5 billion through 2026 for zero- or low-emissions school bus purchases. Last year, nearly 400 school districts were awarded a total of nearly $1 billion from EPA's Clean School Bus Program to add more than 2,400 battery-powered buses to their fleets. According to the latest estimates from the World Resources Institute (WRI), there are now 5,612 committed electric school buses in the United States, located in all states across the country; almost double the number of buses since the release of WRI's September 2022 dataset.[25]

At a state level, last year, New York passed a law that will require all newly purchased school buses to be zero-emissions by 2027 and all of the roughly 47,000 school buses in the state to be electric by 2035 — a mandate accompanied by a commitment of $500 million in environmental bond funding.

Colorado, Connecticut, Maine, Maryland, and New Jersey also passed electric-school-bus mandates and funding laws last year.[26]

The sheer volume of policy activity underway regarding transportation electrification signals that utilities will need to plan ahead to minimize grid impacts from an increasing number of megawatt-scale public, corridor, fleet, and private charging sites, and prepare to identify and invest in needed EV charging infrastructure grid upgrades. As just one example, recognizing the key role of utilities in supporting the growing number of EVs, in late 2021, the Edison Electric Institute (EEI) announced the launch of the National Electric Highway Coalition (NEHC), a collaboration among electric companies that share the common goal of deploying EV fast charging infrastructure along major U.S. travel corridors.[27]

The Role of Utilities

The increase in EVs on the road stands to shift the traditional utility approach to planning to become more anticipatory of electric service requests rather than simply responding to them. Even in states without a policy mandate or target to deploy more EVs, planning for transportation electrification makes sense as EVs represent an opportunity to proactively build the infrastructure to support vehicle charging. From a light-duty EV perspective, a 2023 report from NREL estimating the demand for charging infrastructure from light-duty EVs drew a number of conclusions on the scale of charging infrastructure needed to support 30-42 million light-duty EVs by 2030. This included the conclusion that at or near home charging needs to be supported by reliable public fast charging with an estimated 26.8M private Level 1 and 2 charging ports at home and work; 182,000 public fast charging ports on highway corridors and in communities; and 1 million public Level 2 charging ports near homes and workplaces.[28]

For fleet electrification, analyzing how and where fully electric fleets could impact the electric grid will be critical to enable transportation electrification at scale while minimizing costs. Building out the utility investment to support large-scale charging needs can take years of advanced planning and millions of dollars of investment. As noted in the ACEEE 2023 State Transportation Electrification Scorecard, EV's are impacting power demand and load shapes and there is a need to plan in advance for infrastructure on both the transmission and distribution side so utilities can continue providing reliable and affordable power.[29] While there is concern about the potential ratepayer impact from this infrastructure buildout, a recent report that focused on two New York state utilities found that ongoing electricity sales to medium- and heavy-duty electric vehicle fleets can more than make up for the upfront investment required to make that charging possible.[30]

To understand how the rising loads associated with EV charging will begin to stress the power grid over the next few years, industry groups like the Electric Power Research Institute (EPRI) have started initiatives to help facilitate the data exchanges needed to help align plans for EV charging with the grid's available hosting capacity. EPRI's new EVs2Scale2030 includes efforts to visualize energy and power needs from transportation electrification down to the distribution circuit level, along with processes and tools to help facilitate the interconnection and serving of new transportation loads.[31]

In the meanwhile, utilities are also developing company specific assessments. For example, Eversource has taken on an advanced forecasting method for their distribution grid to assess the impact of EVs (as well as electrification of heating).[32]

In addition, recognizing the need for proactive planning efforts, in April 2023, the New York State Public Service Commission began a proceeding to implement policies and develop programs related to medium- and heavy-duty electric vehicle charging infrastructure and planning. The proceeding will also begin the process for proactive investment in the utility infrastructure required to serve transportation electrification.[33]

An example of what type of grid build out may be required can be found in a recent case study from the Northeast that demonstrates the need for utilities to prepare for transportation electrification where it will stress their grid assets and require long-term planning and investments in their distribution network as well as (where necessary) at the transmission level.[34] The study, undertaken by National Grid and transportation data and analytics leaders CALSTART, RMI, Stable Auto, and Geotab, observed charging station behavior and traffic data to model expected power demand growth between 2022 and 2045 across 71 sites in New York and Massachusetts. The objective of this first of its kind study was to characterize site-specific impacts at likely highway charging locations; it concluded that sites with significant charging loads, as in multiple megawatts (MW), will necessitate considerable electric distribution system upgrades and, in many cases, high-voltage transmission-level interconnection.

The study found that, by 2030, over a quarter of the 71 highway sites studied will require more than 5 MW in charging capacity to meet peak charging demand. As a reference, 5 MW of electric capacity is roughly equivalent to the electric demand of an outdoor professional sports stadium. Depending on local system voltages, this level of electric demand at a specific site may exceed the delivery limits of a typical distribution system interconnection and therefore require interconnection to the high-voltage transmission system.

As utilities plan for mandatory aging infrastructure investments, they should proactively consider the impacts of transportation electrification as the timelines required for grid infrastructure upgrades, particularly transmission, are much longer than those required for EV supply equipment installation. While charger installation can be completed in a matter of months, larger transmission interconnections and upgrades take years to construct. By utilizing DLR, a capacity creating technology, utilities can optimize their existing infrastructure to more quickly address the needs of multiple sites at once, thereby reducing costs and increasing the reliability of fleets and other EV electric load. Without this proactive planning approach, including the use of DLR to optimize existing infrastructure to its maximum capacity, investments associated with piecemeal upgrades on the distribution system might be pursued to enable individual fleets at a time, whereas a single transmission enhancement could potentially serve multiple fleets at once.[35]

Additional Supportive Utility Investments/Programs

Utilities can also enable smoother integration of EVs by managing the load from EV charging, whether through behavioral time-of-use rates for EVs, smart charging programs, or vehicle-to-grid (V2G) interaction, thus increasing the utilization of power from renewable energy sources while mitigating excessive power demand. Battery storage technology can also be utilized to help reduce costs and timelines as these tools can help flatten the load curve for a depot by charging the battery off-peak, and discharging the battery during peak-charging periods.

How DLR Can Build Transmission Capacity for an Electrified Future

While transportation electrification is a long-term pursuit, it represents a rapid growth in demand unlike any sector in the past. Whereas buildings take time to reach full occupancy and factories often ramp up over time, EV charging, particularly for trucks and fleets, requires the utility to be ready to meet all the expected demand from day one.[36] All stakeholders involved need to plan carefully to ensure that the billions of dollars in investments by utilities effectively serve grid needs and use ratepayer dollars wisely.

As utilities prepare to accommodate this dramatic increase in load growth, DLR is a critical tool to increase the capacity and enhance the resilience of the existing infrastructure needed to fuel our electrified future as it provides grid operators with the most accurate view of the grid's true capacity capabilities by accounting for factors such as ambient weather conditions. By enabling accurate and adaptive power line ratings, DLR empowers utilities to maximize grid capacity, minimize congestion, and ensure efficient and reliable EV charging. DLR is also critically important in helping extend visibility and control throughout the grid. As noted by the GridWise Alliance, most electric utilities today would benefit from extended real-time situational awareness to both support increased EV charging infrastructure and maintain customer reliability and power quality.[37]

Planning and building new transmission typically takes five to ten years, if not longer, however, GETs like DLR are deployed in as little as 3 months and have the ability to rapidly create critically needed transmission capacity while new projects are put in place over a longer-term timeline. DLR technology is in use across the country and the benefits are significant:

New York

- Working with National Grid, LineVision has deployed sensors in the western region, which along with five miles of circuit rebuilds, is projected to reduce curtailments by over 350 megawatts while increasing capacity by 190 megawatts. This will provide enough capacity to existing power lines to power some 80,000-100,000 homes.[38]

PJM

- Working with Duquesne Light Company, LineVision has been able to increase capacity by up to 25% in southwestern Pennsylvania,[39] part of the PJM footprint.

MISO/West

- LineVision sensors were installed in Xcel's Minnesota, Wisconsin, and Colorado territory to investigate the capacity provided by DLR. Average DLR exceeded static reference ratings by 9-33% in winter months and 26-36% in summer months. Overall, increased capacity was available 85% of the time.[40]

As LineVision projects are actively demonstrating, DLR can play a critical role in ensuring that the grid is an enabler to the EV transition by substantially increasing the capacity and enhancing the capability of the existing grid as well as increasing the cost-effectiveness of new transmission projects that are being evaluated through the local and regional planning process. DLR solutions like LineVision are a timely and cost-effective way, a "least regrets" approach to ensuring the grid has the capacity needed to accommodate transportation networks powered by clean, affordable, reliable energy.

Key Recommendations

Utilities

Utilities will benefit from taking a proactive and holistic approach to grid planning by studying the anticipated needs for all fleets in a given area and incorporate them into system forecasting and planning processes alongside overall electrification efforts, including light-duty vehicle charging and building electrification.[41]

When undertaking this comprehensive approach to planning for fleet electrification, utilities should pursue "least regrets" approaches like DLR to add affordable bridge sources of transmission capacity while new transmission infrastructure is planned and built. Best practices are to:

- Identify near term constraints occurring within 1-5 years and study the impact of the deployment of GETs to resolve or alleviate the constraints more quickly and affordably.
- Perform a cost comparison study on the deployment of GETs against traditional network upgrades to identify cost savings for customers.
- Where longer term, more capital intensive upgrades are identified as necessary such as reconductoring or new construction, assess where deployment or redeployment of GETs during and after construction would provide complementary benefits.

State Regulators

State regulators should create frameworks for, and remove barriers to, more holistic and proactive planning for grid strengthening to support transportation electrification[42] - recognizing the projected growth of EVs and that potential for demand in certain areas stands to go beyond distribution system limits.

In addition, states can take action in a number of ways including through advocacy before an RTO/ISO, existing utility commission proceedings like Integrated Resource Plans (IRPs), or opening a new proceeding looking into the role of GETs. There is no one-size fits all approach, but state action could take the form of:

- Direct utilities to study GETs deployments as part of their holistic planning to support EV charging buildout and overall electrification of end uses. For example, a commission initiated proceeding could address how to proactively plan grid infrastructure to support EV charging and overall electrification, including the evaluation of GETs to create headroom on transmission systems to provide needed capacity.
- Advise utilities to plan for solutions needed in both the near and long-term timeframes to facilitate meeting state electrification goals. For example, states in RTOs/ISOs can request RTOs to consider transmission needs driven by public policy requirements, including increasing electrification, in regional transmission planning. For example, New Jersey is currently leveraging the State Agreement Approach in PJM for the second time to solicit transmission solutions for offshore wind.[43]
- Consider incentives, such as a performance incentive mechanism (PIM)[44] for utilities who propose GETs as part of transmission-level investments tied to meeting state electrification policies and decarbonization goals. Another option would be to consider and design a shared-savings incentive for GETs, like what has been proposed at FERC, which suggests transmission owners be granted a portion of the congestion cost savings created by a GETs deployment.[45]

EV Charging Companies:
As EVs represent a new paradigm for utilities to plan for, collaboration and communication among key stakeholders, including electric vehicle supply equipment (EVSE) companies, will be critical to help understand where EV load will be located so that infrastructure investments can be made to ensure the fastest, least cost way to electrify.

For charging stations, proximity to transmission lines should be considered in tandem with expected charger utilization during site selection. DLR's role in ensuring sufficient capacity on these lines is a critical benefit as it may not be feasible to extend the transmission network to every site, particularly in locations where there would be impacts to local residents and the environment.

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