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New York State Grid-Interactive Vehicle Roadmap

Stephanie Morse[1], Ingrid Malmgren[2], Steven E. Letendre, PhD[3], Adam Ruder[4]

[1] *Vermont Energy Investment Corporation, 128 Lakeside Avenue, Burlington Vermont, 05401, smorse@veic.org*

[2] *Vermont Energy Investment Corporation (VEIC)*

[3] *Green Mountain College*

[4] *New York State Energy Research and Development Authority (NYSERDA)*

Summary

A shift from fossil fuels to electricity for transportation energy will pose challenges for utility providers while also presenting opportunities for economic, grid reliability, and environmental benefits. Strategic integration of electric vehicles (EVs) with the grid would more fully realize the benefits that EVs offer and potentially make EV ownership more affordable through the provision of reliability and resilience services to the grid. The New York State roadmap presented here was informed by a preliminary research report, gap analysis, and stakeholder feedback; it identifies the current state of grid-interactive vehicles, examines how to overcome existing barriers, and presents a strategic plan for EV grid-integration.

Keywords: energy storage, EV (electric vehicle), load management, smart grid, V2G (vehicle to grid)

1 Introduction

Reductions in greenhouse gas emissions are expected from the transportation sector as electric vehicle (EV) adoption increases and transport fueling is slowly shifted from gasoline to an increasingly clean electricity mix. Greenhouse gas emissions from power production will decline as power suppliers meet renewable portfolio standards and comply with regional greenhouse gas initiatives. A link between the transportation industry and the electric power industry is being propelled by the emergence of EVs in the marketplace.

EVs are important to clean transportation, but a shift from fossil fuels to electricity as the primary supplier of energy for transportation will likely pose new challenges for utility providers with regard to peak power management and an increasingly constrained distribution network. That is, EVs represent the single largest potential new demand for electricity in several decades. But this shift also presents new opportunities that, if properly managed, could result in economic, grid reliability, and environmental benefits.

EVs are well suited for electrical demand-side management (DSM) because vehicles are typically in use for mobility less than 5 percent of the time [1,2] and EVs, on average, are actively charging only 20 percent of the time they are plugged into charging equipment [3]. Thus EVs represent a flexible load that lends itself to shifting the timing of vehicle charging. EVs can also potentially contribute to electrical system reliability as distributed energy resources (DERs) providing storage. EVs have been shown to be capable of integration

with the electric grid with bi-directional flow of power (both charging and discharging of the vehicle battery) occurring in response to signals from regional grid operators [4]. Widespread integration of EVs with the electric grid has the potential to both more fully realize the environmental benefits that EVs offer and make EV ownership more affordable through lower-cost charging and possible monetary compensation to the owner for providing valuable reliability and resilience services to the grid.

1.1 Objectives

New York State policies and programs have committed the State to supporting the expansion of clean energy and transportation options. It is through recognition of both the challenges and opportunities presented by increased adoption of EVs and grid-interactivity that the New York State Energy Research and Development Authority (NYSERDA) commissioned the New York State Grid-Interactive Vehicle Study. The Vermont Energy Investment Corporation (VEIC), in partnership with Steven Letendre, PhD, conducted the study and was tasked with:

- Engaging key stakeholders and soliciting their input on topics related to grid-interactive EVs
- Conducting preliminary research on grid-interactive vehicle technologies, electricity markets, and the regulations and standards surrounding them
- Developing a gap analysis to identify areas that require further work and thought from State agencies and industry actors, necessary for widespread acceptance of grid-interactive vehicles
- Creating a roadmap for decision-making about the introduction of grid-interactive vehicles

The resulting roadmap [5], presented in summary here, was informed by a preliminary research report and gap analysis, as well as extensive New York State stakeholder feedback. This roadmap identifies the current state of grid-interactive vehicles, examines how to best overcome existing barriers to full interactivity, and presents a strategic plan for the integration of EVs with the grid. The roadmap was developed around three distinct tracks—technology and standards, retail and wholesale markets, and policy and regulation. While there are certainly areas of overlap among these three tracks, it provides a useful framework for understanding the barriers and opportunities for grid-interactive vehicles in New York.

This roadmap follows a linear progression from the current state to capturing the resource opportunities of EVs, but all three tracks discussed rely on continued research, economic valuation, review, and incorporation of new technologies and policies to develop an iterative process to inform a path forward. With proper planning and implementation, integration between the energy sector and the transportation sector has the potential to lead to a cleaner, more efficient, reliable, and resilient electrical grid while still meeting the needs for clean transport.

With a focus on New York State, the roadmap also establishes a framework for other states or regions to develop a process to assess the benefits of grid-interactive vehicles and examine the strategic path or steps necessary for implementation.

1.2 Background on Grid-Interactive Vehicles

For the purposes of this study, grid-interactive vehicles are defined as plug-in EVs that leverage smart grid systems, allowing for (1) optimal timing of vehicle charging and (2) the use of these vehicles for providing grid services from frequency regulation to reserve capacity. This focus on the value of EVs in providing both DSM—through smart charging and distributed storage—and grid services, guide this study.

Because EVs represent new load, a critical first step in the integration of EVs into existing power systems must involve ensuring that charging occurs primarily at off-peak times. DSM, defined as the "utility sponsored programs designed to encourage consumers to modify their level and pattern of energy usage," [6] provides the means for off-peak charging. With EVs, this form of load management can be accomplished through either direct or indirect control of charging. In a direct-control scenario, EV owners grant an external party (for example, the utility) the ability to directly control the timing of electricity flows into their vehicles. In an indirect-control scenario, charging behavior of EV owners is passively manipulated through price signals, such as time of use (TOU) rates or emerging dynamic pricing schemes.

The batteries of EVs can also be used for behind-the-meter energy storage, enhancing the impact of DSM through vehicle-to-building (V2B) applications. When combined with software and hardware designed for

smart charging management, EVs can aid the integration and optimal use of intermittent renewable energy resources. EV batteries can also reduce building demand charges by reducing peak power use, and potentially responding to demand response events. Additionally, V2B systems establish the potential for EV batteries to serve as back-up power for homes and shelters in emergency situations.

In addition to representing new demand for electricity and contributing to more efficient use of existing infrastructure, EVs also have the ability to contribute to grid reliability as a resource in wholesale markets. Because the power grid is very limited in its capacity to store electricity, most of the power generated must be used at the exact moment it is produced. In regions with competitive wholesale markets, the grid operator is responsible for maintaining perfect balance between generation and demand. The New York Independent System Operator (NYISO) manages this system balance through three primary markets:

1. Energy markets - establish the mechanisms for energy to be bought and sold between Load Serving Entities (LSEs) and wholesale suppliers.
2. Installed Capacity (ICAP) Markets - enable load-serving entities (LSEs) to secure capacity to meet their customers' peak demands.
3. Ancillary services markets - maintain reliable operation of the transmission system.

NYISO has also developed several demand response (DR) programs that allow demand-side resources to participate in wholesale markets and provide incentives for curtailable loads to be called upon when reserve capacity drops below what is required for reliable operations.

EVs could potentially serve as resources in these wholesale markets and participate in DR programs. When equipped with appropriate connections to the grid, in addition to communication links to central dispatch centers, EVs can dispatch energy back to the grid and pull energy from the grid while charging. This has been termed vehicle-to-grid (V2G) power. Although pilot projects are beginning to show proof of concept, this is an emerging idea that requires some technology advances, regulatory and market reforms, and business model development.

For example, participation in any of these wholesale markets requires aggregation. EV batteries are currently too small to meet minimum resource size requirements for participation in wholesale markets. Given the average power level of current EVs on the road, hundreds of vehicles must be combined to present one resource to NYISO. No one yet knows if existing third-party aggregators (for example, of DR resources) will be the best option for providing aggregation, as well as the necessary communication and metering services, or if another entity (for example, utilities) will be better suited.

The biggest concerns regarding EV deployment and opportunities, as identified through stakeholder engagement, are at the distribution system level. Most stakeholders in New York State see wholesale integration of EVs as a longer-term prospect and believe that initial planning should focus on mitigating the impacts of EV charging on distribution systems.

2 Roadmap

As noted above, this roadmap is split into three parallel and interrelated tracks to address technology and standards, wholesale and retail electricity markets, and policy and regulation. Each of these tracks is broken down into three main steps: lay groundwork, mitigate impacts, and capture resource opportunities. Throughout the process, there is a continued emphasis on collecting information through research and using this information to revisit and recalibrate the roadmap. Following the steps outlined in this roadmap with a focus on distribution system integration could pave the way for a seamless and valuable integration between EVs and bulk power markets in the longer term. Technological improvements, economic evaluation, and continued research will lend themselves to an iterative process of reviewing and modifying the roadmap, allowing for the cost-effective integration of vehicles with the grid to maximize the overall benefits to the State.

2.1 Track 1: Technology and Standards

2.1.1 Current State

As detailed in the full New York State Grid-Interactive Vehicle Study: Roadmap [7], many of the technologies necessary to facilitate grid-interactive vehicles have been demonstrated in pilot projects. Advanced metering infrastructure (AMI) has the potential to accurately meter EV charging for time-of-use (TOU) and dynamic-pricing rate plans. New software allows electric vehicle supply equipment (EVSE) and EVs to receive signals from owners or utilities to control charging. Vehicle-to-grid (V2G) pilot projects have demonstrated that EVs can receive and respond to independent system operator (ISO) calls to charge or discharge their batteries and thus can be accurate and fast responding sources for frequency regulation.

However, most of these technologies have been integrated and tested only in small pilot projects or demonstrations. Research is still needed to test various other technologies, evaluate the costs and benefits of their applications, and determine which options provide the most cost-effective opportunities that can be advanced as industry standards.

2.1.2 Lay Groundwork

While many of the necessary technologies for grid-interactive vehicles are already in place, gaps exist in the integration of systems with vehicles, charging equipment, and grid operations, just as there is a lack of comprehensive standards and consistency to harmonize control signals and communication protocols. Many of these technologies and systems have broader applications beyond EVs to other distributed energy resources (DERs), including fuel cells and stationary energy storage devices. These gaps will need to be addressed to facilitate widespread development and adoption of grid-interactive vehicle infrastructure, in addition to other DER technologies as envisaged in the New York State Reforming the Energy Vision (REV) proceeding (discussed in more detail in following sections).

From the standpoint of this roadmap and the potential for New York State stakeholders to affect the technological advancements of grid-interactive vehicles, many of these issues fall outside the State's influence or jurisdiction. Although New York State represents a potentially large market for EVs and the technologies and systems to enable grid-interactive vehicles, it is the automakers and original equipment manufacturers (OEMs), EVSE manufacturers, and standards-making bodies (for example, the Society of Automotive Engineers and IEEE) that will likely play a more direct role in how technological and standardization gaps are addressed in the development of grid-interactive vehicles. For this reason, the Technology and Standards steps in this roadmap are constrained.

That is not to say, however, that New York State EV stakeholders cannot influence the development of grid-interactive vehicle technologies. Because much of the necessary technology exists, one of the most significant tasks at hand is to conduct the research necessary to evaluate the costs and benefits of various technologies, advocate for the advancement of the most cost-effective options, and ensure that a business case can be made for all entities involved in the grid-interactive EV value chain. In addition, New York State can continue to coordinate with other states to advance EV adoption and the technologies and systems to enable grid-interactive vehicles.

2.1.3 Mitigate Impacts

To advance the technology aspects of grid-interactive vehicles, one area in which EV stakeholders in New York State can be proactive is in mitigating the impacts of increased EV adoption at the distribution level. A 2011 study by the Electric Power Research Institute (EPRI) for NYSERDA concluded that impacts of EV charging will largely occur at the distribution level and not at the bulk system level [8]. The study's assessment indicated that EVs have a likelihood of "clustering" in discrete locations, magnifying the impact of EV charging on distribution transformers and other distribution system components.

To ensure adequate infrastructure is in place for the additional charging load, EVSE siting will need to be coordinated with utilities. Further, the development of a program to notify utilities of EV purchases is within the State's jurisdiction, and will help utilities prepare at the distribution level, as necessary.

To plan for distribution level impacts, it is also important to be able to accurately measure EV charging load. Options for metering the charge and discharge of EV batteries include sub-meters, AMI interval data, separate meters, EVSE, and EVs themselves. Not all of these options qualify as revenue grade meters, nor do they all meet State regulatory performance standards. Research that measures the accuracy of these metering options, as well as cost-benefit analyses (as discussed in following sections), will be critical in the development of

grid-interactive vehicle programs. If the accuracy and cost-effectiveness of a specific metering option can be shown, the New York State Public Service Commission (PSC) can expand its definition of revenue grade meters to include technologies that meet requisite performance standards.

As with metering, the communication technology necessary for a third party to control the charging of an EV has been developed and proven in various pilot projects, and first-generation control systems have been in operation for decades to control energy use from various appliances (primarily air-conditioners and water heaters). Applying this technology to EVs enables smart charging, providing utilities with more control and the means to directly determine when charging occurs. An EPRI-led Utility-Automotive OEM Smart Charging Collaborative is conducting much of the research necessary to determine the most accurate and cost-effective approach to smart charging [9]. Consolidated Edison, Inc. is participating in this Collaborative, and New York State will benefit from that utility's continued engagement.

Finally, with respect to standards, it is not likely that the State will be directly involved in the development of safety codes and standards related to grid-interactive vehicles, and it will therefore be important for New York utilities to track the development of these codes and ensure that every level of EV grid-interactivity meets these standards. For example, if vehicle-to-building (V2B) applications are deemed economically feasible, utilities will need to ensure that there are no concerns with electrical system faults or intentional system islanding and subsequent reconnecting of circuits.

2.1.4 Capture Resource Opportunities

To move from mitigating impacts at the distribution level to grid-interactive vehicles serving as wholesale market resources, one of the most critical steps for New York State will be to again analyze and assess the costs and benefits to ensure that a business case can be made for all involved entities, ranging from the EV owner to the grid operator.

One technological development needed for fully integrated EVs as grid resources is one largely outside the influence of New York State: the capacity for bidirectional energy exchange to and from EV batteries. This technology has been developed, and bidirectional transfer has been accomplished on retrofitted and custom-built EVs. But this technology is not yet commercially available in personal EVs in the United States. The lack of bidirectional charging is not a limiting factor for all grid-interactive vehicle applications (such as when they might be used as DR resources). But this technology is necessary for the full economic and grid benefits of EVs to be realized in providing power back to the grid. New York State will benefit from analyzing the additional value created through bidirectional opportunities and from an understanding of the full value of wholesale market participation.

Additionally, as noted above, to participate as wholesale market resources, aggregation is necessary. Wholesale electricity markets require a minimum resource size; NYISO requires 1 MW power blocks for participation in the majority of its markets. Therefore, many EVs need to be grouped or aggregated into a single resource to qualify for market participation. As with other technological needs for grid-interactive vehicles, aggregation software has been demonstrated in multiple pilot projects, but widespread applications or adoption require further development. In the case of aggregation, less research is required to test the technological aspects; instead, suitable business models, program design, and willingness to participate are much more significant factors that must be better understood.

2.1.5 Ongoing Research, Data Collection, and Valuation

The costs and cost-effectiveness of various technologies will be a critical consideration in the evolution of grid-interactive vehicle programs. The adoption of controlled charging software and equipment, for example, will be feasible only if the value generated by smart charging outweighs the costs. And this must be the case for all aspects of the EV value chain. A utility is unlikely to implement such a program unless a business case can be made that illustrates its economic value. Likewise, an EV owner will need to see and understand that the savings from participating in a TOU rate program, for example, will be greater than the cost of any additional metering equipment required. Understanding the costs and the value generated from various grid-interactive technologies, and developing a business case for all involved parties will require considerable research and analysis.

2.2 Track 2: Retail and Wholesale Markets

2.2.1 Current State

EVs represent a small percentage of the light-duty vehicle fleet in New York State. Of the 9 million light duty vehicles registered in the State, only about 14,000 EVs are on the road. EV charging infrastructure has seen steady growth in the past five years and totals about 1,200 charging stations [10]. New York State has a goal to have 30,000 EVs on the road by 2018, and 1 million by 2025 through the ChargeNY initiative. Reaching these goals will be necessary to create a substantial fleet of EVs to provide value in retail and wholesale markets.

There are no current, significant efforts in New York State to encourage off-peak EV charging, either indirectly through TOU rates or directly with controlled charging. Although the voluntary TOU rates offered by several retail utility providers were not specifically designed for off-peak EV charging, EV owners might benefit from signing up for a TOU rate. Furthermore, there are no significant efforts to unlock the value that EVs could provide as DERs at the retail and wholesale levels.

2.2.2 Lay Groundwork

Understanding and planning effectively for grid-interactive vehicle opportunities in New York State's retail and wholesale markets should begin with an identification of the value of EVs as energy storage devices. The underlying assumption is that finding cost-effective ways to promote off-peak charging and developing market opportunities that unlock the value of EVs as DERs will expand EV ownership and accelerate the deployment of the charging infrastructure.

Laying the groundwork to maximize the market opportunities of an emerging grid-interactive vehicle infrastructure should start with a clearly defined common framework and articulation of the various use cases. One approach to defining grid-interactive vehicle use cases in New York, according to the increasing complexity of the technology and market structure, is presented below. Seven use cases include five that will contribute directly to mitigating impacts on the distribution system and two that focus on capturing resource opportunities.

2.2.3 Mitigate Impacts

Use case 1: TOU Rates. TOU rates have been used by utilities for several decades. As stipulated by New York State law, utility TOU rates are voluntary, meaning customers can choose to either stay with a fixed rate or move to a TOU variable rate tariff. From a utility and grid perspective, TOU rates enhance reliability by shifting load from peak periods to off-peak periods when the grid typically has excess capacity. From a customer perspective, TOU rates provide customers with more control over their electric bills and offer opportunities for saving money if they are able to shift a considerable amount of energy use from on-peak to off-peak periods.

NYSERDA recently released a comprehensive review and analysis by M.J. Bradley & Associates, LLC (2015) of pricing strategies for EV charging, including TOU rates and utility direct-controlled charging [11]. The study concludes that the benefits of off-peak charging, in terms of reduced energy costs, are significant in New York State. Furthermore, the study finds that the simplest mechanism to incentivize off-peak EV charging would be the use of "EV-optimized," whole-house TOU rates. However, limited experience in New York suggests that TOU rates are not popular with EV owners. The M.J. Bradley study's authors have recommended not pursuing EV-specific TOU rates because of perceived regulatory barriers, administrative hurdles, and financial impacts associated with the requirement for a second utility grade meter or submeter that must be under the control of the utility to assure accuracy. Rather than develop EV-specific rates in New York, the study's authors recommended modifying existing whole-house TOU rates to better promote off-peak EV charging and consumer acceptance.

Utilities and the PSC should, however, monitor the development of technologies and systems that could cost-effectively allow for EV-specific TOU rates in the State.

Use Case 2: Direct Control Charging: Utility Benefit. An alternative to TOU rates for achieving the desired goal of off-peak EV charging is direct-controlled charging by utilities. EV owners would receive an incentive

to allow a third party to control EV charging within set parameters. For example, the EV owner might specify that his or her EV must always be fully charged by 7:00 a.m. on all weekdays, or that the battery level not be allowed to dip below a 30 percent state of charge. Direct control of EV charging can include both on/off charging or modulation of the rate of charge. The experience with these types of programs is not wide or deep, but several pilot projects are currently underway.

The M.J. Bradley report suggested that direct control of EV charging under utility control could be cost effective, particularly in locations with significant EV clustering [12]. The benefits of avoiding distribution system upgrades on a particular circuit with an EV cluster might justify investments in the infrastructure and in customer incentives to encourage EV owner participation in the program. New York utilities and the PSC could benefit from a more complete evaluation of the costs and benefits of direct-controlled smart charging systems, and monitor the experiences in other regions with EV direct load control pilot programs, and perhaps consider conducting a demonstration.

Use Case 3: Direct Control Charging: Building Owner Benefit. Building owners who host employer-based or public charging stations could also potentially derive value from systems that allow for the direct control of EV charging. Increasingly, employers and retail establishments are installing EVSEs as an amenity for employees and patrons. The value of direct-controlled charging would result from the ability to avoid having EV charging contribute to the building's peak demand. Industrial and commercial building tariffs typically include a demand charge component. A per-kilowatt (kW) charge is often applied to the highest monthly demand, which can carry over for several months under certain tariff designs. The direct control of EV charging for EVSE owners and operators could be particularly valuable for DC fast-charging systems that can have power draws as high as 100 kW. This grid-interactive vehicle use case could be particularly challenging as consumers will have an expectation that they will be able to charge when plugged in. A full analysis of this opportunity in New York would help to educate EV stakeholders on the costs and benefits to building owners who host EV charging stations for direct-controlled charging.

Use Case 4: V2G, Distribution Level. Direct utility control of EV charging is a promising approach to minimizing the distribution system impacts of EV charging; direct utility-controlled charging with energy dispatch capabilities using V2G systems could offer additional operational flexibility for utilities to manage distribution system reliability. EVs could one day play an important role in shaping distribution system load. Most V2G valuation studies focus on the value of V2G in providing grid services in wholesale power markets. However, V2G capability in a given area can also alleviate localized distribution system overloading and better manage the effects of intermittent distributed generation systems on distribution-level voltage. EV stakeholders in New York should consider studying this use case, which could offer value to distribution utilities well beyond that associated with shifting EV charging to off-peak periods without V2G functionality. In 2012, Consolidated Edison contracted with an economic consulting firm to assess the marginal costs of electric distribution service [13]; this type of information could help to identify high-value locations for distribution system support services as well as allow for a greater understanding of the benefits that V2G-equipped EVs could provide at the distribution level more broadly.

Use Case 5: V2B. V2B leverages two-way power flows to minimize building energy costs through peak shaving, in addition to providing other valuable services to building owners. The U.S. Department of Energy (DOE)/EPRI 2013 Electricity Storage Handbook noted three additional values of behind-the-meter energy storage, beyond demand charge management: enhanced power quality, reliability in the form of emergency power, and retail energy time-shift [14]. To date, however, there is no comprehensive analysis of the aggregated value of these functions that energy storage systems, such as EVs with V2B, could provide to building owners in New York.

2.2.4 Capture Resource Opportunities

Use Case 6: Demand Response Programs. NYISO offers five DR programs: the Day-Ahead Demand Response Program (DADRP); the Demand-Side Ancillary Services Program (DSASP); the Emergency Demand Response Program (EDRP); the Targeted Demand Response Program (TDRP); and the Installed Capacity Special Case Resource Program (ICAP SCR). Two of these programs—DADRP and DSASP—are market-based and allow end-use loads to participate in NYISO's Energy and Ancillary Service wholesale markets. The three remaining DR programs address reliability, with participating resources being paid

directly by NYISO [15]. The costs of these programs are allocated to all load-serving entities within New York State.

To participate as a reliability-based DR resource, a load must first pay as a capacity resource. In other words, a load obligation is a prerequisite for shedding load. Load curtailment is valued during peak periods and thus only EV charging that is occurring on peak would qualify as a reliability-based DR resource. New York State would be well advised to ensure that EV charging during peak load periods is minimized. It is conceivable that EV charging occurring during peak load periods could qualify as a reliability-based DR resource; however, efforts should be on programs and incentives to encourage off-peak charging. The economic incentive for off-peak charging should be at least as large as the benefit EVs would generate as reliability-based DR resources.

EV charging curtailment could possibly qualify for participation in NYISO's market-based DR programs. During the few hours each day that an EV is charging, that charging could be interrupted or modulated to deliver energy in the day-ahead market. However, this timeframe offers an extremely limited opportunity for meaningful participation. It is unlikely that the benefits of participation would exceed the costs associated with vehicle aggregation and the necessary control and communication systems. Participation in the DSASP with one-way power flows would similarly be rather limited. The charging infrastructure restricts the amount of per-vehicle capacity that could be bid into these programs. In addition, the energy storage capability of EVs limits the number of hours that EVs could physically provide these services. At this stage, the economic costs and benefits of EVs participating in these market-based DR programs are speculative. It seems, however, that the barriers are significant. These barriers involve the minimum market participation bidding blocks of 2 MW and 1 MW for DADRP and DSASP, respectively. As vehicle prices decline and battery performance improves in the coming years, this opportunity might later become viable.

Use Case 7: V2G, Wholesale Market Participation. A grid-interactive vehicle infrastructure that allows two-way flows of power would expand the capabilities of EVs to participate in wholesale power markets. NYISO has a specific program that allows limited energy storage systems to participate in the frequency regulation market. The Limited Energy Storage Resource (LESR) program makes it possible for energy storage systems of 1 MW or larger to participate in the frequency response regulation market. Of the wholesale market opportunities in New York, this program seems to be the most promising for EVs. Regulation services are required 24/7/365, and are priced at a premium in the market. In 2014, the average market price for regulation was $12.87/megawatt-hour (MWh), up from $10.11/MWh in 2013 [16]. The LESR program in its current form does not specifically allow aggregated resources to meet the minimum 1 MW bidding block. However, it is conceivable that when EV penetration reaches critical mass and a V2G infrastructure evolves, the program could be modified to accommodate EVs. EV stakeholders in New York State should monitor developments and perform feasibility studies to determine the economic costs and benefits of EVs' providing frequency response regulation services.

2.2.5 Ongoing Research, Data Collection, and Valuation

A baseline accounting of the costs and benefits of EV deployment in New York State should be the starting point for decisions regarding prioritizing activities and programs to encourage the development of the grid-interactive vehicle infrastructure in the State. Developing these use cases and understanding the economic costs and benefits of each will serve to further enhance the value, beyond the baseline, of EVs in the State.

The opportunity for grid-interactive vehicles to participate in wholesale power markets in the short term appears to be rather limited. In the longer term however, when EVs reach critical mass in New York State, EV participation in wholesale power markets could enhance the efficient operation of wholesale power markets. A comprehensive assessment is needed of the different rules for participating in NYISO wholesale markets with an eye toward modifications that would addresses the barriers and maximize the value of the unique characteristics of EVs as grid-connected resources.

2.3 Track 3: Policy and Regulation

2.3.1 Current State

Section 177 of the U.S. Clean Air Act allows states to adopt the California zero emissions vehicle (ZEV) regulations, which require automakers to sell a growing number of ZEVs in the adopting states. New York is one of 10 states to adopt these regulations. New York's adoption of this mandate requires an increasing number of ZEVs to be sold in New York. The requirement to increase the number of ZEVs will significantly ramp up in 2018 to reach approximately 15 percent of new-vehicle sales by 2025. It is projected that this will result in the sale of approximately 800,000 EVs in the State in that period [17].

Within the regulatory realm, the REV proceeding is currently under review by the PSC. The REV proceeding is a broad-based regulatory initiative to promote energy efficiency, expansion of renewables, a more distributed (and therefore resilient) grid, and increased customer engagement. Elements of the REV proceeding include: doubling net metering capacity; innovative DSM programs; and encouragement of utilities and third parties to propose demonstration projects, strengthen DR programs, and develop load aggregation programs for small businesses. A more distributed grid sets the stage for EVs to potentially provide storage resources as part of an overall grid modernization plan.

Meanwhile, a recent initiative supported by the Governor's office is the Clean Energy Fund (CEF) proposal, which cites "accelerated electrification of the transportation sector" as one of its Strategic Priorities and Target Areas to reaching advanced sustainable transportation goals. Additional initiatives such as ChargeNY, Clean Fleets NY, and Clean Cities also support the deployment of electric vehicles. These initiatives, coupled with policies to promote cleaner, more sustainable electricity generation, create favorable conditions for a shift to electric transportation and grid-interactive vehicles.

2.3.2 Lay Groundwork

Because EV adoption is at such an early stage and EV technology is evolving, it is important to maintain a focus on customer confidence. Any program that uses EVs for energy storage or controls EV charging must ensure that customers' transportation needs are met first. If EVs are not perceived by customers as providing reliable transportation value, the EV market will deteriorate. Sound economic analysis of the benefits and costs of EV deployment in the State should inform the creation of incentives, programs, and utility investments that are cost effective while still supportive of the clean transportation goals.

One key element of laying the groundwork for grid-interactive vehicles relates to metering and communication. As previously noted, technologies exist for the communication, metering, and control of grid-interactive vehicles. Within the jurisdiction of State regulators however, is the definition of a revenue grade meter. The PSC's definition should be revisited and potentially expanded if the accuracy of on-board EV meters and EVSE metering or residential submeters is established with data and analysis.

Another key element is land use planning. At the State level, an EV infrastructure plan should be developed for primary travel corridors to ensure adequate fast-charging for long-distance travel. At both the State and local levels, building codes should be adapted, as necessary, to promote EVSE. One example of how this strategy has been implemented already is the law passed in 2013 by the City Council of New York requiring that 20 percent of new parking spaces be designed for EV charging [18]. Municipalities should incorporate EVSE siting into urban planning and zoning regulations, including assessments of parking and transportation functions of the vehicle, as well as proximity to substations or distributed generation. Existing automobile fueling stations should also be considered to accommodate EV charging, especially DC fast-charging stations. In addition, planning assessments should involve coordination of public and private charging stations as well as clearly defined guidelines for owners and operators to facilitate charging and integration with the grid.

Because the primary role of EVs is expected to be transportation, it is important to involve transportation agencies in long-range planning. EVSE at transit hubs, train stations, and airports should be included in long-range transportation planning to facilitate multimodal EV transportation. In 2015, charging stations were introduced at four travel plazas along the New York State Thruway. Continuing this trend by adding more charging stations on the Thruway and other limited access highways as well as interstate highways supports the use of EVs for long-distance travel throughout the State. At some point, these chargers could be linked to stationary energy storage facilities or renewable distributed generation to further support the goals of more distributed energy generation and storage as outlined in the REV proceeding.

The opportunity for partnerships among agencies and sectors extends to other agencies as well, such as the Department of Environmental Conservation. Evaluating the environmental benefits of EVs will help assess their value toward reducing environmental externalities associated with traditional fossil fuel vehicles and reaching greenhouse gas emission reduction goals.

2.3.3 Mitigate Impacts

Increased EV adoption will require greater electricity use, but the timing of when that electricity is delivered is important. As discussed earlier, perhaps the easiest way to avoid added peak demand is through rate design or other incentives. Regulators such as the PSC might require utilities to offer specific TOU rates or other incentives to encourage off-peak EV charging. Regulators also have the authority to determine levels of differentiation between on-peak and off-peak rates for EV charging, thus determining the impact of the incentive for charging off-peak. If incentives are too low, EVs are more likely to add to peak load. However, administrative barriers and cost of implementation could preclude utilities from offering EV-specific TOU rates. At least in the near term, the PSC might consider requiring utilities to offer monthly incentives (rather than separate rates) for off-peak EV charging. Again, this strategy brings up the necessity of a cost-benefit analysis of the value of EVs in this capacity.

Another important element in mitigating distribution level impacts is utility planning. A combination of land use planning and distribution level impact assessments will be necessary to minimize impacts at the distribution level. Hosting capacity analyses are currently used in planning for distributed generation impacts on distribution feeder systems. Similar analyses should be conducted to assess power quality and reliability issues of local distribution networks as EV penetration increases, and prior to EVSE installations. Local and regional planners may want to consider this information when siting ESVE as a step toward mitigating impacts of EVs on the grid.

2.3.4 Capture Resource Opportunities

Again, planning will be important in determining the best application of EVs as resources in the wholesale electricity markets. The first step, as described above, is conducting a cost-benefit analysis to determine the value of EVs in wholesale markets, either as DR or V2G market resources. If either is determined to be cost effective, several regulations, market reforms, and policies should be adopted to facilitate activity. Currently, wholesale market rules preclude battery storage (EVs) from providing multiple benefits to the grid (for example, as both DR resources and LESR). Stacking value of energy storage in the form of EV batteries is important to promote higher penetration of these resources.

Additionally, developing a business model and breaking out charge and compensation mechanisms will be necessary for EVs to be resources in wholesale markets. Exploring aggregation models and developing policy guidance for these models will also be necessary, given the small energy capacity of EV batteries. Assessing and determining compensation for each participant in the value chain—EV owners, EVSE operators, distribution utilities, and grid operators—will be important in identifying the best opportunities for EV interaction with the grid.

Perhaps most important in capturing the resource opportunity of EVs in New York is consideration of their role and integration in the State's REV proceeding. The current REV proceeding lists six objectives, each of which EVs could contribute to [19]:

1. Enhanced customer knowledge and tools that will support effective management of the total energy bill.
2. Market animation and leverage of customer contributions.
3. System-wide efficiency.
4. Fuel and resource diversity.
5. System reliability and resiliency.
6. Reduction of carbon emissions.

Now is the time to incorporate EV systems and technologies into REV discussions to fully realize the potential benefits. The progression of policies, regulations, and applications based on technological innovation and the expansion of the EV market can support the goal of the REV proceeding to identify ways to achieve better load factor and smoother load shapes for the State's electric grid.

2.3.5 Ongoing Research, Data Collection, and Valuation

Continued data collection and analysis will be important in effective planning for grid-interactive vehicles. As more research is conducted and as new technologies become available, plans will need to be adjusted to accommodate this information and these technological improvements. It will be particularly important to quantify and monetize the benefits of EVs—to utilities, to the environment, to society, and to ratepayers. This information will be necessary to help determine appropriate incentive levels for different participants in the EV value chain and to provide a comprehensive picture of the value of EVs to the State and its passengers, electricity ratepayers, and citizens.

3 Conclusion

The path forward to widespread grid-interactive vehicle integration in New York State will proceed along three tracks:

- Technology and standards
- Retail and wholesale markets
- Policy and regulatory

Each of these tracks will support a critical element to grid-interactive vehicles. And each will follow the same sequence of steps from laying the groundwork, to mitigating negative impacts of EVs on the grid, and finally, to capturing the value that EVs could provide to the State's grid. The path forward, however, is not entirely linear. It will rely on continued research and review of the value of EVs and new technological opportunities, to inform whether changes in trajectory should be made.

New York State has a history of innovation in the energy sector. By merging the grid-interactive vehicle concept into the State's policies and regulatory environment, New York will bring its history of energy innovation into transportation, one of the most challenging sectors. And while the focus of this roadmap is on New York State, it also presents a framework other states or regions can adapt to similarly assess the benefits of grid-interactive vehicles and examine the strategic steps necessary for implementation.

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Authors

Stephanie Morse, Transportation Efficiency Consultant, VEIC, focuses on transportation behavior research and analysis. She conducts spatial and statistical analyses and manages projects involving electric vehicles as grid resources, consumer eco-driving assessment, and location efficiency. Stephanie has a Master of Science degree in Natural Resources from the University of Vermont, a certificate in ecological economics from the Gund Institute of Ecological Economics, and a Bachelor of Arts degree in Environmental Economics from the University of Binghamton.

Ingrid Malmgren, Transportation Policy Manager, VEIC, has a broad background in social science research including behavioural health research, housing research, and energy efficiency program research. Most recently, Ingrid has worked in energy efficiency policy and utility regulation. Much of her research has focused on the benefits of energy efficiency programs beyond energy savings including health benefits, economic development benefits, and other ancillary benefits. Ingrid has a Master of Arts degree in Geography from the University of Vermont and a Bachelor of Arts degree in Geography from Penn State University.

Steven E. Letendre, PhD, holds a Master's degree in Economics from Binghamton University and a doctorate in energy policy from the University of Delaware. His career in the energy field spans more than 20 years. Dr. Letendre has conducted many studies on the grid impacts of EVs for various organizations. He is a professor of economics and environmental studies at Green Mountain College and an instructor at Vermont Law School. Dr. Letendre lectures regularly at professional meetings and conferences and has published more than 50 technical papers and reports on a variety of energy topics.

Adam Ruder, Program Manager, NYSERDA, leads NYSERDA's Clean Transportation group, which focuses on developing and demonstrating new technologies, policies, and business models that support five key focus areas: alternative fuels, public transportation, smart mobility, transportation demand management, and freight. Adam has led the implementation of Gov. Cuomo's ChargeNY initiative to advance electric vehicle adoption in New York State and he closely collaborates with other states and the federal government to jointly advance EV policies and programs. Before joining NYSERDA, Adam received a Master in Public Policy degree from the John F. Kennedy School of Government at Harvard University.