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New York State Grid-Interactive Vehicle Study: Roadmap

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New York State Grid-Interactive Vehicle Study: Roadmap

Final Report

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Acronyms and Abbreviations List

AMI	advanced metering infrastructure
CEF	Clean Energy Fund
ConEd	Consolidated Edison, Inc.
DADRP	Day-Ahead Demand Response Program
DER	distributed energy resource
DG	distributed generation
DSASP	Demand-Side Ancillary Services Program
EDRP	Emergency Demand Response Program
ICAP SCR	Installed Capacity Special Case Resource Program
DOE	U.S. Department of Energy
DR	demand response
EPRI	Electric Power Research Institute
EV	electric vehicle
EVSE	electric vehicle supply equipment
GSP	gross state product
HOV	high-occupancy vehicle
ISO	independent system operator
kW	kilowatt
kWh	kilowatt-hour
LESR	limited energy storage resource
MW	megawatt
MWh	megawatt-hour
NYISO	New York Independent System Operator
NYSERDA	New York State Energy Research and Development Authority
OEM	original-equipment manufacturer
PSC	New York State Public Service Commission
REV	Reforming the Energy Vision
TDRP	Targeted Demand Response Program
TOU	time-of-use
V2B	vehicle-to-building
V2G	vehicle-to-grid
ZEV	zero emissions vehicle

Summary

Recent New York State policies and programs have committed the State to supporting the expansion of clean energy and transportation options. Electric vehicles (EVs) represent one of these clean transportation options. Initiatives such as ChargeNY, which is geared toward accelerating the adoption of EVs and to build EV infrastructure, demonstrate the State's investment in the future of cleaner transportation. New York's adoption of policy initiatives like zero emission vehicle (ZEV) mandates demonstrates the State's commitment to air quality and health benefits associated with EVs. In the context of the electric grid, a New York State Public Service Commission (PSC) proceeding called Reforming the Energy Vision (REV) proposes a more stable, resilient, clean, and distributed grid infrastructure.

EVs are important to clean transportation, but a shift from fossil fuels to the electric grid as the primary supplier of energy for transportation will likely pose new challenges for utility providers with regard to peak power management. 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 net economic and environmental benefits to the State. Widespread integration of EVs with the electric grid would both more fully realize the environmental benefits that EVs offer and make EV ownership more affordable through lower-cost charging and possible financial compensation to the owner for providing valuable reliability and resilience services to the grid.

The New York State Energy Research and Development Authority (NYSERDA) recognized both the challenges and opportunities presented by increased adoption of EVs and grid-interactivity and commissioned the New York State Grid-Interactive Vehicle Study. Two reports were created to inform this ***Roadmap***, a strategic plan for the integration of EVs with the electric grid. The ***Preliminary Research Report*** **(Appendix A)** examined the current state of grid-interactive vehicles including research, technologies and standards, wholesale and retail electricity markets, and the regulatory landscape in New York State. The ***Gap Analysis*** **(Appendix B)** specifically identified barriers in large-scale integration of EVs with the grid. Both of these reports incorporated feedback from stakeholders in the State gained through document review and facilitated stakeholder meetings. This Roadmap identifies the current state of grid-interactive vehicles in the State and examines how to best overcome the barriers identified in the Gap Analysis to maximize their potential value in the State.

This Roadmap follows the existing framework used throughout this study and divides the strategic plan into three parallel tracks: Technology and Standards (Track 1), Retail and Wholesale Markets (Track 2), and Policy and Regulatory (Track 3). Although there is considerable overlap between the three tracks, they will generally progress simultaneously. Each of the tracks can be broken down into three consecutive steps toward integrating EVs: laying the groundwork, mitigating impacts, and capturing resource opportunities. Each track also identifies the current state of grid-interactive vehicle development for that particular track as well as ongoing iterative processes that will inform next steps.

The technology and standards track (Track 1) begins in a current state of advancement where all of the technologies necessary for grid-interactive vehicles are in existence, but have only been used in pilot projects and small-scale demonstrations. Laying the groundwork for expanding these technologies involves developing consistent technology standards as much as is possible at the State level and providing for consistent integration of these various technologies. The next step is to mitigate impacts from EV adoption and their associated electric load on the grid. Elements of this step include coordination of EV charging with distribution utilities, the evaluation of metering and communication standards, and development of safety standards for vehicle-to-building (V2B) applications. As EV penetration in the State grows and is successfully managed to prevent additional peak load, resource opportunities become more viable. At this point, it will be important to consider the value of bi-directional charging technologies and assess the technological options for various aggregation models.

In looking at the retail and wholesale markets in Track 2, it becomes clear in the current state that the value of EVs to utilities and the electric grid in New York State is not easily understood. Determining this value is a logical first step in laying the groundwork for grid-interactive vehicles. Once this value is determined, it should be built into incentives for fleet development. Part of this value assessment should be the development of a common framework of use cases. To address the second step and mitigate impacts from EV growth, time-of-use (TOU) rate design options, direct controlled charging by distribution utilities, and V2B applications are the next necessary considerations. Finally, maximizing the resource opportunities of EVs in markets involves participation of EVs in demand response programs and providing services in the wholesale markets.

The third track outlined in the Roadmap is policy and regulatory. While the State currently has policies in place to promote EV fleet development, the policies do not focus on the potential of these vehicles to serve as resources to the grid. To plan for a robust and effective integration between EVs and the grid, land-use planning must incorporate electric vehicle charging stations (also known as electric vehicle supply equipment [EVSE]) and multi-mode transportation that includes EVs (such as EV charging stations at commuter train stations). Other elements of this preparation include metering and communication research and guidance supported by the PSC and statewide development of an EV infrastructure plan for primary travel corridors throughout the State. Similar to the other two tracks, the second step in this track focuses on mitigating impacts of EV deployment on the grid. To accomplish this within the regulatory realm, hosting capacity analyses should be required as a precursor to large-scale EVSE development. A system should be developed to notify utilities of EV sales for planning and peak load mitigation purposes. TOU rates should be encouraged for residential EV charging, and metering and communication requirements should be developed to facilitate this. In addition, safety regulations will need to be considered and policies put into place for V2B applications. To capture the maximum resource opportunities from EVs, the PSC could adopt storage mandates or goals and market regulations should be amended to allow a resource to serve multiple functions in the wholesale markets. Further research should explore the value of the mobility of storage resources in the State.

Whereas this Roadmap outlines a progression from the current state to capturing the resource opportunities of EVs, the three tracks discussed in this Roadmap rely on continued research, economic valuation, review, and incorporation of new technologies and policies to develop an iterative process to inform the path forward. With proper planning and implementation, integration between the energy sector and the transportation sector in New York State has the potential to lead to a cleaner, more efficient, reliable, and resilient electrical grid while transporting people and products to their destinations.

1 Roadmap Introduction

Imagine driving home from work in your electric vehicle (EV). You park in your garage, and plug the car into your Level 2 charging station. With a remote command from the local distribution utility, your car—which has remaining stored energy—starts powering your house to avoid overloading your neighborhood circuit. You cook dinner and light your home for a few hours in the evening, before your vehicle begins to provide regulation frequency for the grid. This benefit to the grid earns you money, and will show up as a credit on your electric bill. Your car then recharges for a few pennies per kilowatt-hour (kWh) during the middle of the night, and you awake to a fully charged vehicle—ready to provide you with transportation, emergency power backup for your house, and a small amount of income on the side from participating in the ancillary services market.

The ***New York State Grid-Interactive Vehicle Study*** was funded by the New York State Energy Research and Development Authority (NYSERDA). The study resulted in three documents. The first report, the ***Preliminary Research Report*** (Appendix A), described existing technology and standards, reviewed current and past studies and pilot projects, recognized where EVs might participate in wholesale and retail electric markets in New York State, and looked at the regulatory landscape and policies in the state pertaining to electric vehicles and their interconnection with the grid. The second report was the ***Gap Analysis*** (Appendix B), which identified barriers to the implementation of grid-interactive vehicles in the State. Both of these reports incorporated stakeholder feedback to accurately capture the current state of technologies, regulations, and markets in the state. The findings of these two reports informed this ***Roadmap***, which is the third document. It incorporates the information obtained through stakeholder engagement and research to develop a strategic plan for integrating EVs with the grid in New York State.

Like the appendices, the Roadmap is split into three parallel and interrelated tracks to address technology and standards, wholesale and retail electricity markets, and policy and regulation (see Figure 1). 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. As the process unfolds, it might become evident that the value of having EVs participate in wholesale electricity markets simply isn’t feasible at scale. Conversely, following the steps outlined in this Roadmap could pave the way for a seamless and valuable integration between EVs and bulk power markets. In either case, 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.

Figure 1. Relationship of the three steps to the three tracks in the Roadmap

Step	Track 1 Technology and Standards	Track 2 Retail and Wholesale Markets	Track 3 Policy and Regulatory
Current State	Technologies exist, but have only used in pilot projects to date	Value of EVs to utilities and the NY grid is not well understood	Policies in place to promote EV sales, but not necessarily their interaction with the grid
Step 1: Lay Groundwork	• Follow development of technology standards • Integrate technologies	• Develop common framework of use cases • Conduct economic analysis to determine value to utilities and New York stakeholders • Build this value into fleet development as incentives	• Develop land use plans to accommodate EVSE and multi-mode transportation including EVs • Conduct metering and communications study and incorporate guidance from PSC • Develop Master EVSE plan
Step 2: Mitigate Impacts	• Coordinate EV charging with utilities • Evaluate available metering and communication technologies • Follow development of safety standards for V2B	• Evaluate TOU rate design options • Implement distribution level direct-controlled charging • Develop vehicle-to-building programs	• Conduct hosting capacity analyses for EVSE • Develop EV TOU rate requirements • Develop metering and communication requirements • Develop V2B regulations
Step 3: Capture Resource Opportunities	• Assess value of bi-directional charging technologies • Assess technological options for aggregation models	• Incorporate EVs into wholesale level demand response programs • Incorporate EVs into wholesale level markets with 2-way power flows	• Adopt storage mandates or goals • Adjust regulations to allow multiple wholesale market participation • Explore value of mobile storage resources
Ongoing Research, Data Collection, and Valuation	• Integrate national and international standards • Evaluate cost-effectiveness of integrating new technologies	• Continue research on driving and charging behaviors in New York • Develop business model for EV integration with the grid • Assess economic value of grid-interaction	• Evaluate and revise policies and regulations based on updates in research and technology

2 Track 1: Technology and Standards

2.1 Current State

As discussed in the Preliminary Research Report (Appendix A) and Gap Analysis (Appendix B), many of the technologies necessary to facilitate grid-interactive vehicles have been demonstrated in pilot projects, including some that are not directly related to EVs but to other distributed energy resources. Advanced metering infrastructure (AMI) has the potential to accurately meter EV charging for time-of-use (TOU) and dynamic-pricing rate plans. New software now allows electric vehicle supply equipment (EVSE) and EVs to receive signals from 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 frequency regulation resources.

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.

2.2 Step 1: Lay Groundwork

Many of the necessary technologies for grid-interactive vehicles are already in place. However, 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.

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) 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.

2.3 Step 2: 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.

2.3.1 Distribution Level Infrastructure

A 2011 study by the Electric Power Research Institute (EPRI) for NYSERDA concluded that impact of EV charging will largely occur at the distribution level and not at the bulk system level.[1] The study's preliminary market assessment indicated that EVs have a likelihood of "clustering" within discrete locations, magnifying the impact of EV charging on distribution transformers and other distribution system components.

[1] NYSERDA. 2011. "Transportation Electrification in New York State Technical Update." NYSERDA Report 11-07. Prepared by Maitra, A. of Electric Power Research Institute (EPRI).

To ensure adequate infrastructure is in place to handle 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 realm of the State's jurisdiction, and will help utilities prepare at the distribution level, as necessary. A California study assessed the impacts of new technologies, including EVs, on the on electric distribution system operation and performance.[2] The final report proposed an Advanced Monitoring Plan that could be the basis for further research and development to address the demands of the future distribution grid.

2.3.2 Metering

To plan for distribution level impacts, it is important to be able to measure EV charging load. Accurately metering EV charging is another important step in planning for and minimizing the impacts of increased EV charging load. The Preliminary Research Report and Gap Analysis offer options for metering the charge and discharge of EV batteries. These options involve 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) will need to expand its definition of revenue grade meters to include technologies that meet requisite performance standards, as discussed in Section 4.

2.3.3 Communication

The Preliminary Research Report and Gap Analysis discussed an effective way to minimize distribution level impacts of EVs: controlled charging, by ensuring that charging does not occur at a time that increases peak load. Although simple TOU rate programs might be effective in indirectly controlling EV charging, smart charging provides utilities with more control and the means to directly determine when charging occurs. The implementation of rate and smart charging programs is discussed in Section 3. With respect to technology, 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 (see

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[2] Von Meier, Alexandra, Merwin Brown, Reza Arghandeh, Laura Mehrmanesh, Lloyd Cibulka, and Bob Russ. 2015. *Distribution System Field Study with California Utilities to Assess Capacity for Renewables and Electric Vehicles*. Report prepared for California Energy Commission by California Institute for Energy and Environment. Publication number: CEC-500-2015-058.

Appendix A), and first-generation control systems have been in operation for decades to control energy use from various end use appliances (primarily air-conditioners and water heaters). The 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.[3] Consolidated Edison, Inc. (ConEd) is participating in this Collaborative, and New York State will benefit from that utility's continued engagement.

2.3.4 Standards

Because it is not likely that the State will be directly involved in the development of safety codes and standards related to grid-interactive vehicles, it will 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.

2.4 Step 3: Capture Resource Opportunities

To move from mitigating impacts on the grid 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.

2.4.1 Bidirectional Charging

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

3 Electric Power Research Institute. 2014. "EPRI, Utilities, Automakers to Demonstrate Technology Enabling Plug-in Electric Vehicles to Support Grid Reliability," Press release, http://www.epri.com/Press-Releases/Pages/EPRI,-Utilities,-Automakers-to-Demonstrate-Technology-Enabling.aspx

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 demand response [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. These opportunities, and the distinction between one- and two-way power flow use cases is described in Section 3.

2.4.2 Aggregation

To participate as wholesale market resources, aggregation is necessary. Wholesale electricity markets require a minimum resource size; the New York Independent System Operator (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 (see Appendix A), 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.

2.5 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 as shown in Figure 1 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. This understanding should also involve the broader societal benefits to New York State. Primary among those benefits would be emissions reductions from petroleum displacement that may not be reflected in market transactions, but could be the basis for State incentives and support for a grid-interactive infrastructure.

3 Track 2: Retail and Wholesale Markets

3.1 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, the vast majority of which are Level 2.[4] 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. It will be necessary to create a substantial fleet of EVs to provide value in retail and wholesale markets.

The State currently offers an income tax credit for 50 percent of the cost, up to $5,000, for the purchase and installation of alternative fuel vehicle refueling and electric vehicle recharging stations. Targeted for commercial and workplace charging, the credit is set to expire on January 1, 2018. Although there are no direct financial incentives in the State for EV purchases, beyond the federal EV tax credit, high-occupancy vehicle (HOV) lane exemptions and discounted tolls are available for EV owners.

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. Much of the work occurring under the REV proceeding, particularly that relating to a more dynamic grid with greater penetration of distributed generation (DG) resources, is directly relevant to enabling grid-interactive vehicles.

3.2 Step 1: 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. The following recommendations on specific

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[4] U.S. Department of Energy's Alternative Fuels Data Center, http://www.afdc.energy.gov/

actions would allow EV stakeholders to evaluate grid-interactive vehicle distribution- and wholesale-level opportunities and thus begin to prioritize developing the infrastructure, incentives, and policies that can realize the full value that EVs could bring to the State.

3.2.1 Common Framework

Laying the groundwork to maximize the value of an emerging grid-interactive vehicle infrastructure should start with a clearly defined common framework and articulation of the various use cases. Table 1 presents one approach to defining grid-interactive vehicle use cases in New York, according to the increasing complexity of the technology and coordination necessary among participants in the EV value chain. Table 1 offers seven use cases in four different categories.

Table 1. Possible grid-interactive vehicle use case framework in New York State

Use Case	Description
Distribution Level: 1-way power flows	
TOU rates	Indirect incentives for EV charging through off-peak EV rates are proven to be effective in encouraging EV charging in late evening and early morning hours, when electricity demand is at its lowest. The utility benefits through potential deferrals of distribution system upgrades, and EV owners benefit from reduced costs of charging.
Direct control of EV charging—utility benefit	Direct load control programs have been in use by utilities for decades to manage peak loads. Although most of the emphasis has been on the industrial and commercial customers, there are a number of residential direct load control programs in various locations. Advanced control and communication systems are used to either turn EV charging on or off, or regulate the rate of charge. The utility again benefits from potential deferral of distribution system upgrades. These systems could also provide voltage control within particular circuits. With the increase of distributed generation (DG), this service could become increasingly valuable to utilities. Presumably, EV owners would be offered incentives to participate in EV charging direct load control programs, thus lowering the overall cost of EV ownership.
Direct control of EV charging—building owner benefit	Direct load control systems used by building owners could mitigate impacts of vehicle charging on building demand charges. Building energy management systems could integrate direct control of EV charging systems to mitigate the peak demand impacts of EV charging on premises. Conceivably, building owners would offer incentives to EV owners to participate. There would be considerable challenges in implementing this type of program that must be more fully explored.

Table 1 continued

Use Case	Description
Distribution Level: 2-way power flows	
V2G—distribution level	Bidirectional systems could expand the benefits to utilities over those associated with direct load control with 1-way power flows. The ability to dispatch power from parked EVs would provide greater operational flexibility to manage voltage disturbances on circuits. Increasing deployment of DG—in particular, solar—creates new challenges for managing distribution system reliability. The commensurate higher value of V2G to the distribution system could ultimately be reflected in incentives offered to EV owners to participate in such programs.
V2B	V2B offers potential benefits to building owners, including enhanced power quality, reliability in the form of emergency power, retail energy time-shift, and demand charge mitigation.[5] Again, EV owners could be compensated for allowing their EVs to provide these services lowering the overall cost of EV ownership.
Wholesale Level: 1-way power flows	
Demand response programs	NYISO has several DR programs that contribute to bulk system reliability. Aggregated EVs could potentially qualify for one or more of these programs and thus the members within the aggregated group could receive compensation for providing these services.
Wholesale-Level: 2-way power flows	
V2G - wholesale market participation	NYISO has specific programs that allow loads and limited energy storage devices to participate in wholesale power markets for ancillary services and energy. EV owners would be compensated at market rates for the services they provide, similar to conventional generators.

3.2.2 Economic Analysis

Although several studies on the benefits of EV deployment are available, there is not yet a comprehensive study of the energy and nonenergy benefits and costs of EVs in New York State. The 2011 EPRI study for NYSERDA found significant statewide economic net benefits using regional input-output analysis. The analysis quantified the gross state product (GSP) and employment effects under four different fuel price scenarios. Positive economic benefits were demonstrated for all scenarios, ranging from $4.45 to

[5] Akhil, Abbas A. et al. *DOE / EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA*. Report prepared by Sandia National Laboratories. 2013. http://www.emnrd.state.nm.us/ECMD/RenewableEnergy/documents/SNL-ElectricityStorageHandbook2013.pdf

$10.73 billion per year in increased GSP and 19,800 to 59,800 additional jobs created.[6] The economic analysis did not consider infrastructure costs, nor did it factor in the incremental capital costs of EVs relative to conventional gasoline vehicles. In addition, the study found modest air quality improvements with the transition from gasoline to electricity for transportation. But the study did not estimate the carbon dioxide emissions reduction potential or the associated economic benefits of these reductions. A 2012 study by the Union of Concerned Scientists, a nonprofit energy policy think tank, found that nearly half of Americans live in regions where driving an electric vehicle means lower global warming emissions than driving even the best hybrid gasoline vehicle available.[7] Furthermore, the study found that the lifetime savings are more than 6,000 gallons of gasoline per EV. Finally, the report highlights that the emissions benefits of EVs are tightly linked to a cleaner power grid, which is being driven across the country by state requirements for greater use of renewable forms of energy including in New York State.

EV stakeholders in New York would benefit from a comprehensive analysis of the benefits and costs of EV deployment, including both energy and non-energy benefits. A baseline economic analysis would inform a more detailed economic analysis of each use case identified in Table 1. A 2014 study of EV deployment in California compared the monetized costs and benefits of actual cash transfers into or out of the state to determine whether net economic benefits accrued to the state with additional EV adoption. The benefits included in the analysis were the federal tax credit for EVs, gasoline savings, and reduced cap-and-trade greenhouse gas allowance costs, which total approximately $20,000 per vehicle.[8] The costs included the incremental costs of the vehicle, charging infrastructure costs, distribution system upgrades, and the avoided costs for delivered energy. Total costs were estimated to be just under $15,000 per vehicle, for a net benefit of approximately $5,000 over the life of each EV. A societal cost-benefit analysis that included the value of reduced petroleum reliance brought the net benefit to just over $6,000 per vehicle.

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[6] NYSERDA. 2011. "Transportation Electrification in New York State Technical Update." NYSERDA Report 11-07. Prepared by Maitra, A. of Electric Power Research Institute (EPRI).

[7] Anair, Don and Amine Mahmassani. *State of CHARGE: Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings across the United States*. Report prepared by the Union of Concerned Scientists: Cambridge, MA. 2012.

[8] *California Transportation Electrification Assessment Phase 2: Grid Impacts*. Report prepared by Energy and Environmental Economics, Inc. San Francisco, CA. 2014. http://www.caletc.com/wp-content/uploads/2014/10/CalETC_TEA_Phase_2_Final_10-23-14.pdf

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 economics of each will serve to further enhance the value, beyond the baseline, of EVs in the State.

3.3 Step 2: Mitigate Impacts

Although EV load forecasts indicate minimal impact on transmission levels, a proliferation of EVs clustered in a neighborhood could negatively affect the distribution grid. Thus, efforts to mitigate the distribution system impacts of EV charging should be the highest priority in designing and deploying grid-interactive vehicle systems. Of the seven use cases described in Table 1, the first five pertaining to both one- and two-way power flows at the distribution level will contribute directly to these efforts. The other two are understood as creating benefits for building owners, but these use cases can also likely mitigate the effects of EV charging on distribution load profiles.

3.3.1 TOU Rate Design

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.

Since the development of the Preliminary Research Report, NYSERDA released a commissioned comprehensive review and analysis by M.J. Bradley & Associates, LLC (2015)[9] of pricing strategies for EV charging, including TOU rates and utility direct-controlled charging.[10] 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

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[9] Jones, Brian M. *Electricity Pricing Strategies to Reduce Grid Impacts from Plug-in Electric Vehicle Charging in New York State*. Report prepared for New York State Energy Research and Development Authority (NYSERDA Report 15-17) by M.J. Bradley and Associates LLC. Albany, NY: NYSERDA. June, 2015. http://www.mjbradley.com/sites/default/files/NYSERDA-EV-Pricing.pdf

[10] Ibid

the use of “EV-optimized,” whole-house TOU rates. The 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.[11] 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.

Additionally, the study’s authors proposed an alternative idea of a rebate program for off-peak EV charging whereby customers are given a monthly credit or rebate for consistent off-peak charging, allowing the household to remain on a standard fixed rate tariff. This approach is viewed as being similar to other load control programs and would only require a one-way communication link to document the timing of current flows from the charging circuit. The study did not analyze the costs of such a system, but the authors speculated that this approach may be less costly than expanding TOU rates, either “EV-optimized” whole house or EV-specific TOU rates.

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

3.3.2 Direct Control Charging: Utility Benefit and Building Owner 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 under way.

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11 Jones, Brian M. *Electricity Pricing Strategies to Reduce Grid Impacts from Plug-in Electric Vehicle Charging in New York State*. Report prepared for New York State Energy Research and Development Authority (NYSERDA Report 15-17) by M.J. Bradley and Associates LLC. Albany, NY: NYSERDA. June, 2015. http://www.mjbradley.com/sites/default/files/NYSERDA-EV-Pricing.pdf

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. 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 rebate and utility control 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.

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. These charging stations might be linked to a central meter for the entire facility, or to some significant portion of the facility. 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.

3.3.3 V2G: Distribution Level and V2B

The Preliminary Research Report (Appendix A) shows that bidirectional power flows from parked EVs have been extensively analyzed in the literature, and via several small-scale V2G demonstrations. Given that vehicles are parked over 90 percent of the time and that EV charging profiles suggest that the time a vehicle is connected to a charging station regularly exceeds the time necessary to deliver a full charge,[12] there are opportunities for EVs to be distributed energy storage systems.

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12 Letendre, S., K. Gowri, M. Kintner-Meyer, and R. Pratt. 2013. *Intelligent vehicle charging benefits assessment using EV Project data*. Report published by the Pacific Northwest National Laboratory, PNNL-23031.

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.[13] 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 DG 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, ConEd contracted with an economic consulting firm to assess the marginal costs of electric distribution service;[14] 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. This type of analysis is consistent with supporting other REV initiatives within New York State.

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.[15] 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.

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[13] Ipakchi, Ali and Farrokh Albuyeh. 2009. "Grid of the Future: Are We Ready to Transition to a Smart Grid?" *IEEE Power & Energy Magazine*, March/April.

[14] *Marginal Cost of Electric Distribution Service Final Report*. 2012. Report prepared for Consolidated Edison Company of New York, Inc. by NERA Economic Consulting.

[15] Akhil, Abbas A. et al, DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA

3.4 Step 3: Capture Resource Opportunities

3.4.1 Wholesale Level: 1-Way Power Flows for Demand Response Programs

Table 2 lists the five DR programs offered by NYISO. Two of the programs (DADRP and DSASP) are market-based and allow end-use loads to participate in NYISO's Energy and Ancillary Services wholesale markets. The three remaining DR programs address reliability, with participating resources being paid directly by NYISO. The costs of these programs are allocated to all load-serving entities within New York State.

Table 2. NYISO Demand Response Programs

	DADRP (Day-Ahead Demand Response Program)[c]	**DSASP** (Demand-Side Ancillary Services Program)	**EDRP**[d] (Emergency Demand Response Program)	**TDRP**[d] (Targeted Demand Response Program)	**ICAP SCR**[e] (Installed Capacity Special Case Resource Program)
Description[a]	Allows energy users to bid their load reductions into the day-ahead energy market, as generators do.	Provides retail customers an opportunity to bid their load curtailment capability into the day-ahead and / or real-time market to provide operating reserves and regulation service.	Industrial and commercial companies are paid for reducing energy consumption when asked to do so; the program is voluntary with no penalties for not responding to requests.	Similar to EDRP, this program deploys DR resources specifically within NYISO load zone J (NYC).	Participants are required to reduce power use and, as part of their agreement, are paid in advance for agreeing to cut power use upon request.
Aggregation size requirement	2 MW	1 MW	100 kW of load per zone and aggregation of at least 0.5 MW	Same as EDRP	100 kW

[a] Source: http://www.nyiso.com/public/markets_operations/market_data/demand_response/index.jsp

[b] *Limited storage* refers to the inability to sustain continuous operation at maximum energy withdrawal or maximum energy injection for a minimum period of one hour.

[c] Source: *NYISO DADRP Manual.*

[d] Source: *NYISO EDRP Manual.*

[e] Source: *NYSIO ICAP Manual.*

The Preliminary Research Report (Appendix A) notes that 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.

3.4.2 Wholesale Level: 2-Way Power Flows for 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 megawatt (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.

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.

3.5 Ongoing Research, Data Collection, and Valuation

The electric power industry is undergoing significant change, driven by technology and the imperative to develop a low-carbon energy economy. New York State is proactively preparing for these changes through the REV proceeding. Many of those issues directly bear on the evolution of a grid-interactive vehicle infrastructure. The REV proceeding have explicitly recognized the need for more data on the distribution system impacts of DG and the development of new business models for utilities, energy services companies, and customers to be compensated for activities that contribute to grid efficiency. The PSC has made progress on some of these issues, including producing white papers on a benefit-cost analysis framework for utility REV initiatives and ratemaking and utility business models directly related to the REV proceedings.[17,18]

16 Patton, David B, P. LeeVanSchaick, and J. Chen. *2014 State of the markets report for the New York ISO markets.* Report prepared for the New York ISO by Potomac Economics, Market Monitoring Unit. May 2015.

17 *Staff White Paper on Benefit-Cost Analysis in the Reforming Energy Vision Proceeding, 14-M-0101*. Prepared by the New York State Department of Public Service. July 1, 2015.

18 *Staff White Paper on Ratemaking and Utility Business Models, Case 14-M-0101*. Prepared by the New York State Department of Public Service. July 28, 2015.

Data on consumer EV driving and charging behaviors are necessary to better evaluate the ways in which EVs can most effectively take advantage of distribution and wholesale market opportunities. As discussed in the Gap Analysis (Appendix B), ConEd and NYSERDA have only been able to collect a relatively small amount of data on this topic. These efforts should be expanded and access to data should be given to EV stakeholders. New business models also need to be developed that allow EVs to be grid resources that compensate EV owners, thus reducing the net cost of EV ownership. This strategy would create a virtuous cycle to accelerate the adoption of EVs while capturing the economic and environmental benefits that transportation electrification can offer in New York State.

4 Track 3: Policy and Regulation

4.1 Current State

EV adoption in New York and the United States has been slow. Although consumers have access to many plug-in EV models in dealer showrooms, retail sales of EVs are not strong. EVs make up less than 1 percent of new-vehicle sales nationally. Meanwhile, 40 percent of the State's greenhouse gas emissions come from the transportation sector. With so few EVs on the road in the State, the increased electricity demand for EV charging is minimal; in aggregate, the current EV fleet represents a relatively insignificant grid resource.

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 see an increasing number of ZEVs is currently in effect, but will significantly ramp up beginning in 2018 to reach approximately 15 percent of new-vehicle sales by 2025, resulting in the sale of approximately 800,000 EVs in the State in that period.[19]

Within the regulatory realm, the PSC issued its Track 1 Order in the REV proceeding. PSC's Track 2 Order, which will review the State's regulatory, tariff, and market designs, as well as incentive structures to align utility interests with the PSC's policy objectives,[20] is expected as the next step in the proceeding. Meanwhile, the Clean Energy Fund (CEF) proposal cites "accelerated electrification of the transportation sector" as one of its Strategic Priorities and Target Areas to reaching advanced sustainable transportation goals.

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19 "ZEV Program," Center for Climate and Energy Solutions website, http://www.c2es.org/us-states-regions/policy-maps/zev-program.

20 "REV: Reforming the Energy Vision. Case 14-M-0101 *Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision*," New York State Public Service Commission, http://www3.dps.ny.gov/W/PSCWeb.nsf/a8333dcc1f8dfec0852579bf005600b1/26be8a93967e604785257cc40066b91a/$FILE/REV%20factsheet%208%2020%2014%20(2).pdf

Although not specific to the promotion of EVs, the State supports and participates in a number of initiatives to promote clean energy development that ultimately supports a transition to a cleaner transportation sector through electric vehicles. Initiatives such as the Regional Greenhouse Gas Initiative (RGGI); Cleaner, Greener Communities; New York Energy Highway; K-Solar; NY Prize; BuildSmart NY; NY-Sun, and NY Green Bank establish a policy commitment toward a cleaner, sustainable, reliable, and more resilient energy system for the State. As a result of these and earlier initiatives, carbon emission rates from electricity generation have fallen by over 40 percent in the state since 2000.[21]

Initiatives such as ChargeNY, Clean Fleets NY, and Clean Cities more specifically 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.

4.2 Step 1: Lay Groundwork

EV fleet development is implied in the Preliminary Research Report (Appendix A) and in the Gap Analysis (Appendix B). However, the development of a substantial fleet is imperative for the future of EVs as a grid resource in the State. For EVs to be a grid resource, their numbers will need to reach critical mass—the point at which their impact on the grid will become measurable. Even at fairly aggressive adoption rates, EVs are a long way from affecting the bulk power system. As discussed earlier, EV adoption rates in New York are currently low, but are expected to increase rapidly as part of the ZEV mandate beginning in 2018. Now is the time to lay the policy and regulatory foundations for grid-interactive vehicles. Any policies and regulations that are adopted now will result in either incentives or deterrents to EV adoption, EVSE infrastructure planning and deployment, and ultimately, grid-interactive vehicles.

4.2.1 Fleet Development

Because EV adoption is at such an early stage, and because EV technology is rapidly changing and improving, it is important to maintain a focus on customer confidence. Any program that uses EVs for energy storage or controls EV charging should ensure that customers' transportation needs are met first. If EVs are not perceived by customers as providing reliable transportation value, the EV market will

21 "Power Trends 2014, Evolution of the Grid," New York Independent System Operator, http://www.nyiso.com/public/webdocs/media_room/publications_presentations/Power_Trends/Power_Trends/ptrends_2014_final_jun2014_final.pdf.

deteriorate. It is also important that EVs are likely to be the single-largest new source of sales revenue for utilities. As policymakers think about supporting transportation fuel switching to EVs, electric distribution utilities should approach the transformation as investment and revenue opportunities. Existing programs like ChargeNY, Clean FleetsNY, and Clean Cities will continue to support the widespread adoption of EVs. Sound economic analysis of the benefits and costs of EV deployment in the State must help create incentives, programs, and utility investments that are cost-effective.

4.2.2 Communication and Metering

One element of planning for grid-interactive vehicles relates to metering and communication. Technologies exist for the communication, metering, and control of grid-interactive vehicles. Within the jurisdiction of State regulators is the definition of a revenue grade meter. The PSC's definition should be revisited and potentially expanded to include EVs and EVSE, as more information about the accuracy of on-board EV meters and EVSE metering or residential submeters is collected and assessed.

4.2.3 Land Use and Transportation Planning

Thoughtful planning and carefully crafted policies are a necessary step for developing a grid-interactive vehicle network. One 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 level, 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.[22]

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[22] Motavalli, Jim, "New York Requires Garages and Lots to be Built EV-Ready," *PluginCars*, December 10, 2013, http://www.plugincars.com/new-york-requires-lots-and-garages-be-built-ev-ready-129063.html

Municipalities should incorporate EVSE siting into urban planning and zoning regulations. Assessments made by municipalities and planners should consider 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.

The primary role of EVs is expected to be transportation. Thus, it is important to involve transportation agencies in long-range planning. Grid-interactive 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 on the New York State Thruway. Continuing this trend by adding more DC fast charging stations on the Thruway and other limited access highways as well as interstate highways will facilitate the use of EVs for long-distance travel throughout the State. Eventually, these DC fast 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 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 goals, like that set by Executive Order No.24,[23] to reduce greenhouse gas emissions in New York State by 80 percent below the levels emitted in 1990 by the year 2050.

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 value chain and to provide a comprehensive picture of the value of EVs to the State and its passengers, electricity ratepayers, and citizens.

[23] "Climate Action Planning," New York State Department of Environmental Conservation, http://www.dec.ny.gov/energy/80930.html

4.3 Step 2: Mitigate Impacts

It is appealing to consider a long-term vision of millions of EVs plugged in and at the ready, charging or discharging to maintain an optimally functioning electric grid—while EV owners are happily counting their compensation. However, in the near term, this vision might not be best role for EV integration with the grid. One potential problem with this vision is that the most cost-effective way of incorporating EVs with the grid will be to ensure that they *never* show up as additional peak load. EVs will require more electricity, but the timing of when that electricity is delivered is key. If additional load of EV charging can be structured in such a way as to avoid contributing to peak demand, additional costs can be avoided. Therefore, planning now for large-scale EV adoption is imperative. Stakeholder feedback collected as part of this study suggests that it might be more cost-effective to manage EV load than to have EVs participate in wholesale markets.

4.3.1 Dynamic Pricing Rates

As discussed earlier in this Roadmap, the easiest way to avoid this 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. As addressed in the Section 3 of this Roadmap, administrative barriers and cost of implementation could preclude utilities from offering EV-specific TOU rates. At least in the near term, until these hurdles can be addressed, 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 EV in this capacity. If incentives are too low, EVs are more likely to add to peak load.

Additional behavioral programs should also be explored as options for mitigating peak load. A paper by the Edison Foundation and the Institute for Electric Efficiency found that EV owners were disproportionately engaged electric customers: [24]

> Interestingly, our analysis also revealed that the strategy with the potential to return the greatest financial benefit to utilities and customers alike is to focus on accelerating the adoption of EVs. Households that have EVs, which represented only about 1.25 to 1.5 percent (12,500 to 15,000) of the hypothetical 1 million customers in a service territory, created a disproportionately high share of the overall consumer-driven savings, indicating that even modest increases in EV adoption will have a large impact on benefits.

However, as EVs become more widespread and EV owners are no longer early adopters, this level of engagement could change and financial incentives for off-peak charging might become more important.

4.3.2 Distribution Level Planning

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 EVSE as a step toward mitigation impacts of EVs on the grid.

4.4 Step 3: Capture Resource Opportunities

Again, planning will be important in determining the best application of EVs as a resource into the wholesale electricity market. The first step is conducting a cost-benefit analysis to determine whether EVs could provide services and value in wholesale markets, either as DR or V2G market resources. If either is determined to be the case, several regulations 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 demand response and frequency regulation). Stacking value of energy storage in the form of EV batteries is important to promote higher penetration of these resources.

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[24] Faruqui, A. et al. *The Costs and Benefits of Smart Meters for Residential Customers*. Report prepared for The Edison Foundation Institute for Electric Efficiency. 2011. http://www.edisonfoundation.net/iei/Documents/IEE_BenefitsofSmartMeters_Final.pdf

4.4.1 Distribution of Benefits

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.

Identifying and assessing the value of locational and mobility value of EV resources could also be considered. Mobile storage functionality has the potential to offset the need for new substation capacity in particular locations, if EVs are able to serve as a grid resource during critical times. This could save a utility, and ultimately ratepayers, money. Transparency of where EVs are charging on the grid, as well as mechanisms for notifying distribution utilities of new EVs and EVSE on the distribution network, will help in planning and targeting planned concentrations of EV charging.

4.4.2 EV Integration as Part of the State's REV Proceeding

The current REV proceeding in New York State lists six objectives, each of which EVs could contribute to: [25]

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

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[25] *Case 14-M-0101, Order Adopting Regulatory Policy Framework and Implementation Plan*, State of New York Public Service Commission, 2015. http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b0B599D87-445B-4197-9815-24C27623A6A0%7d

Now is the time to incorporate EV systems and technologies into REV discussions. As referenced in the REV Track 1 Order, the U.S. DOE cited risks associated with poorly managed EV deployment: [26]

> Achievement of carbon reduction goals will likely require electrifying transportation, including a substantial shift to electric vehicles. A large penetration of electric vehicles has potential to strain distribution infrastructure, as recharging may occur during evening hours which are already a summer peak time on many residential distribution circuits.

Alternately, 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.

4.5 Overarching Research, Data Collection, and Valuation

This entire process is iterative. Policies and regulations will need to be developed, enacted, evaluated, and adjusted in response to technological advancements, adoption of standards outside the State's jurisdiction, and other variables. The overarching sequence of grid-interactive vehicles seems to follow a general process of planning, mitigating peak, and finally providing resources to the grid. However, this path could be modified via variables such as additional information, technology, and markets.

In addition, understanding and accounting for the iterative nature of these dynamics is an important element of appropriate compensation. Ultimately, these questions must be addressed to determine how to most fairly and appropriately compensate each participant, including EV owners, EVSE owners, distribution utilities, and the grid operator. Ongoing research, data collection, and valuation will provide continuous feedback and will inform the future of electric vehicles and their integration with New York's electric grid.

[26] Case 14-M-0101, Order Adopting Regulatory Policy Framework and Implementation Plan, page 24.

5 Conclusion

The path forward to widespread vehicle-to-grid 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 vehicle-grid integration. Each of these tracks will also follow the same sequence of steps for laying the groundwork, for mitigating negative impacts of EVs on the grid—and finally, for capturing the value that EVs could provide to the State's grid.

The path forward 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 or whether the path is clear.

New York State has a history of innovation in the energy sector. By merging the grid-interactive vehicle concept into the State's REV proceeding, New York State will bring its history of energy innovation into transportation, one of the most challenging sectors.

Appendix A. New York State Grid-Interactive Vehicle Study: Preliminary Research Report

New York State Grid-Interactive Vehicle Study: Preliminary Research Report

Final Report

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Notice

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Acronyms and Abbreviations List

AC	alternating current
AMI	Advanced metering infrastructure
ANSI	American National Standards Institute
API	application programming interface
BCEMD	Branch Circuit Energy Management Devices
C&I	commercial and industrial
ConEd	Consolidated Edison, Inc.
DADRP	Day-Ahead Demand Response Program
DC	direct current
DER	distributed energy resource
DOD	United States Department of Defense
DPS	New York State Department of Public Service
DR	demand response
DSASP	Demand-Side Ancillary Services Program
DSM	demand-side management
EDRP	Emergency Demand Response Program
EEPS	Energy Efficiency Portfolio Standard
EPA	United States Environmental Protection Agency
EPRI	Electric Power Research Institute
ESCO	energy services company
EV	electric vehicle
EVSE	electric vehicle supply equipment
EVSP	Electric Vehicle Standards Panel
FERC	Federal Energy Regulatory Commission
ICAP	installed capacity
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers (IEEE)
ISO	International Organization for Standardization
kW	kilowatt
LESR	Limited Energy Storage Resource
LSEs	load-serving entities
MTA	Metropolitan Transit Authority
MW	megawatt
NYISO	New York Independent System Operator
NYPA	New York Power Authority
NYSDOT	New York State Department of Transportation
NYSERDA	New York State Energy Research and Development Authority

PHEV	plug-in hybrid electric vehicle
PSC	New York State Public Service Commission
REV	Reforming the Energy Vision
RPS	Renewable Portfolio Standard
RTO	regional transmission organization
SAE	Society of Automotive Engineers
SBC	system benefits charge
SCR	Special-case resources
TCC	Transmission Congestion Contract
TCI	Transportation and Climate Initiative
TDRP	Targeted Demand Response Program
TOU	time of use
V	volt
V2B	vehicle-to-building
V2G	vehicle-to-grid
VTOU	voluntary time of use
ZEV	zero emission vehicle

Summary

Recent New York State policies and programs have committed the State to supporting the expansion of clean energy and transportation options. Electric vehicles (EVs) represent one of these clean transportation options. Initiatives such as ChargeNY, which is designed to accelerate the adoption of EVs and to build EV infrastructure, and the Metropolitan Transit Authority's (MTA), which acquired hybrid-electric transit buses, demonstrate the State's investment in the future of cleaner transportation. New York's adoption of policy initiatives like zero emission vehicle (ZEV) mandates demonstrates the State's commitment to air quality and health benefits associated with EVs. In the context of the electric grid, the New York State Public Service Commission (PSC) proceeding called Reforming the Energy Vision (REV) proposes a more stable, resilient, clean, and distributed grid infrastructure.

EVs are important to clean transportation, but a shift from fossil fuels to the electric grid as the primary supplier of energy for transportation will likely pose new challenges for utility providers with regard to peak power management. 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 net economic and environmental benefits to the State.

This research assumes that EV adoption and infrastructure development will increase statewide, and explores the opportunities made possible by a grid-interactive vehicle infrastructure. Grid-interactive EVs, that can act as flexible, distributed energy resources (DERs), can contribute to a more reliable, resilient, and sustainable grid in which generation and demand are ultimately decoupled. By providing storage capacity and a flexible load, grid-interactive EVs could allow greater integration of renewable resources and enable more efficient use of generation, transmission, and distribution assets.

Demand-side management (DSM) uses price signals to encourage EV charging when demand on the grid is low, and smart-charging programs that directly control EV charging; DSM mitigates power system impacts that the additional load from EVs introduce. All of the State's major electric utilities offer voluntary time-of-use (TOU) rates to encourage energy use when demand is low. Adapting these programs for EV charging is a logical next step. Smart-charging advances the load-leveling potential of EV charging, and could even support greater integration of intermittent renewable energy resources. Further development and oversight of rate structures and dynamic pricing approaches for EV charging represent the first steps in the development of grid-interactive vehicles and EVs as DERs.

Another potential behind-the-meter benefit of EVs as DERs is through vehicle-to-building (V2B) applications. V2B systems can include renewable storage for buildings with solar or wind generation and energy arbitrage (buying power when it is abundant and storing it for use when power is in limited supply). EVs also have the potential to store electricity for emergency use during a power outage, for residences and also at emergency shelters.

A more distant opportunity may be for grid-interactive vehicles to qualify as grid resources in wholesale electricity markets. The New York Independent System Operator (NYISO) has developed several demand response (DR) programs that (1) allow demand resources to participate in wholesale markets and (2) offer incentives for curtailing load when reserve capacity drops below what is required for reliable operations. NYISO has also established market structure and rules enabling the participation of Limited Energy Storage Resources (LESRs) in their wholesale markets. Both DR programs and LESR participation enable load reduction and behind-the-meter energy storage systems to compete as an alternative to generating resources in the wholesale markets.

Prior research and ongoing deployment and demonstrations suggest that grid-interactive vehicles are well suited for participation in the Ancillary Service Markets, particularly as frequency regulation resources. In the context of the NYISO wholesale markets, grid-interactive vehicles could potentially participate in these markets via the Demand-Side Ancillary Services Program (DSASP) or as LESRs. EVs are able to provide near-instantaneous balancing of load and generation—either as a DR resource, by curtailing or modulating charging, or as an LESR through bi-directional power flows. Regulation is typically the highest value ancillary service, potentially generating the highest revenue potential for grid-interactive vehicles. However, grid-interactive vehicles can also be resources in other wholesales markets, as spinning reserves (within the Operating Reserves Market), energy imbalance (to help smooth out power flow variability caused by renewables), and voltage control (a service that EVs currently provide in Texas, France, and Denmark).

Participation in any of these wholesale markets, however, 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. Not only is aggregation a critical factor in grid-interactive vehicle participation in New York's wholesale markets, but communication and metering technologies are also integral requirements for market participation. Communication requirements ensure that the grid resource receives market signals. Metering is necessary for resource verification and compensation to the resource provider (EV owner or operator). No one yet knows if existing third-party aggregators (for example, of DR resources) will be the best option for providing aggregation, communication, and metering services, or if another entity (for example, utilities) will be better suited. NYISO establishes the communication and control standards required for resource participation in its markets. It also sets the minimum resource size. Thus, NYISO will play an important role in the evolution of the State's grid-interactive vehicle infrastructure. No current business models have been developed that can address these factors, and establish how EV owners or operators will be fairly compensated for their grid contributions at a profit.

EVs will require regulation by both transportation agencies and electricity sector actors. These might be the Office of the Governor; the New York State Legislature; and the New York State Public Service Commission (PSC), supported by the New York State Department of Public Service (DPS). One of the PSC's critical roles in promoting a grid-interactive vehicle infrastructure is the oversight of rate structures that encourage dynamic pricing for EV charging and other cost-effective incentive programs to encourage the use of EVs as DERs. Statewide policy initiatives such as REV will likely lead to regulatory changes encouraging grid-interactive vehicles.

The New York State Energy Research and Development Authority (NYSERDA), NYISO, and the State's distribution utilities will be important stakeholders in the development of grid-interactive vehicles. As the efficiency and renewable programs administrator, NYSERDA will be integral to the full realization of grid-interactive vehicles. Through incentives, programs, and research, NYSERDA is critical to market transformation. NYSERDA works closely with the PSC and carries out both legislative initiatives and PSC orders.

Although several barriers exist in EV integration with the grid in New York State, there are also many opportunities for this transportation resource to serve as load-shaping mechanisms and DR resources, and ultimately as grid storage in the wholesale markets. Energy policies and programs under development can facilitate the adoption of grid-interactive vehicles. EVs are currently being used in all of the recommended capacities, albeit on an experimental basis in many cases, in other jurisdictions providing models for New York to adapt to its own energy and transportation goals.

1 Background

New York State will continue to experience net greenhouse gas reductions as owners of plug-in electric vehicles (EVs) shift from gasoline to electricity. Governor Andrew M. Cuomo created ChargeNY, an initiative to accelerate the adoption of EVs and to build EV infrastructure. ChargeNY will further EV research, make EVs more affordable, promote cleaner transportation, and make infrastructure development more efficient.[1] Furthermore, greenhouse gas emissions from power production in the State will decline as power suppliers seek to (1) meet the State's renewable portfolio standards, and (2) comply with the Regional Greenhouse Gas Initiative cap on greenhouse gas emissions and new United States Environmental Protection Agency (EPA) emission regulations.[2] The emergence and adoption of EVs create a link between the transportation energy sector and the electric power industry, but simply displacing tailpipe emissions with stack emissions from fossil fuel generation stations is insufficient. An integrated approach to managing carbon emissions from the electric power and transportation sectors can serve to accelerate emissions reduction overall; the emergence of EVs in New York State creates an exciting opportunity for such an integrated approach.

Another benefit of EVs is that they can potentially contribute to electrical system reliability as distributed energy resources (DERs) and grid resources. Widespread integration of EVs with the electric grid would 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 services to the grid.

Vehicle-to-grid (V2G) and vehicle-to-building (V2B) demonstrations are not new, but they have occurred on only a small scale and in only a few locations. The technology is available today and there appear to be significant potential power system benefits.[3] However, considerable research and coordination are needed to identify potential opportunities for grid-interactive vehicles in New York. Standards and regulations need to be developed specifically to integrate EVs as new loads and energy storage devices into existing

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1 New York State Governor's Office, "Governor Cuomo Announces Charge NY Program to Accelerate use and Benefits of Electric Vehicles in New York," *News item*, September 6, 2013, http://www.governor.ny.gov/news/governor-cuomo-announces-charge-ny-program-accelerate-use-and-benefits-electric-vehicles-new

2 "Clean Power Plan Proposed Rule," United States Environmental Protection Agency, http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule

3 NYSERDA. 2011. *Transportation Electrification in New York State Technical Update*. (NYSERDA Report 11-07) Prepared by Maitra, A. at the Electric Power Research Institute (EPRI).

power system management and market structures. These issues facing grid-interactive vehicles are similar to the challenges facing other DERs, from behind-the-meter stationary storage to fuel cells. Nevertheless, the automobile industry and utilities have not yet resolved their concerns about battery degradation associated with increased cycling of vehicle battery systems to provide grid services. However, grid-interactive vehicles could provide value, and ease the transition to greater use of electricity for the transportation sector without the need for bidirectional power flows and the associated increased cycling of vehicle batteries. Over time as battery technologies improve and costs are reduced, there may be a compelling economic argument for using EVs as grid resources; however advance planning must occur to fully capture this opportunity when and if it arises.

New York State will benefit from (1) an understanding of existing barriers to EV integration from both the electric grid and automobile industry perspectives; (2) an understanding of opportunities for integrating and controlling EVs with the electric grid; (3) an understanding of how grid interoperability with EVs can be achieved; and (4) a roadmap explaining decisions necessary for the build-out and management of EV grid-interactive infrastructure.

This report is part of the *New York State Grid-Interactive Vehicle Study,* which was funded by NYSERDA. The report provides research and stakeholder engagement to inform investment, policy, and regulatory decisions regarding whether and how to integrate EVs into New York's electric grid. Specifically, the study involved:

- Engaging key stakeholders and soliciting their input on primary topics.
- 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 market acceptance of grid-interactive vehicles.
- Creating a roadmap for decision-making about the introduction of grid-interactive vehicles in the State.

This report represents one task of the overall project, and provides several functions in understanding grid-interactive EVs. It details findings on current and pending technologies for grid-interactive vehicles, roles for industry participants in deploying grid-interactive vehicles, State electric markets and how grid-interactive vehicles might be able to participate in them, and an assessment of the State's regulatory landscape for grid-interactive vehicles. The report also identifies cross-agency coordination necessary for realizing the full benefits to New York from the transition to an electrified transport sector.

2 Grid-Interactive Vehicles and Vehicles for Distributed Storage

2.1 Introduction

A shift from fossil fuels to the electric grid as the primary energy for transportation can pose new challenges for utility providers' management of peak power demand. But this shift also presents new opportunities that, if properly managed, could result in net economic and environmental benefits to the State.[4]

Although EVs represent the single largest potential new demand for electricity in several decades, there are unique opportunities to mitigate the system-wide impacts of vehicle charging. EVs are well suited for Demand-Side Management (DSM) because vehicles are typically in use for mobility less than 5 percent of the time[5,6] and EVs, on average, are actively charging only 20 percent of the time they are plugged into charging equipment.[7] Thus EVs represent a flexible load that lends itself to shifting the timing of vehicle charging, and they can serve as storage resources. EVs have also been shown to be capable of integration with the electric grid, with bidirectional flow of power (both charging and discharging of the vehicle battery) occurring in response to signals from regional grid operators.[8] This integration enables EVs to potentially provide valuable services to the grid, enhancing reliability and resilience while creating a new value stream for EV owners.

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4 NYSERDA. 2011. *Transportation Electrification in New York State Technical Update*. (NYSERDA Report 11-07) Prepared by Maitra, A. at the Electric Power Research Institute (EPRI).

5 Galus, Matthias D., Marina González Vayá, Thilo Krause, and Göran Andersson. "The Role of Electric Vehicles in Smart Grids." *Wiley Interdisciplinary Reviews: Energy and Environment* 2, no. 4 (2013): 384–400. doi:10.1002/wene.56.

6 Kempton, Willett, and Jasna Tomić. "Vehicle-to-Grid Power Fundamentals: Calculating Capacity and Net Revenue." *Journal of Power Sources* 144, no. 1 (June 1, 2005): 268–279. doi:10.1016/j.jpowsour.2004.12.025.

7 Langton, Adam, and Noel Crisostomo. *Vehicle-Grid Integration: A Vision for Zero-Emission Transportation Interconnected throughout California's Electricity System*. Report prepared by California Public Utilities Commission, Energy Division, 2013. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M081/K975/81975482.pdf

8 Kempton, Willett, Victor Udo, Ken Huber, Kevin Komara, Steve Letendre, Scott Baker, Doug Brunner, and Nat Pearre. 2008. "A Test of Vehicle-to-Grid (V2G) for Energy Storage and Frequency Regulation in the PJM System."

In this report, *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 will guide this report as well as the full project.

2.1.1 Demand-Side Management

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 or during other periods of excess capacity. DSM, defined as the “utility sponsored programs designed to encourage consumers to modify their level and pattern of energy usage,”[9] 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. Electric utilities have several decades of experience with direct load control programs as a part of a portfolio approach to meeting reliability goals and objectives. 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 of and optimal use of intermittent renewable energy resources. EV batteries can also minimize and reduce building demand charges by reducing peak power use, and potentially responding to DR events. Additionally, V2B systems establish the potential for EV batteries to serve as back-up power for homes and shelters in emergency situations. The viability of these ancillary uses of the storage systems on EVs is dependent on a variety of factors including vehicle manufacturers’ warranty policies, market acceptance, and the net economic benefits to vehicle owners.

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9 “Clean and Secure Energy Actions Report, 2010 Update: Energy Efficiency, Utility Demand-Side Management,” National Governors Association, http://www.nga.org/files/live/sites/NGA/files/pdf/1008CLEANENERGYEFFICIENCYUTILITYDEMAND.PDF

2.1.2 Grid Services

In addition to representing new demand for electricity and contributing to the 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, as the grid relies on stored chemical (e.g., natural gas) and potential (e.g., hydro) forms of energy, most of the power produced must be used at the exact moment it is produced. In regions with competitive wholesale markets, the grid operator is responsible for managing and maintaining perfect balance between generation and demand. NYISO maintains 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 DR programs that allow demand 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 wholesale markets and participating 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 a few pilot projects are beginning to show proof of concept, this is still an emerging idea that requires significant technology, regulation, and business model development.

The structure of these energy markets and the potential of EVs to be resources in them is the focus of Section 2.

2.2 The Technology

The concept of grid-interactive vehicles represents the system of plug-in EVs, charging equipment, and control and communications systems that can control the flow of energy to the vehicle and potentially provide energy from the vehicle battery storage system back to the electric grid or for other applications. Several approaches to grid interactivity are in varying stages of development. Generally, these systems create combinations of on-board vehicle charging and telematics, vehicle power supply connections, and control standards and technologies. Together they provide financial return, operational efficiencies, or other benefits to related entities, including the vehicle owner. The applications of grid-interactive vehicles rely on controllable vehicle power supply connections to external circuits. EV charging systems typically are the foundation for these links, as described in Section 2.2.1.

2.2.1 Electric Vehicle Charging Systems

EV charging systems allow the transfer of energy from the electric grid, through electric vehicle supply equipment (EVSE), and into the vehicle battery storage.[10] Figure A-1 depicts alternating current (AC) EVSE, essentially a safety and control device that establishes a communication link with the vehicle to deliver power through the charging cord and connector, when charging is needed. It also monitors the flow of electricity for safe operation. The power delivered to the vehicle inlet port is then routed through on-board battery charging systems to rectify the AC power into direct current (DC) for storage in the battery. Fast-charging DC EVSE operates similarly, but inverts AC to DC power off-board the vehicle, and delivers high-voltage direct current, typically around 400 volts (V), straight to an EV's battery system.

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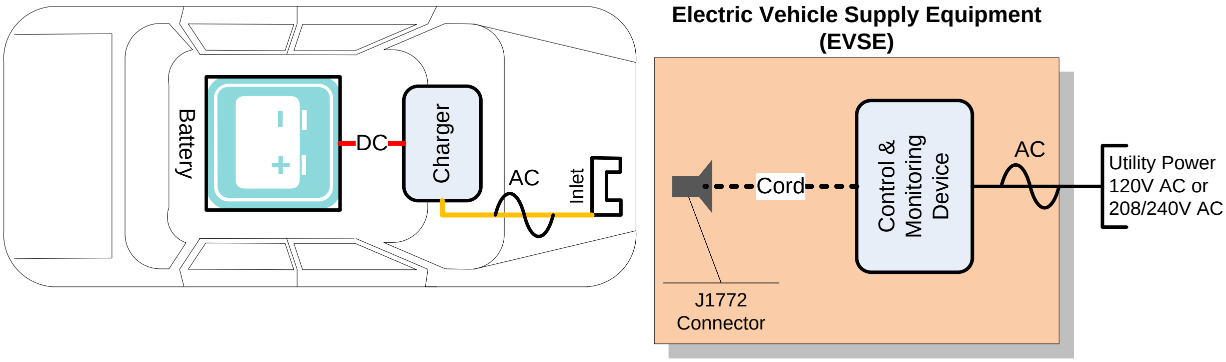
10 "SAE J1772 Standard," SAE International, http://standards.sae.org/j1772_201210/

Figure 1. Alternating Current Electric Vehicle Supply Equipment and How It Works



There are three distinct levels of EV charging in widespread use—Level 1 (120V), Level 2 (208 / 240 V), and DC fast charging (208-480 V). Table A-1 lists their specifications, and the subsequent sections provide further description. Using common standards for charging has greatly aided the adoption of EVs and the development of charging infrastructure. Figures A-2 through A-4 provide charging method examples.

Table 1. EV Charging Level Power Requirements

Charge Method	Nominal Supply Voltage	Branch Circuit Breaker Rating (Amps)	Charging Power
AC Level 1	120 vac, 1-phase	15 (minimum)	~ 1.5 kW
AC Level 2	208 to 240 vac, 1- or 3- phase	40-80	3.3 –7.7 kW for most EVs; Tesla up to 20 kW
DC fast charging	208 to 480 vac, 3-phase	Up to 200	25-50 kW; Tesla up to 100 kW

Level 1 Charging (120 V)

- EVSE unit comes standard with vehicle.
- Vehicle coupler: Standard SAE J1772 connector, which is compatible with all EVs, except Tesla (has its own adapter).
- Power supply connection: Standard 120 V outlet.
- Charge time is 7+ hours, depending on the vehicle.

Figure 2. Examples of Level 1 Charging

Level 2 Charging (208 / 240 V)

- EVSE unit usually purchased separately from vehicle. Many vendors offer equipment (ChargePoint, Clipper Creek, Eaton, GE, Leviton, Aerovironment, Bosch, and others).
- Vehicle coupler: Standard SAE J1772 connector, which is compatible with all EVs, except Tesla (has its own adapter).
- Power supply connection: Often hardwired, but several EVSE vendors offer plug-connected units for different NEMA standard receptacle types.
- Charge time is 4 - 8 hours, depending on the vehicle.

Figure 3. Example of Level 2 Charging

DC Fast Charging

- Intended for high-use locations. Limited to certain EVs equipped with this capability. More expensive equipment and high power connection required.
- Converts AC power to DC outside the vehicle for direct DC connection to charge the EV battery.
- Vehicle coupler: SAE Combo, CHAdeMO or Tesla Supercharger connectors, depending on vehicle model and options.
- Power supply connection: Hardwired 3-phase power typically required, depending on equipment.
- Charge time is 80 percent charge in about 30 minutes.

Figure 4. Example of DC Fast Charging

2.2.2 Demand-Side Management Enabling Technologies

DSM opportunities—indirect control of charging (for example, TOU rates), direct control of charging (for example, DR), or using EV batteries as distributed storage (for example, V2B)—require different levels of technology.

2.2.2.1 Indirect Charging Control

Mass market EVs are equipped with scheduling systems to control charging activity, or have the ability to remotely control the start or end of charging. Ford has an automated, mobile application with TOU rate tracking for local distribution utilities to indicate when off-peak times start and to help EV owners charge at the lowest possible cost.

Customer metering systems are a key enabler for EV TOU rates. Advanced metering infrastructure (AMI), often referred to as *smart grid technology*, provides a two-way flow of information among users, distributors, and electricity producers. AMI can be used for TOU rates for all loads on a meter, referred to as *whole-house TOU* for residential customers. Some AMI systems can establish network connections to EVSE to allow for submetering of EV charging times. This practice enables the application of appropriate rates for an EV-specific TOU rate, without the additional expense of a separately metered service. New York faces challenges in implementing these measures because the State trails in smart meter adoption according to a 2014 report prepared by the Edison Foundation.[11] The need to advance the AMI within New York State has been acknowledged by stakeholders involved in the REV proceedings.

2.2.2.2 Direct Charging Control

DSM programs, in which a utility has direct control of EV charging, are most commonly referred to as *DR* and require more advanced systems. At the most basic level, DR allows the controlling entity to turn charging on or off, either through the supply equipment or by using vehicle telematics systems. More advanced DR varies the power delivered to increase or reduce load as conditions warrant.

There is the potential for DR to be managed through utility AMI. However, more advanced communication will likely be needed as EV owners will require some level of confidence that their vehicles will be charged when they need them, or that they can override a DR event. This latter case would be less critical for plug-in hybrid electric vehicles (PHEVs) which can run on gasoline when needed.

General Motors' OnStar system involves smart grid application programming interfaces (APIs) capable of managing DR programs by connecting with the utilities' AMI technology. This technology can also communicate vehicle charging data to utilities, making it useful for metering TOU rate programs. Pilot demonstrations have proven capabilities to start, stop, and modulate the amount of charge going to a fleet

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[11] Edison Foundation Institute for Electric Innovation. *Utility-Scale Smart Meter Deployments: Building Block of the Evolving Pow*er Grid. 2014. http://www.edisonfoundation.net/iei/Documents/IEI_SmartMeterUpdate_0914.pdf

of Chevrolet Volts. Cadillac recently released the ELR with the OnStar smart grid capability built in. Customized smart-charging software packages have also been developed and are currently being used in United States Department of Defense (DOD) pilot projects.[12]

EPRI is leading the Utility-Automotive OEM Smart Charging Collaborative, in collaboration with nine automakers[13] and a growing number of utilities.[14] The goal of this collaborative is to develop an open platform that integrates EVs with smart-grid technology and facilitates *demand charging*, or as referred to here, *controlled charging.* EPRI anticipates that this open platform will eventually allow EVs to participate in both DSM programs and wholesale markets. Standardization and coordination among automakers, utilities, and regional transmission organizations (RTOs) in developing the software is likely to increase flexibility and ease for EV drivers to participate in smart-charging efforts. The first demonstration of the software platform occurred in October 2014, at the Sacramento Municipal Utility District. It involved eight vehicles and demonstrated DR and load curtailment capabilities.[15]

2.2.2.3 Distributed Storage

Expanding controlled charging to a system in which EVs act as DERs providing distributed storage or V2B requires additional capability in the vehicle, and integrated into the charging system. Because energy is stored in the battery, an inverter connected to the charging system is necessary to convert the DC power in the battery to AC electricity for the home or building. EVs now contain one or more inverters to convert AC to DC for storage in the battery, and then DC to AC to the drive motor. However, no EVs yet

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12 Morse, Stephanie and Karen Glitman. 2014. *Electric Vehicles as Grid Resources in ISO-NE and Vermont*. Report prepared for Efficiency Vermont. Burlington, VT: Vermont Energy Investment Corporation.

13 The primary auto manufacturers participating in this project are Honda, BMW, Chrysler, Ford, General Motors, Mercedes-Benz, Mitsubishi, and Toyota.

14 Utilities and regional transmission organizations participating in this project are Austin Energy, CenterPoint Energy, Commonwealth Edison, Con Edison, CPS Energy, DTE Energy, Duke Energy, Manitoba Hydro, Northeast Utilities, Pacific Gas & Electric Company, PJM, Sacramento Municipal Utility District, San Diego Gas & Electric, Southern Company, Southern California Edison, and the Tennessee Valley Authority.

15 Electric Power Research Institute, "EPRI, Utilities, Automakers to Demonstrate Technology Enabling Plug-in Electric Vehicles to Support Grid Reliability," *EPRI News item*, October 14, 2014, http://www.epri.com/Press-Releases/Pages/EPRI,-Utilities,-Automakers-to-Demonstrate-Technology-Enabling.aspx

have factory-installed bidirectional charging capabilities for Level 1 or Level 2 charging. EVs with DC fast-charging ports might be able to handle bidirectional power transfer if they are connected to capable equipment. That is, DC fast charging bypasses in-vehicle charging electronics.[16] Safety controls are also necessary to prevent unexpected flow of energy back onto the grid.

Although this technology is not widely available in the United States, Nissan is offering a Leaf-to-Home device in Japan. It connects to the CHAdeMO DC Fast Charge port on the vehicle and enables Leafs to discharge power to the home. This practice supports peak shaving, emergency power supply, and reductions in the cost of electricity. Nissan is also field-testing a V2B technology that will connect up to six Leafs to an office building, enabling their batteries to supplement the building's electricity consumption when it is most expensive. The system is designed so that the amount of power drawn from the vehicles ensures that the vehicles are fully charged by the end of the day for owners to drive home.[17]

2.2.3 Grid Services Enabling Technologies

As with DSM opportunities, EVs offering grid services require varying levels of technology. Because the charging and discharging of a battery can be adjusted quickly and accurately, EVs have the potential to serve as attractive resources in ancillary service markets by injecting or withdrawing small amounts of power to and from the grid. However, it should be noted that the first and highest value use of EVs is in providing clean transportation services; the use of EVs as grid resources must not interfere or compromise the mobility needs and expectations of vehicle owners.

2.2.3.1 Aggregation

Participation in NYISO wholesale markets requires different technologies, but one consistent feature is the need for aggregation. Wholesale energy markets require a minimum resource size. In NYISO's case, it is 1 MW. With the Chevrolet Volt's average charging power rating of 3.3 kilowatts (kW), it would take more than 300 vehicles to provide the minimum resource of 1 MW. The number of vehicles needed for aggregation varies by many factors, but the most important is the power level. The power level is determined by either the charger (on-board or off-board) or the EVSE connection, whichever is lowest.

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16 Nissan Motor Company, "CEC EPIC S9 Workshop – Smart Charging and V2X." June 2014. http://www.energy.ca.gov/research/epic/documents/2014-06-30_workshop/presentations/Nissan_North_America-Smart_Charging_and_V2X.pdf

17 Renault-Nissan Alliance Team, "Nissan LEAFs can now power the office, as well as the home," *Renault Nissan blog*, November 29, 2013, http://blog.alliance-renault-nissan.com/blog/nissan-leafs-can-now-power-office-well-home

Aggregation can be of EVs or EVSE. In the case of EVs, the vehicles will communicate with the aggregator; the location of charging does not matter. If EVSE is aggregated, the aggregator dispatches the equipment, and the specific vehicle connected is less relevant. This distinction is important because it largely determines where the intelligence (controls and communication technology) needs to be located.

In either case, technology is needed to combine the multiple resources (either EVs or EVSE) into what appears to be a single resource to the ISO. This technology will be the point of contact with the ISO, receiving the dispatch signals, and will be the point at which the ISO monitors the accuracy of the grid service performance. The aggregation technology will also be responsible for dispatching vehicles in response to the ISO's signals. Once the technology receives a signal from the ISO, the software will need to process the vehicles available, their state of charge, and the schedule of each vehicle (that is, the level of charge needed at what time), and will need to control the charging (or discharging) of each vehicle.

A demonstration under way at the University of Delaware uses software and control technology to present an aggregated resource from individual vehicles as a single resource to the grid operator, to deliver frequency regulation services. Additionally, the DOD demonstration projects have developed a software suite to aggregate and manage the charging and discharging of EVs, and to optimally schedule vehicles accounting for vehicle needs for transportation, energy cost, and ancillary service market prices simultaneously.[18]

2.2.3.2 Communication and Metering

When aggregating multiple EVs or EVSE into one resource, communication and metering technologies are also integral. NYISO establishes the communication and telemetry requirements for all resources participating in wholesale markets, enabling the communication of dispatch instructions and monitoring of performance. These requirements must be met and tied into aggregation technology to form a system that allows NYISO to send dispatch instructions. The aggregation software then dispatches vehicles or EVSE as appropriate. NYISO subsequently can monitor and measure the resource's performance. If individuals own the vehicles, there will be necessary features for the communication and metering systems: metering of performance, appropriate consumer protections, and consumer parameters (for example, charge completion time).

[18] Morse, Stephanie and Karen Glitman. 2014. *Electric Vehicles as Grid Resources in ISO-NE and Vermont*. Report prepared for Efficiency Vermont. Burlington, VT: Vermont Energy Investment Corporation.

2.2.3.3 Bidirectional Energy Flow

EVs are now equipped with charging systems that function in one direction: inverting AC power from the grid to DC power to be stored in the battery. Other capabilities are required to provide bidirectional grid services, including feeding AC power back onto the power grid. Retrofitted vehicles in pilot projects show this is possible on-board, whereas the Nissan devices in Japan show the potential for off-board feedback through DC fast charging equipment.

Even though the necessary technology for bidirectional energy flow currently exists, there are concerns associated with the impact of the additional battery cycling and the implications for the battery warranty. As of January 2015, the major automakers have expressed concern that V2G operation of the vehicle could affect long-term battery health.

2.3 Standards

The American National Standards Institute (ANSI) created an Electric Vehicle Standards Panel (EVSP)[19] to foster coordination and collaboration on standards development related to EV technology. The panel has identified more than 450 standards related to EVs, covering interactions with energy storage, charging systems, and communications. The standards listed below cover several important aspects of grid-interactive vehicle system operation. The Society of Automotive Engineers (SAE) developed many of these standards.[20] The International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), and the Institute of Electrical and Electronics Engineers (IEEE) also have participated in the creation of standards related to EVs and grid interactivity. Standards-making bodies have adopted the following standards, and are continuing to refine the communication protocols and equipment requirements to enable more capabilities through updated standards.

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19 "Electric Vehicles Standards Panel (EVSP)," ANSI Standards Activities, November 2014, http://www.ansi.org/standards_activities/standards_boards_panels/evsp/overview.aspx?menuid=3

20 McGlynn, Hank, "SAE V2G Standards Activities." Presented at First Annual California Multi-Agency Update on Vehicle-Grid Integration Research, November 19, 2014. http://www.energy.ca.gov/research/notices/2014-11-19_workshop/presentations/Hank_McGlynn_AEYCH-VGI-CEC_2014-11-19.pdf

ISO / IEC 15118: V2G Communication

- Creates a global standardization of communication interface for V2G activities.

SAE J1772: Electric Vehicle and Plug-in Hybrid Electric Vehicle Conductive Charge Coupler

- Establishes basic EVSE and charging requirements, including the plug connector standards for AC Level 1, AC Level 2 and SAE combo DC fast charging.

SAE J2836: Customer-to-EV Communications

- Establishes use cases for EVs that are communicating with an energy management system as a DER.

SAE J2847: Surface Vehicle Recommended Practice

- Applies to communication between EVs and the utility grid.

SAE J3072: Surface Vehicle Standard

- Establishes requirements for a utility-interactive inverter system that is integrated into an EV.

IEEE P2030.1.1: Standard Technical Specification of a DC Quick Charger for Use with Electric Vehicles (CHAdeMO DC Fast Charging)

- The IEEE Project Authorization Request states that other organizations are developing quick-charging applications, such as the SAE Combo interface, and that this standard is not intended to overlap those activities. Instead, it is to provide an additional solution in the marketplace. It notes that other standards or projects with a similar scope are IEC 62196-3, and IEC 61851-23 and -24.

Open Charge Point Protocol (OCPP)

- An open-standards communications protocol between EV charging equipment and centralized servers, to control pricing, charging activity, and monitoring.

Open Automated Demand Response (OpenADR)

- An open and interoperable information exchange model and standard for dynamic price and reliability signals for utilities, ISOs, and energy management and control systems.

Smart Energy Profile 2 (SEP2)

- A forthcoming standard for applications that enable home energy management via Internet protocol (IP).

2.4 Regulatory and Policy Considerations

Helping a grid-interactive vehicle system move forward, in which EVs are resources to the grid (based on sound economic and technology assessments), regulators, NYISO, utilities, and other stakeholders will need to make decisions about how these systems should be structured. This will clarify ownership of revenue and participation requirements. A clearly defined program in which customers understand what they are signing up for, and how they benefit from participating, will be necessary. To date, no grid services or DSM pilot project has explicitly addressed consumer protections to ensure that the owner of the asset (the vehicle) is adequately compensated for the grid use of the vehicle and that the consumer is adequately informed about program details. Research and pilot testing will also be critical in determining interest and level of participation. Many of the regulation and policy needs for EVs to provide grid services are similar to those needed for all distributed energy resources.

Participation in DSM programs at the utility level and serving as resources in wholesale markets are good first steps in understanding EVs' roles as grid resources. But ultimately, a comprehensive approach to grid-interactive vehicles could lead to much more substantial benefits. When EVs are fully integrated and acting as flexible storage resources, they can contribute to a more reliable, resilient, and sustainable grid in which generation and demand are ultimately decoupled. This option will allow greater integration of renewable resources and enable more efficient use of existing resources.

The regulatory landscape for grid-interactive vehicles in New York is presented in Section 3.

3 Electricity Markets in New York

3.1 Introduction to New York Electricity Market Structure

In 1997, the New York Public Service Commission (PSC) ordered that supply and delivery of electricity be unbundled, and required divestiture of generation by private transmission and distribution utilities.[21] As a result of this Competitive Opportunities Proceeding, New York now has retail energy markets. Although customers still rely on their utilities for delivery of electricity, they can shop among energy services companies (ESCOs) or other load serving entities (LSEs) to find the best value for their electricity supply.

The Federal Energy Regulatory Commission (FERC) conditionally authorized the establishment of NYISO in 1998. NYISO is responsible for the reliable operation of generators, transmission, and wholesale power markets in New York. Although it is required to comply with FERC regulations, NYISO can design and structure its wholesale markets to optimize efficient operations, while meeting regional reliability standards.

NYISO is responsible for the dispatch of more than 500 electric power generators to meet New York's load requirements, which experienced an all-time peak demand of 33,956 MW on July 19, 2013. Through its auction-based markets, NYISO stacks energy resource bids, by lowest cost first, to meet load requirements. Generators bid energy into the markets and LSEs such as utilities and ESCOs buy energy in these markets. Prices are established through either the competitive wholesale energy market process or directly between LSEs and suppliers via bilateral transactions. Market clearing prices (or locational marginal prices) are calculated for each of the 11 zones across New York.

NYISO operates day-ahead and real time wholesale markets for both energy and ancillary services. Approximately 98% of energy is scheduled in the day-ahead market, while the remaining 2% is accounted for in the real-time market. About half of the energy settled in the day-ahead market is scheduled through bilateral contracts.

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21 New York Independent System Operator website (click on 1997 to see unbundling story), http://www.nyiso.com/public/flash/timelinenyiso/NYISO/index.jsp

3.2 Retail Market Opportunities

Because consumers in New York can choose whom they purchase their electricity from, the customer bases of ESCOs and utilities vary. Therefore, ESCOs and utilities have a market incentive to create and develop programs to retain existing customers and attract new customers. EVs represent significant, potential new demand for electricity, and they also create new load that can be flexible. This strategy introduces an opportunity for New York to maximize the benefits of the new demand for electricity and establish programs to provide it most efficiently.

Again, DSM activities—particularly indirect-controlled charging through mechanisms such as TOU rates, direct-controlled charging or smart charging, and behind-the-meter services such as storage and V2B applications—make it possible for LSEs to optimally manage the new demand. This strategy offers potential benefits to both them and their customers.

It is widely recognized among New York EV stakeholders, that the system impacts of EV charging will be noticed first at the distribution level. A clustering of Level 2 chargers in a residential neighborhood on a particular distribution feeder could conceivably lead to reliability impacts as there may not be sufficient capacity to meet the new demand for EV charging. Thus, the retail opportunities for grid-interactive vehicles are based on the value that smart charging can provide in terms of addressing distribution constraints and avoiding costly upgrades.

3.2.1 Indirect-Controlled Charging

In indirect-controlled charging, price signals such as TOU rates passively manipulate EV owners' charging behavior, where rates are structured to encourage electricity use during certain hours.

TOU rates are a fairly blunt but effective approach to encouraging off-peak EV charging. Letendre et al. found that EV owners do respond to TOU incentives, but this practice can lead to sharp spikes in demand for power when the off-peak rate goes into effect.[22] A grid-interactive vehicle infrastructure could stagger the start and stop times of vehicle charging to avoid these spikes, and still allow vehicles to be fully

[22] Letendre, S., K. Gowri, M. Kintner-Meyer, and R. Pratt. 2013. *Intelligent vehicle charging benefits assessment using EV Project data*. Report published by the Pacific Northwest National Laboratory, PNNL-23031.

charged for the morning commute. This option might, however, require more complex rate structures to create effective incentives for EV owners.

At the time this report was prepared, all major New York utilities offer residential voluntary time of use (VTOU) service rates. Consolidated Edison, Inc. (ConEd) offers a VTOU rate with a peak versus off-peak differential of 17.67 cents/kWh from June 1 through September 30. TOU customers are offered a reduced rate for electricity to encourage load shifting to between midnight and 8:00 a.m. Since New York has deregulated residential electric markets, these potential savings are reflected in delivery rates. For example, New York is a summer peaking state and during the summer months off-peak delivery rates from ConEd are 1.34 cents/kWh and 19.01 cents/kWh for peak and super-peak times.[23]

ConEd is also running a PHEV pilot program to monitor charging habits of 50 EV owners to gain insights on EV charging behavior and help develop EV-specific charging rates in the future.[24] Branch Circuit Energy Management Devices (BCEMD) were installed at each of the participating customers' homes to allow separate metering of EV charging from general household use, although the units used in the pilot program are not revenue-grade meters. Initial results show that over half of the charging by participants on regular flat rates occurs during peak hours. Conversely, they found that the majority of charging by customers on VTOU rates occurs off-peak. ConEd is also evaluating the savings potential for customers on flat rates if they were to switch to a VTOU rate. Initial analysis finds that over half of the customers on flat rates could save money by switching to the VTOU rate.

3.2.2 Smart Charging

In direct-controlled charging, EV owners or operators grant an external party (for example, the utility) the ability to directly control the charging of their vehicles. The EV owner is able to set parameters (for example, an 80 percent charge required by 7:00 a.m.) and then the external party is able to adjust charging levels to use electricity at the best (least expensive) times.

As EV adoption spreads throughout New York, utilities could explore and offer voluntary pricing programs for EVs as interruptible load. This option would offer the utility greater control over load impacts of participating EVs. Currently, some utilities offer direct load control options to their customers.

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23 "Electric Vehicles Rates," ConEdison website, http://www.coned.com/electricvehicles/rates.asp

24 Consolidated Edison Company of New York, Inc. *Electric Vehicle Pilot Report*, Case 13-E-0030.

For example, the Long Island Power Authority initiated a residential direct load control program for air-conditioning units in 2001.

A 2010 FERC survey reported that approximately 5.7 million residential utility customers in the United States participated in some form of direct load control program.[25] In a typical program, the utility offers a special off-peak rate to customers who are willing to pay for and install a second electric meter in their home. That meter is then connected to only one or more appliances, giving the utility the ability to interrupt the specific load (for example, water heaters), as necessary. Direct load control programs yield financial benefits for both ratepayers and utilities, while adding greater stability and efficiency to the grid. The next logical step would be to implement a similar program for EV charging.

As discussed in Section 1, smart charging requires either controlled charging-enabled Level 2 EVSE or AMI. With AMI penetration in New York at less than 15 percent, Level 2 charging with the required software would be necessary for controlled charging of EVs. However, through the REV proceedings, stakeholders have acknowledged the need to invest in greater AMI deployment across New York State.

3.2.3 Behind-the-Meter Storage

Furthering the impact of DSM activities, the batteries of EVs can also be used for behind-the-meter storage in V2B applications. That is, EV batteries can be used to aid in the integration of renewable resources (absorbing and discharging electricity to smooth the intermittent nature of renewables), allowing them to be used most efficiently; and to discharge energy back to buildings to minimize demand charges.

Of particular interest is the potential value of EV storage in managing peak load. Commercial and industrial (C&I) rates, with demand charges, create an opportunity for EVs to reduce demand charges. They also offer the most economical use of behind-the-meter storage systems.[26] New York has several examples of storage systems being deployed in these applications, particularly in New York City, which has very high demand charges for ConEd C&I customers.

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[25] Federal Energy Regulatory Commission (FERC). *Assessment of Demand Response & Advanced Metering*, Staff Report. February 2011. http://www.ferc.gov/legal/staff-reports/2010-dr-report.pdf

[26] Neubauer, J. and M. Simpson. *Deployment of Behind-The-Meter Energy Storage for Demand Charge Reduction*, Report published by the National Renewable Energy Laboratory NREL/TP-5400-63162, 2015.

The Metropolitan Transit Authority (MTA), one of the largest single users of energy in the United States, has partnered with ConEd to install behind-the-meter battery storage in its headquarters. The storage units are three CellCube vanadium flow batteries.[27] The MTA building is highly energy efficient, and thus battery storage can charge when electricity prices are low and discharge at other times, to support building functions during peak hours (or even in outages). Glenwood, a company that builds and owns luxury rental property in Manhattan, offers another example of a planned storage project. It has contracted with EnerSys and Demand Energy to install 1 MW of energy storage capacity in several buildings.

Currently, there are no known examples in which EV batteries are used as behind-the-meter storage systems in New York State. However, one NYSERDA-supported demonstration project is set to commence during the summer of 2015. Five EVs on Queens College campus will be configured with bidirectional chargers to demonstrate the use of EVs in providing emergency back-up power and building peak shaving for demand charge management.

3.3 Wholesale Market Opportunities

NYISO operates wholesale markets to procure electricity generation, meet load requirements, and ensure regional reliability. NYISO markets have been credited with being "at the forefront of market design" and "a model for market development."[28] This section summarizes the NYISO markets structure, and discusses the opportunities for grid-interactive vehicles to be resources in these markets. There is much uncertainty about the economic value associated with EVs participating as grid sources in wholesale power markets. Although these markets represent a potential source of revenue, they must be judged against the costs associated with battery degradation from increased cycling and developing the control and communication infrastructure to enable EVs to participate in wholesale markets. A full analysis of the benefits and costs of EVs participating in New York State's wholesale power markets is beyond the scope of this report.

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[27] Casey, Tina, "'Exceptional Step Forward' For Energy Storage In New York City," *Clean Technica*, April 23, 2014, http://cleantechnica.com/2014/04/23/exceptional-step-forward-energy-storage-new-york-city/

[28] Patton, David B, P. LeeVanSchaick, and J. Chen. *2013 State of the markets report for the New York ISO markets.* Report prepared for the New York ISO by Potomac Economics, Market Monitoring Unit. May 2014.

3.3.1 Markets Structure Overview[29,30]

The current grid relies on energy stored in chemical (e.g., natural gas) and potential (e.g., hydro) forms of energy, with very little capacity to store electricity produced off-peak to meet peak energy demands. NYISO ensures that statewide electricity needs are met and perfect balance is maintained between generation and demand through three primary markets:

1. **Energy Markets,** which establish the mechanisms for energy to be bought and sold between LSEs and wholesale suppliers.
2. **Installed Capacity (ICAP) Markets,** which enable LSEs to secure capacity to meet their customers' peak demands.
3. **Ancillary Services Markets,** which maintain reliable operation of the transmission system.

In addition to these markets, NYISO also operates multiple DR programs, allowing load reduction to compete as an alternative to generating resources in the wholesale markets or to serve as reliability resources under NYISO's control. Energy users who participate in NYISO's DR programs participate by removing demand from the grid. This reduction in demand lowers wholesale prices and avoids reliability issues during supply shortages.

3.3.1.1 Energy Markets

Energy is bought and sold, between LSEs and wholesale suppliers, through either contractual bilateral agreements, or a competitive auction process in the NYISO Energy Markets. In the bilateral transactions, prices and quantities are agreed upon directly between the suppliers and the LSEs. In the auction process, prices are established through a two-settlement process. NYISO administers both a Day-Ahead Auction and a Real-Time Auction. In the Day-Ahead Auction, market participants secure prices for electricity. LSEs are scheduled to buy a certain amount of load, and generators are scheduled to dispatch during each hour of the following day, based on bids and corresponding schedules and prices in the first settlement. Then, in real time, variation in operating conditions and in actual load from the day-ahead settlement are rectified through the Real-Time Auction at the real-time price. The real-time price setting and dispatch occurs every five minutes.

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29 "Understanding the Markets," New York Independent System Operator website, http://www.nyiso.com/public/about_nyiso/understanding_the_markets/index.jsp

30 Federal Energy Regulatory Commission (FERC). *Energy Primer, A Handbook of Energy Market Basics*, Staff report of The Division of Energy Market Oversight, Office of Enforcement. July 2012.

3.3.1.2 ICAP Market

Capacity needed to meet forecasted load is procured by LSEs in NYISO's capacity market, either through self-supply, bilateral agreements, or through the ICAP auctions. These auctions cover three different durations: the Capability Period (Strip) Auction, covering six months; the Monthly Auction; and the Monthly Spot Auction. The shorter auctions are intended to account for changes in the LSE's load forecasts.

3.3.1.3 Ancillary Services Markets

Ancillary services maintain the reliable operation of transmission systems. In New York, NYISO maintains markets for Regulation and Operating Reserves, Energy Imbalance, Voltage Control, and the unassisted generating resource known as Black Start. [31]

Regulation maintains continuous balance between load and generation. If load exceeds supply, regulation resources ramp up to provide additional supply and return balance. If load falls below supply levels, regulation resources ramp down to reduce supply. These small, moment-by-moment adjustments enable interconnection frequency to be maintained at the optimal 60 Hz. Regulation services are bid into the markets in two parts: a Regulation Capacity Bid, indicating the available MW and price ($/MW) and a Regulation Movement Bid, indicating the price ($/MW) for the MW of service they provide. These services are selected for both the Day-Ahead Market and the Real-Time Market.

Operating Reserve resources provide backup power (generation or DR) in the event of a real-time emergency requiring corrective action. Operating Reserves involve both Spinning Reserves (resources already synchronized to the power system) and Non-Synchronized Reserves (resources that can be started, synchronized, and loaded within a given time), both at 10-minute and 30-minute periods.

[31] New York Independent System Operator. *Ancillary Services Manual,* Report prepared by NYISO Auxiliary Market Operations. March 2015.

Energy Imbalance resources true-up supply and demand in real time. Internal energy imbalances happen when generation or load deviates from earlier commitments. External energy imbalances occur between an RTO and its neighbors. An increase in the amount of highly variable renewable energy resources on the grid requires close monitoring by NYISO. The Energy Imbalance services offered by NYISO smooth out power flows to maintain grid reliability.[32]

Voltage Control, by producing or absorbing reactive power, maintains voltage levels within acceptable limits on the transmission system. Voltage Control is a cost-based service and is priced on embedded costs.

Black Start is the ability of a generating resource to start delivering power without assistance from the synchronized grid. Following a system wide blackout, resources are needed that can start without an outside electric supply to help system restoration. Like Voltage Control, Black Start is a cost-based service and is priced on embedded costs.

3.3.1.4 Demand Response and Limited Energy Storage Resources

In DR programs, load reduction is an alternative to generation in NYISO's competitive markets and provides reliability services directly to NYISO, both of which allow energy users to participate by removing demand from the grid. NYISO can ask DR resources to reduce their energy consumption. NYISO administers five DR programs. Two of them, the Day-Ahead Demand Response Program (DADRP) and Demand-Side Ancillary Services Program (DSASP), allow economical DR resources to participate in the day-ahead market and ancillary services markets, respectively. The other three programs, Emergency Demand Response Program (EDRP), Installed Capacity (ICAP) Special Case Resources (SCR), and Targeted Demand Response Program (TDRP), are reliability DR resources that are called when NYISO or the local transmission owner forecasts a shortage of energy supply. Currently, more than 95 percent of the 1.3 GW of DR resources registered in New York are reliability DR resources, most participating as ICAP SCR.[33]

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32 PacificCorp, *California ISO Shaping a Renewed Future, Fast Facts,* http://www.pacificorp.com/content/dam/pacificorp/doc/About_Us/Energy_Imbalance_Market/EnergyImbalanceMarketPartnershipFASTFACTS.pdf

33 Patton, David B, P. LeeVanSchaick, and J. Chen. *2013 State of the markets report for the New York ISO markets.* Report prepared for the New York ISO by Potomac Economics, Market Monitoring Unit. May 2014.

In addition to DR programs, NYISO has also established market structure and rules enabling the participation of LESRs in their wholesale markets. LESRs are characterized by limited energy storage—that is, the inability to sustain continuous operation at maximum energy withdrawal or maximum energy injection for at least one hour. In 2009, NYISO became the first grid operator in the country to do this, recognizing that LESRs could provide balancing services without the environmental impact associated with ramping up or down gas generators. LESRs can complete these activities with no direct emissions. Currently, LESRs are permitted as ancillary service resources only in the Regulation Market. Participation to date in the LESR program has been minimal.

3.3.2 Grid-Interactive Vehicle Opportunities

3.3.2.1 Proof of Concept

Several projects across the country have demonstrated that EVs can in fact respond to market signals and serve as resources in wholesale markets.[34] Although EV batteries offer limited storage, their ability to ramp (either up or down) is nearly instantaneous. Batteries can ramp without the carbon emissions associated with ramping generators. Thus, there are significant environmental and health benefits associated with the use of batteries as grid resources. This phenomenon has driven initial research and demonstration projects on EVs serving as regulation resources.[35]

However, new research is investigating the potential for EVs to serve as energy imbalance resources. A recent study by Pacific Northwest National Laboratory examined the role of EVs in mitigating energy imbalances caused by wind generation. The study found that "Using electric vehicle charging as a means to help offset the additional imbalance associated with a higher penetration of renewable generation shows significant promise."[36]

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[34] Morse, Stephanie and Karen Glitman. 2014. *Electric Vehicles as Grid Resources in ISO-NE and Vermont*. Report prepared for Efficiency Vermont. Burlington, VT: Vermont Energy Investment Corporation.

[35] Kempton, Willett, and Jasna Tomić. "Vehicle-to-Grid Power Fundamentals: Calculating Capacity and Net Revenue." *Journal of Power Sources* 144, no. 1 (June 1, 2005): 268–279. doi:10.1016/j.jpowsour.2004.12.025.

[36] Tuffner, F. K. and M. Kintner-Meyer. *Using Electric Vehicles to Mitigate Imbalance Requirements Associated with an Increased Penetration of Wind Generation*. Prepared by IEEE. http://energyenvironment.pnnl.gov/ei/pdf/Using%20electric%20vehicles%20to%20mitigate%20.pdf

Studies in Texas,[37] France,[38] and Denmark[39] indicate that EVs can provide voltage support, and potentially offer a valuable, low-cost opportunity to provide voltage support for distributed generation, such as photovoltaic arrays, and can offset more expensive distribution system upgrades.

3.3.2.2 Opportunities in New York

The core service that EVs provide is clean transportation. The use of EVs as grid resources must not diminish the value that EV owners derive from the core mobility services provided. At the same time, the capacity factor of vehicle use is low, approximately 5%. Thus, there is a significant amount of time each day that an EV is idle and could potentially create value to the EV owner serving as a grid resource.

Each NYISO wholesale market has its own set of rules and regulations that will determine the feasibility of EVs participating as resources in them. But perhaps the most significant characteristic pertaining to EV participation is the fact that NYISO has established mechanisms for non-generating resources to participate in the markets and to provide reliability services directly to NYISO. DR programs as well as the rules establishing LESRs as accepted market participants set the stage for EV participation; however some modifications to these programs may be necessary given the unique characteristics of EVs serving as grid resources.

Because EVs on the road are not equipped with bi-directional capacity, the first step for EVs to participate in NYISO wholesale markets may be through the DR programs. EV charging can be curtailed entirely, or the level of charging can be slowed and modulated. This uni-directional curtailment and control can act as a resource in the ICAP SRC or DSASP, participating specifically in the Reserve and Regulation markets.

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[37] Caramanis, Michael. "Plug-In Electric Vehicle and Voltage Support for Distributed Solar: Theory and Application." *IEEE Systems Journal* 7, no. 4 (December 2013): 881-888. doi: 10.1109/JSYST.2012.2223534.

[38] Hably, Ahmad. *Voltage Support by Optimal Integration of Plug-in Hybrid Electric Vehicles to a Residential Grid.* Conference paper, IECON 2014. http://www.researchgate.net/publication/265929189_Voltage_support_by_Optimal_integration_of_Plug-in_Hybrid_Electric_Vehicles_to_a_Residential_Grid

[39] Huang, Shaojun, J. R. Pillai, B. Bak-Jensen, and P. Thogersen. "Voltage Support from Electric Vehicles in Distribution Grid." *Power Electronics and Applications (EPE)* (September 2-6, 2013): 1-8. Doi: 10.1109/EPE.2013.6634344.

It should be noted that to qualify as a demand resource, the load obligation that would be curtailed as part of participating in a DR program must first be established as load. Establishing what is known as the Customer Base Line, which is defined as average hourly energy consumption used to determine the level of load reduction provided, for EV charging may be more complicated than that for building load. To participate in these DR programs, EVs will need to meet the minimum resource block required for each program. These vary from a 1 MW requirement for the DSASP to 100 kW for the EDRP. Therefore, it will be necessary to aggregate individual EVs to present as a single resource for participation in one of NYISO's DR programs (see Section 1).

Once EVs can provide bidirectional energy flows, without concern for voiding battery warranties, aggregated EVs could potentially be market participants as LESRs if the program is modified to allow aggregated resources to participate. Currently, LESRs are allowed to participate only in the Regulation Ancillary Service Market, and because this market provides the best fit for the characteristics of battery storage systems, this strategy may represent a near-term opportunity for grid-interactive vehicles in New York.

The V2G demonstration underway at the University of Delaware has focused on the high-value regulation market within the PJM Interconnect.[40] EV batteries have proven to be able to provide the quick-responding ramping needed for regulation accurately, and without the environmental and health concerns associated with emissions from ramping generators. Due to the structure of bids in the regulation market, resources that can provide a fast response rate are valued more highly. The regulation market is typically the most expensive market in RTOs and may offer the greatest return for EVs as an energy resource. Most grid-level storage demonstrations are best suited as regulation providers.

If the constraints limiting LESRs to the Regulation Market are lifted and aggregated resources become eligible, EVs also have the potential to serve as Reserve, Voltage Control, and Energy Imbalance resources. Within the Reserve Market, EVs could participate as a Spinning Reserves resource. Again, because battery storage systems can provide a near-instantaneous response and ramping without

40 Willett Kempton et al. "A Test of Vehicle to Grid (V2G) for Energy Storage and Frequency Regulation in the PJM System, Results from an Industry University Research Partnership." 2009. http://www.udel.edu/V2G/resources/test-v2g-in-pjm-jan09.pdf

emissions, when aggregated in sufficient quantities, they can be efficient, clean resources in this market. Voltage Control is a cost-based, rather than market-priced, service in NYISO. But similar to Regulation, it requires low capacity, fast-ramping resources. Energy Imbalance resources perform load-following functions to accommodate the highly variable nature of renewable energy sources such as solar and wind. Because EV batteries can perform this function without emissions, they provide a clean means by which to advance renewable integration.

4 Regulatory Landscape for Grid-Interactive Vehicles in New York

EV adoption in New York and the United States has been slow. Although consumers have access to many plug-in EV models in dealer showrooms, retail sales of EVs are not strong. EVs make up less than 1 percent of new-vehicle sales nationally. In New York State, just over 12,000 EVs are registered, compared to a total light-duty vehicle fleet of over 9 million. At this low level, the increased electricity demand for EV charging is minimal, and in aggregate the current EV fleet represents a relatively small grid resource.

Many factors affect the adoption rates of EVs: vehicle cost, relative cost of gasoline and electricity as fuels, availability of charging infrastructure, and vehicle characteristics such as range. Federal and state regulations and incentives also stimulate consumer adoption of EVs and other alternative-fuel vehicles.

Section 177 of the U.S. Clean Air Act allows states to adopt the California Zero Emissions Vehicle (CA ZEV) regulations with a collective goal of placing 3.3 million zero emission vehicles (ZEVs) on U.S. roads by 2025. New York is one of eight states that have adopted these regulations. New York's adoption of this mandate requires an increasing number of ZEVs to be sold in New York, starting in 2017 and ramping up to approximately 15 percent of new-vehicle sales by 2025, resulting in the sale of approximately 800,000 EVs in the State during that timeframe.[41]

New York has a stable regulatory landscape regarding energy. Policy initiatives such as Cleaner, Greener Communities, New York Energy Highway, the Regional Greenhouse Gas Initiative, ChargeNY, Build Smart NY, NY-Sun, Renewable Portfolio Standard, Energy Efficiency Portfolio Standard, ReCharge NY, and the REV proceeding establish a policy commitment toward a cleaner, sustainable, reliable, and resilient energy system for New York. Carbon emission rates from electricity generation have fallen by over 40 percent since 2000.[42] Initiatives like these, coupled with cleaner, more sustainable electricity generation, align closely with the incorporation of grid-interactive EVs.

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41 "ZEV Program," Center for Climate and Energy Solutions website, http://www.c2es.org/us-states-regions/policy-maps/zev-program

42 New York Independent System Operator, *Power Trends 2014, Evolution of the Grid,* http://www.nyiso.com/public/webdocs/media_room/publications_presentations/Power_Trends/Power_Trends/ptrends_2014_final_jun2014_final.pdf

Within the scope of this preliminary research, it is assumed that EV adoption rates in New York will accelerate in the coming years. EV adoption will constitute a large, new demand for electricity and, in aggregate, a significant storage resource that could contribute to grid reliability. EVs could also play a role in helping to manage the variable nature of wind and solar resources, as they become more prevalent on the New York grid. The State has a target of meeting an aggressive renewable portfolio standard requiring that 30 percent of the state's electricity come from renewable energy resources.

A grid-interactive vehicle infrastructure enables smart charging and unlocks the value that EVs could provide as DERs. However, without advanced planning and some degree of coordination, the build-out of the vehicle charging infrastructure in the State might not necessarily support grid-interactive vehicles. The literature is clear that there are significant benefits from allowing smart charging and the use of parked EVs as grid resources.[43] This report explores the regulatory landscape, identifying the State agencies that can influence the build-out of the New York EV charging infrastructure, EV charging rate structures, and market reforms that encourage cost-effective use of EVs as grid resources.

4.1 New York State Agencies and Industry Participants' Roles and Jurisdiction

Many actors are helping to introduce and adopt electric vehicles and develop the systems to support grid-interactive vehicles. These actors are private corporations, utility companies, the New York State Legislature, and government agencies. Table A-2 lists the different types of organizations and their respective roles in the evolving EV industry in New York.

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43 Letendre, S., K. Gowri, M. Kintner-Meyer, and R. Pratt. 2013. *Intelligent vehicle charging benefits assessment using EV Project data*. Report published by the Pacific Northwest National Laboratory, PNNL-23031.

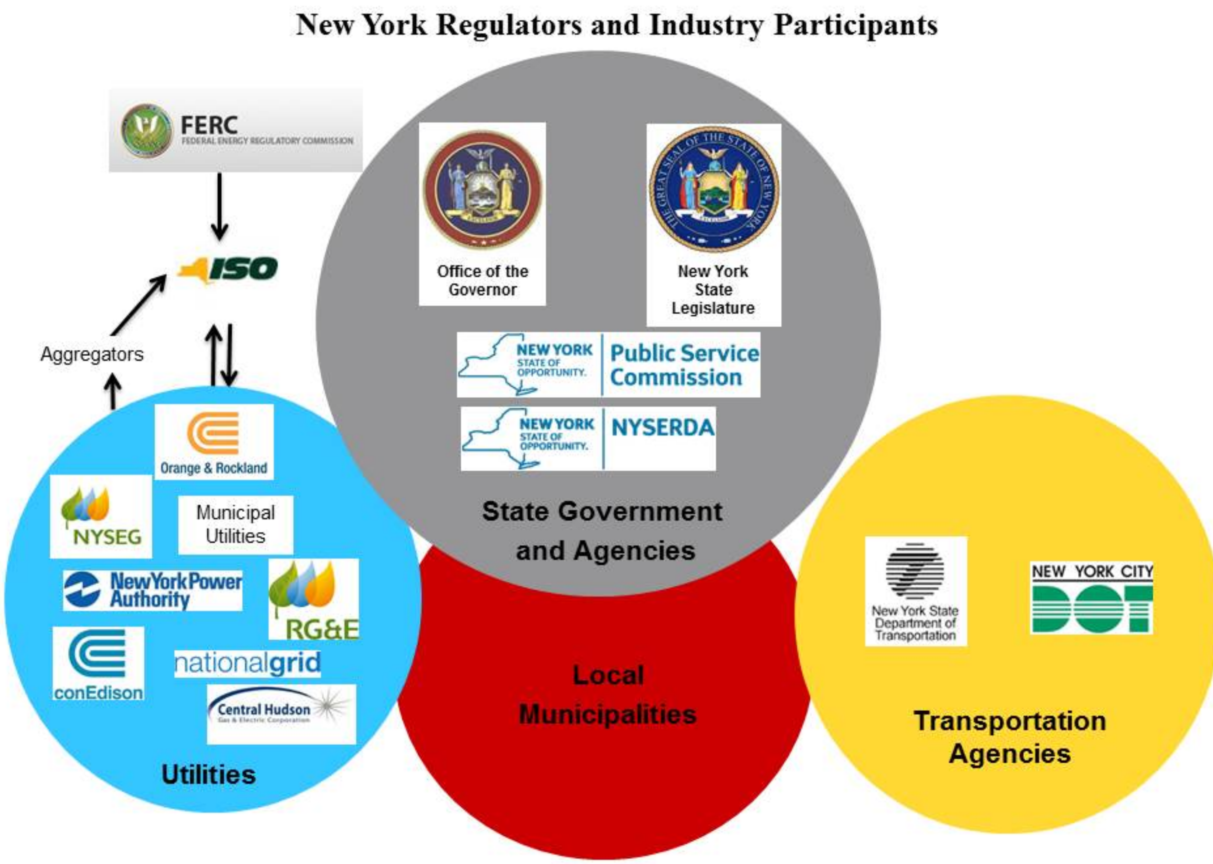
Table A-2. EV industry participants

Agency or Industry Participant	Role and Jurisdiction (if Applicable)
EV manufacturers	Most major automobile manufacturers offer plug-in vehicles to customers. The number of plug-in vehicles in the marketplace is increasing each year. Today there are more than a dozen plug-in EVs available for purchase by New York residents.
EVSE manufacturers	Several companies produce the equipment necessary for EV charging, both at-home and for public access. EVSE standardization among manufacturers will facilitate grid-interactive vehicles.
EV charging network providers	Several companies are developing EV charging networks across the State. These companies could play an important role in the development of the grid-interactive vehicle future.
State and local governments	The State Legislature, the Office of the Governor, and municipal governments all play a role in the EV industry, from creating incentives for EV purchases to direct EV adoption in fleets, to zoning requirements for EVSE installations.
State agencies	State agencies play an important role in many aspects of the evolving grid-interactive infrastructure—from the PSC's regulation of electric utilities to the Department of Environmental Conservation's air pollution programs.
Retail electric power providers / distribution utilities	The State has deregulated retail power providers. In New York, customers can purchase power from electricity distribution utilities (investor-owned and municipal utilities, for example). Alternatively, customers can purchase energy from retail ESCOs. The incumbent utility still delivers the energy. EV charging offers an opportunity for selling more electricity. Many distribution companies are retail power providers in addition to operators of regional distribution systems, with an emphasis on system reliability. EV charging will likely have direct impacts on the distribution system; thus utilities will likely benefit from a grid-interactive vehicle infrastructure and will play an important role in its development.
Independent system operators	NYISO is responsible for the reliable operation of the high-voltage transmission system and the dispatch of electric power generators to meet the electricity demands of all New Yorkers. In addition, the NYISO administers bulk power and ancillary services markets.
Aggregators	For EVs to provide grid resources, it will be necessary to aggregate individual EVs into power resource blocks. Today, companies serve this role in aggregating customer loads for participation in NY's DR programs. NYISO currently has 27 DR aggregators for DR resources.[44]

[44] New York Independent System Operator, *Demand Response Service Providers*, last modified February 27, 2015, http://www.nyiso.com/public/webdocs/markets_operations/market_data/demand_response/Demand_Response/General_Information/dr_providers.pdf

As previously noted, a grid-interactive vehicle infrastructure requires two critical pieces: the development and deployment of interoperable communication and control systems and market and regulatory incentives that facilitate smart charging and the use of EVs as grid resources. The PSC, the State Legislature, retail electricity providers / distribution utilities, aggregators, and NYISO are the core EV industry participants with the power to influence the development of a grid-interactive infrastructure. Figure A-5 illustrates the relationships among the key actors.

Figure 5. EV industry participants and their relationship to grid-interactive vehicle infrastructure.



4.1.1 New York Legislature

The New York Legislature has the power and authority to craft laws that could accelerate the evolution of a grid-interactive vehicle infrastructure, in addition to other incentives for EV adoption and EVSE deployment. This power includes introducing and passing laws outlining incentives on EV purchases (including State tax incentives), laws exempting EVs from having to pay registration fees, and laws defining requirements for installing and maintaining charging stations in State-owned parking facilities. In 2013 legislative session, two bills were introduced in New York exempting charging station owners from utility regulation.[45] The State Legislature also has the authority to revise the State's net metering and interconnection standards to accommodate grid-interactive vehicles providing V2G services. State policy initiatives such as the Community Risk and Resiliency Act, an act passed in 2014 that requires decision makers to take into account risk of extreme weather due to climate change when funding and permitting projects, provide a stepping stone for initiatives such as the REV proceeding undertaken by the PSC.

4.1.2 Office of the Governor

The Office of the Governor promotes initiatives regarding the State's energy and transportation future. With Governor Cuomo's creation of Charge NY, the adoption of EVs and the availability of EV infrastructure are likely to increase. Augmenting the ChargeNY initiative is the Governor's Clean Fleets NY initiative in which 50 percent of new, administrative-use fleet vehicles purchased in 2016 will be ZEVs. These vehicles include battery electric, plug-in electric hybrid, or hydrogen fuel cell vehicles.[46]

Governor Cuomo also recently announced several major energy initiatives for New York, including the REV proceeding currently under review by the PSC. 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.

Other recent initiatives supported by the Governor's office include NY-Sun and the proposed Clean Energy Fund.

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45 Bill S5110-2013 and A7725-2013. http://open.nysenate.gov/legislation/bill/S5110-2013

46 Governor Andrew M. Cuomo 2015 State of the State Book. https://www.governor.ny.gov/sites/governor.ny.gov/files/atoms/files/2015_Opportunity_Agenda_Book.pdf

4.1.3 New York Public Service Commission

The PSC is a bi-partisan, five-member commission (there are currently four members) who are appointed by the Governor and confirmed by the State Senate for terms as long as six years. The Commission, which is supported by the New York Department of Public Service (DPS), regulates electric and other utilities. The PSC is responsible for utility regulation and infrastructure development approval, as well as approval of the Renewable Portfolio Standard (RPS) and the Energy Efficiency Portfolio Standard (EEPS). The PSC established New York's System Benefits Charge (SBC), which supports energy efficiency and renewable energy development and is administered through NYSERDA. The PSC's mission is to ensure affordable, safe, secure, and reliable access to electric, gas, steam, telecommunications, and water services for the state's residential and business utility customers, while protecting the natural environment.

One of the critical roles of the PSC in promoting a grid-interactive vehicle infrastructure in New York is the oversight of rate structures that encourage dynamic pricing approaches for EV charging and other cost-effective incentive programs to encourage the use of EVs as DERs. In addition, the PSC plays a key role in rate-based decisions associated with utility investments. This role will be particularly important because utility investment will be a necessary part of the build-out of a grid-interactive vehicle infrastructure. In a November 14, 2013 declaratory rulemaking, the PSC determined that publicly available EV charging stations and the owners and operators of the charging stations (unless they were already regulated electric utilities) did not fall under the PSC's jurisdiction as regulated utilities. The PSC will also play an important role in encouraging the upgrade and modernization of utility metering, communications, and load control systems.

Two major proceedings are before the PSC, as of this report writing, that will affect the viability of grid-interactive vehicles in New York. 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. This proceeding is being closely followed by regulators and utilities around the country as it attempts to address complex energy issues faced in many jurisdictions.

The second major proceeding before the PSC is the Clean Energy Fund proceeding. The goal of this proceeding is to replace New York's RPS and its EEPS (which expire at the end of 2015), and its SBC (which expires at the end of 2016) with a single Clean Energy Fund, designed to ramp-up renewable generation in the State. The outcome of these proceedings will help inform the direction and future of the electric grid in New York and consequently, the future role of EVs in the State.

4.1.4 Retail Electricity Providers/Distribution Utilities

Electric distribution in New York is carried out by six large investor-owned utilities, the New York Power Authority (NYPA), and many smaller utilities. Since 1997, electricity sales in the State have been deregulated. That is, supply and delivery of electricity have been unbundled. Customers can choose to buy their electricity from an ESCO, or they can buy their electricity from their existing distributing utility. Less than 25 percent of customers buy their electricity from ESCOs. Regardless of whom customers choose to purchase their electricity from, the incumbent distribution utility will provide energy delivery.

ESCOs purchase electric supply through bilateral agreements with generators or through wholesale markets and sell it to customers. ESCOs sometimes offer options to buy electricity through packages with fixed rates or variable pricing, or sourced entirely from renewables. ESCOs do not currently have the ability to provide TOU rates, so customers participating in TOU programs see those rates reflected on the delivery portion of their bill from their utility.

Distribution utilities are the key link to customer engagement, which is critical to educating EV owners of the available EV charging options and market opportunities made possible by a grid-interactive vehicle infrastructure. The distribution utilities in particular will need to administer the communication and control links between EVSE equipment and energy management systems that will allow for smart charging and the use of EVs as grid resources.

The increased load for EV charging will likely have the most direct impact on utility distribution systems, particularly in residential communities with EV clusters. Thus, distribution companies will play a critical role in better understanding the distribution system impacts of EV charging and strategies to manage the new load to avoid major new investments in infrastructure. Furthermore, they have been involved for decades in DSM and DR program development and deployment.

4.1.5 NYSERDA

NYSERDA promotes energy efficiency and renewable energy resource development through the administration of programs and research supported by a statewide SBC, RPS proceeds, State appropriations, and Regional Greenhouse Gas Initiative proceeds. As mentioned earlier in this section, many of these funding sources may soon be replaced with a single Clean Energy Fund.

By offering incentives, programs, and research, NYSERDA is critical to transforming the market to one in which grid-interactive vehicles are widespread. NYSERDA works closely with the PSC and implements both legislative initiatives and PSC orders. NYSERDA has a significant portfolio of past, current, and future EV-related programs and initiatives. It has therefore gained a significant knowledge base on EVs and the opportunities and barriers to their widespread adoption. NYSERDA is also actively involved in the Transportation and Climate Initiative (TCI), which is a regional collaboration tasked with reducing greenhouse gas emissions from the transportation sector. Most recently, this collaboration has focused on developing a network of EV charging infrastructure throughout the region.

4.1.6 Aggregators

Aggregators combine individual curtailable loads from multiple resources, implement the control and communication systems necessary to comply with DR market requirements, and deliver DR services to markets. EVs could become another asset in a larger portfolio of DR resources managed by aggregators. At the end of 2013, the total amount of DR resources provided to the state grid by these aggregators was 1,300 MW.[47]

It should be noted that significant uncertainty in DR markets nationally has emerged due to court challenges to the FERC's Order 745, which determined that DR could serve in lieu of generation resources and must be paid in the same way that generation resources are paid in wholesale electricity markets. In May 2014, the U.S. Court of Appeals for the District of Columbia Circuit ruled that DR is not the same as generation, because it relies on retail customers and is not subject to FERC jurisdiction. It is, however, subject to oversight by state utility commissions.

As bidirectional capacity evolves on EVs, market participation as LESRs will also require aggregation to provide the minimum resource size required of various wholesale markets. It is not yet known if existing third-party aggregators will be the best option for providing this aggregation service, or if another entity (for example, utilities) will be better suited.

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[47] Patton, David B, P. LeeVanSchaick, and J. Chen. *2013 State of the markets report for the New York ISO markets.* Report prepared for the New York ISO by Potomac Economics, Market Monitoring Unit. May 2014.

4.1.7 NYISO

NYISO is responsible for the reliable operation of nearly 11,000 miles of high-voltage transmission lines and the dispatch of more than 500 electric power generators to safely and reliably meet power demands. In addition, NYISO annually administers bulk power markets that trade an average of $7.5 billion in electricity and related products.[48] NYISO is subject to FERC regulation and to New York State legislation.

Section 2 discusses the wholesale markets administered by NYISO. NYISO plays a critical role in creating market opportunities for EVs as grid resources. NYISO establishes the communication and control standards required for resources to participate in its various markets. Thus, they will play an important role in the evolution of the grid-interactive vehicle infrastructure in the State. NYISO also determines minimum resource size requirements that have a direct effect on the viability of EVs as a grid resource. Other RTOs such as PJM and CAISO have a 500-kW minimum resource size for their ancillary services markets. NYISO's minimum resource size is 1 MW, which is double that of PJM and CAISO. If it is determined that aggregated EVs offer a desirable market resource, reducing this minimum resource size will make their market participation more feasible.

4.1.8 New York State Department of Transportation and other Transportation Agencies

The New York State Department of Transportation (NYSDOT) coordinates the comprehensive transportation policy for the State. It develops the comprehensive statewide master plan for public and private commuter and general transportation facilities. It also coordinates the operation of transportation facilities and services: highways, bridges, railroads, mass transit systems, ports, waterways, and airports.[49] Given the dual role of grid-interactive vehicles, both as a transportation and a grid resource, NYSDOT may play a role in fleet development, infrastructure development, and encouraging EV use through clean passes and other mechanisms. In addition to NYSDOT, agencies like Metropolitan

48 "About NYISO," New York Independent System Operator website, http://www.nyiso.com/public/about_nyiso/nyisoataglance/index.jsp

49 "Responsibilities and Functions," New York State Department of Transportation website, https://www.dot.ny.gov/about-nysdot/responsibilities-and-functions

Transportation Authority, the New York State Thruway Authority, and the Port Authority of New York and New Jersey will likely also play a role in the adoption of grid-interactive vehicles. Although this role may initially be minor, as the EV market expands, this role may expand to include the introduction of EVSE at Thruway rest stops; the adoption of electric technologies for transit fleets; and maintaining a long-range comprehensive master plan for transportation, which may someday include grid-interactive vehicles.

4.1.9 Local Municipalities

Local municipalities can greatly influence the adoption of EV technologies and the deployment of grid-interactive vehicles. Towns and cities have the authority to develop land use plans that determine the location of parking, the siting of EVSE, and the prevalence of charging stations. Municipalities can also streamline the permitting process. Retrofitting an existing parking lot for EV charging is expensive, and it is often more cost effective to plan for EVs in future parking installations. In 2013, the City Council of New York passed a law requiring that 20 percent of new parking spaces be designed for EV charging.[50]

Another way in which municipalities can support EV deployment is by purchasing EVs for city fleets. A NYC initiative commissioned by Mayor Bloomberg in 2013 involved a research study examining the feasibility of electrifying one third of NYC's taxi fleet by 2020. The study found that meeting this goal would have a powerful impact on air quality in the city. Other benefits identified were decreased oil dependence and reductions in urban heat and urban noise.[51]

4.2 Policies and Regulation as Relevant to Grid-Interactive Vehicle Infrastructure Development

Many of the policies and regulations relevant to facilitating grid-interactive vehicles—systems that allow for optimal timing of vehicle charging and the use of EVs as grid resources—are similar to those related to behind-the-meter storage and other DERs. Two important distinctions, however, are relevant for grid-interactive vehicles relative to stationary DER. These distinctions are (1) the fact that the ownership of the EVSE point of grid integration might be different from the ownership of the energy

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50 Motavalli, Jim, "New York Requires Garages and Lots to be Built EV-Ready," *PluginCars*, December 10, 2013, http://www.plugincars.com/new-york-requires-lots-and-garages-be-built-ev-ready-129063.html

51 "Are Electric Cars Good for Society," Drive Electric NYC website, http://www.nyc.gov/html/ev/html/society/society.shtml

storage system; and (2) the energy storage system in the EVs are mobile, and thus could be grid-connected at different locations. The fragmentation of ownership and the mobile nature of the energy storage systems might create accounting, metering, and aggregation challenges for the services that EVs could provide when coupled to a grid-interactive vehicle infrastructure.

The policies and regulations relevant to grid-interactive vehicle infrastructure are divided into six categories.

4.2.1 Rate Design

As discussed in Section 2, electricity rates can be designed to send the appropriate economic signals to EV owners, to encourage charging during times when sufficient generation, transmission, and distribution capacity are available. Variable or TOU rates, and controlled charging or interruptible load programs provide the means by which to do this. Rate design is also critical in ensuring that EV owners are fairly compensated for their contribution to the grid.

4.2.2 Metering and Billing

EV-specific variable rates often require disaggregation of power used for EV charging versus total use. This could be accomplished by installing a separate meter just for EV charging or submetering at potentially lower cost. EVs could be allowed to “roam.” That is, they charge and provide grid services at multiple locations, which requires accounting for electricity sales and services provided at different grid connection points. Allowing third-party EVSE owners to bill through existing utility bills is another possible need.

4.2.3 Standardization of Communication and Control Systems

Direct control over vehicle charging, whether by a utility or an aggregator, might offer the best approach for optimal vehicle charging. Standards can be established for the communication and control systems that emerge, to allow direct load control. The modernization of utility communications and metering can occur in a fashion that allows for seamless interfacing with third-party, cloud-based communication networks. These systems are also a prerequisite for EVs serving as grid resources and would have to be consistent with NYISO protocols. With EPRI’s announcement in 2014 of a collaborative effort with 8 automakers and 15 utilities, an open platform is now being developed and demonstrated, which would integrate plug-in electric vehicles with smart-grid technologies. This collaboration will enable utilities to support charging, regardless of location. The platform will allow manufacturers to offer a customer-friendly interface through which EV drivers can more easily participate in utility EV programs (for example, special rates for off-peak or nighttime charging). ConEd is one of the utility partners in this project.

4.2.4 Interconnection

Interconnection standards can be updated to allow EVSEs with bidirectional power flows to interconnect to the utility network. In 2013, FERC passed Order 792, Small Generator Interconnection Agreements and Procedures, amending Order 2006, which established terms and conditions for public utilities to provide just and reasonable interconnection service for small generators. In Order 792, FERC amended the definition of *Small Generating Facilities* in the *Small Generator Interconnection Procedures* to explicitly include storage. The State interconnection standard in place today does not list energy storage as an eligible technology. Given the relatively small power connection of an EVSE with bidirectional capabilities, the process could allow for quick and low-cost interconnection to the utility grid. Best practices in interconnection suggest "fast tracking" interconnection reviews for small generators. Standardization of EVSE equipment could make interconnection of these inverter-based systems similar to that for distributed photovoltaic systems.

4.2.5 Wholesale Market Structure and Participation

The NYISO-administered DR programs and the rules pertaining to LESRs provide the necessary mechanisms for aggregated EVs to participate in wholesale markets. However, it is not explicitly stated that EVs can participate in these programs and markets, and currently, aggregated resources cannot qualify as LESRs. Using demand-side resources in wholesale power markets is still very much in the nascent phase of development and requires further research.

Review of markets and DR program structures with an eye to the value that EVs can provide as grid resources could further the development of grid-interactive vehicles. The market and DR performance standards can be evaluated, relative to the capabilities and value that EVs can provide.

4.2.6 Business Model Development

Another critical area to explore when considering grid-interactive vehicles is the business model that will be used to incorporate EVs into the grid as a resource. The business model can be developed to address several questions. For example, who will be responsible for aggregating resources and how will those resources be aggregated?

The California Public Utilities Commission researched grid-interactive vehicles and identified four options for aggregating vehicles to consolidate resources to meet the minimum resource requirement for the system operator. The four options proposed were: (1) the utility as the sole aggregator, (2) the utility as a meta-aggregator, (3) competitive aggregation without utility participation, and (4) some type of hybrid market approach.[52]

Another question is how EV owners or operators will be compensated for resources to the grid that the vehicles provide. Will they be compensated with free parking? Will their resource be net-metered? Will owners be compensated for potential battery degradation? These questions and others can be addressed in developing a business model of grid-interactive vehicles.

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[52] Langton, Adam, and Noel Crisostomo. *Vehicle-Grid Integration: A Vision for Zero-Emission Transportation Interconnected throughout California's Electricity System*. Report prepared by California Public Utilities Commission, Energy Division, 2013. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M081/K975/81975482.pdf

5 Conclusions

This preliminary research indicates that the implementation of grid-interactive vehicles—both as DSM resources and in providing grid services—is closely aligned with the direction of current State energy policy.

From a practical application standpoint, the growth of EV deployment in the State will lead to increased electricity consumption that can be mitigated through indirect or direct charging control of EVs and, could increase grid efficiency through well-designed programs. As behind-the-meter or distributed energy storage, grid-interactive EVs have the ability to create multiple benefits, such as supporting the reliable operation of the grid to greater integration of renewable energy resources.

EVs can also be grid resources, although the mobility needs and expectations of EV owners must not be compromised in the process of providing grid services. Either through participation in NYISO's DR programs or serving as LESRs, aggregated EVs can participate in wholesale markets, acting as clean, efficient resources. Although the use of demand-side resources in wholesale power markets is still very much in the nascent phase of development, pilot projects and demonstrations show great potential for the contributions EVs can make to grid reliability and resiliency.

By compensating EV owners for these various grid benefits, EVs become more affordable and financially accessible, furthering deployment and adoption.

Both challenges and opportunities exist in the integration of EVs with the grid. The State can take steps to move the process forward for cleaner energy and transportation. This preliminary research report outlines the regulatory landscape and policies as they relate to grid-interactive EVs. The next phase of this research will involve a gap analysis to determine which policies, standards, technologies and market rules are needed to facilitate the interaction between vehicles and the electric grid. Finally, these elements will inform the development of a road map to direct next steps toward a future in which the State of New York can rely on cleaner transportation integrated with a cleaner, more resilient electric grid.

Appendix B. New York State Grid-Interactive Vehicle Study: Gap Analysis

New York State Grid-Interactive Vehicle Study: Gap Analysis

Final Report

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Notice

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Acronyms and Abbreviations List

AMI	Advanced Metering Infrastructure
ANSI	American National Standards Institute
CEF	Clean Energy Fund
ConEd	Consolidated Edison, Inc.
DER	distributed energy resource
DR	demand response
DSM	demand-side management
EPRI	Electric Power Research Institute
ESCO	energy service company
EV	electric vehicle
EVSE	electric vehicle supply equipment
EVSP	Electric Vehicle Standards Panel
LESR	limited energy storage resources
NYISO	New York Independent System Operator
NYSERDA	New York State Energy Research and Development Authority
PSC	New York State Public Service Commission
REV	Reforming the Energy Vision
TOU	time of use
V2B	vehicle-to-building
V2G	vehicle-to-grid
VGI	vehicle grid integration

1 Introduction

As part of the New York State Grid-Interactive Vehicle Study, the Vermont Energy Investment Corporation (VEIC) and Steven E. Letendre, Ph.D., of Green Mountain College, completed a Preliminary Research Report and conducted one stakeholder engagement meeting. Results from of these undertakings revealed a number of gaps in the structure necessary for deployment of grid-interactive vehicles. This report identifies and describes the gaps that need to be addressed for a grid-interactive vehicle infrastructure to become a reality in New York State. This report was presented and discussed in a second stakeholder engagement meeting. Input from the stakeholder group was incorporated into this gap analysis. The gaps are organized into three broad areas following the basic structure of the Preliminary Research Report: Standards and Available Technology, Retail and Wholesale Market Opportunities, and Policy/Regulatory.

The gaps discussed in this report do not necessarily pose barriers to the development or adoption of grid-interactive vehicles. Rather, they present opportunities to establish guidance and coordination to facilitate electric vehicle (EV) and EV infrastructure growth in a way that supports grid-interactive vehicles and maximizes coordination and efficiency statewide and regionally. Because EVs are still a small market in the State, this is an opportune time to develop the framework for their incorporation in both the transportation and energy sectors.

2 Gaps in Available Technologies and Standards

Although the technologies necessary to facilitate grid-interactive vehicles have been developed and demonstrated in pilots and other limited cases, gaps exist in the integration of systems with vehicles, charging equipment, and grid operations. There is also a lack of comprehensive standards and consistency to harmonize a variety of control signals and communication protocols. These gaps must be addressed to facilitate widespread development and adoption of grid-interactive vehicle infrastructure.

2.1 Distribution Level Infrastructure

Although EV charging load forecasts indicate minimal impact on transmission levels, a proliferation of EVs in neighborhoods—when coupled with Level 2 or DC fast chargers—may negatively impact the distribution grid. Utility distribution-level transformers may not be capable of handling charging at power levels as high as 7.7 kW for Level 2 chargers and up to 100 kW for DC fast chargers (especially when clustered in a neighborhood). Electric vehicle supply equipment (EVSE) siting will need to be coordinated with utilities to make sure that adequate infrastructure is in place to handle the additional charging load.

Additionally, modifications to distribution infrastructure may also be required if EVs serve as grid resources through behind-the-meter or vehicle-to-building (V2B) applications. V2B applications may be implemented in a number of ways. For example:

- An EV battery can serve as energy storage to power a building in the event of a power outage.
- An EV battery can be paired with a solar electric system to store energy during peak insolation and power home appliances during evening hours.
- An EV can be used to arbitrage energy by charging at lower cost during off-peak times and discharging to power a home to avoid electricity purchase during peak events.

Connecting an EV to a building in any of these manners requires distribution-level safety considerations, including the establishment of relevant electric codes, protection coordination to prevent electrical system faults, and intentional system islanding and reconnection of the circuit.[1]

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1 Chris Greacen, Richard Engle, and Thomas Quetchenbach, *A Guidebook on Grid Interconnection and Islanded Operation of Mini--Grid Power Systems Up to 200 kW*. (Lawrence Berkeley National Laboratory, Schatz Energy Research Center, 2013). http://www.cleanenergyministerial.org/Portals/2/pdfs/A_Guidebook_for_Minigrids-SERC_LBNL_March_2013.pdf

2.2 Communication

The ability of a distribution utility to control the rate of charge of EVs is an important element in the management of the impact of EVs on the grid. Without this control, utilities must rely on EV owners' and operators' voluntary participation in time-of-use (TOU) rate tariffs. Direct controlled charging (smart charging) requires that a utility have the ability to send a signal to adjust the charging of an EV. This control can be accomplished through various mechanisms, including Advanced Metering Infrastructure (AMI), Level 2 EVSE enabled with smart charging software, or potentially through communication with the vehicle directly.

When EV owners grant a third party control of charging their vehicles, they will require more advanced communication than is likely available through AMI. Because the primary use of an EV is for transportation, owners will need some level of confidence that their vehicles will be charged when they need them for travel. EV owners will need to be able to coordinate and communicate this information with third party controllers. This functionality has been developed, so this gap ultimately becomes more a question of implementation and adoption, and is therefore explored in more detail in Section 4 of this report.

2.3 Metering

Relative to EV charging, metering is defined as the ability of the utility or aggregator to accurately measure the charge and discharge of the EV battery to and from the grid. Therefore, it is necessary to be able to separately measure the EV energy use from the overall building energy use. AMI has the potential to do this operation, although this functionality requires that the EV have its own dedicated circuit, and most utility AMI is installed with a single point of measurement. Submetering mechanisms, such as a branch circuit energy management device, as used in Consolidated Edison Inc.'s (ConEd) EV pilot project,[2] also potentially provide this functionality. However, these mechanisms do not currently qualify as revenue grade meters meeting State regulatory performance standards.

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2 *Electric Vehicle Pilot Report, Case 13-E-0030*. (Consolidated Edison Company of New York, Inc., 2015).

Additionally, EVs are capable of collecting this data, and EVSE can be equipped to measure energy exchanged. These mechanisms do not currently qualify as revenue grade meters either, and it is not clear whether they will meet utility performance standards. Additional metering technology and verification will likely be needed. That need must be determined for utilities to recognize EV or EVSE data for metering and billing purposes and to ensure that EV owners and operators are fairly compensated for their participation in grid-interactive vehicle programs.

2.4 Bidirectional Charging

As grid-interactive vehicle infrastructure and systems evolve, one of the primary questions regarding technological requirements is if or when automakers will make commercially available EVs with on-board, bidirectional inverters. As discussed in this project's Preliminary Research Report, bidirectional power transfer has been accomplished on retrofitted and custom built EVs, but this technology is not yet made available in commercial, personal EVs in the United States. For fully integrated EVs to provide vehicle-to-grid (V2G) and V2B services, vehicles will need to be equipped with bidirectional inverters and safety controls to prevent backflow.

Vehicles with DC fast charging ports are technically capable of this bidirectional power flow (with the AC to DC and DC to AC conversions occurring in the DC fast charging equipment). However, use of EV batteries for bidirectional charging will void the manufacturer's battery warranty. The primary concern is battery degradation. Recent research indicates that batteries in grid-interactive vehicles providing frequency regulation are not subject to significant changes in state of charge, meaning that the battery charge and discharge involve very small amounts of energy over very short durations. Batteries used as a regulation market resource do not indicate increased degradation or decreased battery life from the additional operation.[3] However, like other grid-interactive vehicle uses, this has only been shown in small scale applications and additional research and testing is necessary to determine the impact of this and other types of bidirectional charging on EV batteries.

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[3] S. Shinzaki, H. Sadano, Y. Maruyama, and W. Kempton, "Deployment of Vehicle-to-Grid Technology and Related Issues," (Society of Automotive Engineers, International, 2015). http://papers.sae.org/2015-01-0306/

The lack of bidirectional charging is not a limiting factor for all grid-interactive vehicle applications. Controlled charging, both indirect (through dynamic rates) and direct (through smart charging), can be accomplished through uni-directional charging by modulating the rate of charging or curtailing charging altogether. Also, EVs serving as demand response (DR) resources in wholesale market programs do not require bidirectional power flows. However, for the full benefits of EVs to be realized in providing power back to buildings and to the grid, bidirectional capacity is necessary and a gap exists in understanding the full implications of bidirectional charging.

2.5 Standards

The American National Standards Institute (ANSI) created the Electric Vehicle Standards Panel (EVSP) to "foster coordination and collaboration on the standardization matters among public and private sector stakeholders to enable safe, mass deployment of electric vehicles and associated infrastructure in the United States with international coordination, adaptability, and engagement."[4]

The EVSP developed a strategic roadmap, *Standardization Roadmap for Electric Vehicles Version 2.0*[5] ("roadmap") in May 2013, as well as a *Progress Report: Standardization Roadmap for Electric Vehicles Version 2.0*[6] ("progress report") in November 2014. The roadmap assessed existing standards and identified necessary future standards to enable national EV deployment and identified gaps, or significant issues of concern that are not addressed in current standards. The progress report assessed the progress made in addressing the standardization gaps identified in the roadmap.

In the progress report, the EVSP explored 61 issue areas. Within these issue areas, there were 13 cases in which no gaps were found; four new gaps were identified; three gaps were previously closed; one closed gap was re-opened; and one additional gap was closed. This gap analysis resulted in identifying 44 total open gaps.

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4 Electric Vehicles Standards Panel of the American National Standards Institute, 2014. http://www.ansi.org/standards_activities/standards_boards_panels/evsp/overview.aspx?menuid=3

5 *Standardization Roadmap for Electric Vehicles, Version 2.0.* (Electric Vehicles Standards Panel of the American National Standards Institute, 2013). http://publicaa.ansi.org/sites/apdl/evsp/ANSI_EVSP_Roadmap_May_2013.pdf

6 *Progress Report: Standardization Roadmap for Electric Vehicles, Version 2.0*. (Electric Vehicles Standards Panel of the American National Standards Institute, 2014). http://publicaa.ansi.org/sites/apdl/evsp/ANSI_EVSP_Progress_Report_Nov_2014.pdf

Many of these gaps indirectly apply to grid-interactive vehicles. For example, the report identified one gap that pertains to power rating methods, stating that "standards for electric vehicle power rating methods are still in development" (p. 13).[7] More significantly, within the issue of "Vehicle as Supply," the report identified three gaps, including differences in distributed energy resource (DER) model definitions, certification standards for mobile inverters, and interconnection agreements for mobile inverters.[8] As the EVSP tracks progress in removing barriers or gaps to mass deployment of EVs, it will be critical to address standards related to the development and facilitation of grid-interactive vehicle infrastructure.

2.6 Consistency and Standardization Among Charging Equipment Technologies

Similar to the issue of standards development is standardization, or the adoption of consistent technologies. Specifically for DC fast charging EVSE, there are currently three different types of connector technologies being used: CHAdeMO, Tesla, and SAE Combo. Although manufacturers currently make adaptors for the CHAdeMO and SAE Combo, there is no adaptor between the Tesla charger and other DC fast chargers. Standards exist for DC fast charging, but the adoption of consistent connection technologies for DC fast charging is important in the facilitation of vehicle-to-grid interaction.

In addition to connector technologies, consistency in functionality of chargers will impact the development and adoption of grid-interactive vehicle infrastructure. Features in need of consistency include accepted forms of payments, rates, metering standards, display design, and handicap accessibility. It is possible that the software and hardware necessary for grid-interaction will be able to be applied to various EVSE configurations, but consistency among technologies and connections will best support large-scale, efficient roll out and adoption.

[7] *Progress Report: Standardization Roadmap for Electric Vehicles, Version 2.0*. (Electric Vehicles Standards Panel of the American National Standards Institute, 2014). http://publicaa.ansi.org/sites/apdl/evsp/ANSI_EVSP_Progress_Report_Nov_2014.pdf

[8] Ibid.

3 Retail and Wholesale Electricity Market Opportunity Gaps

As the largest potential source of new electric revenue for utilities and energy service companies (ESCOs), EVs provide opportunities in both retail and wholesale electricity markets. Retail market opportunities include demand-side management (DSM) activities such as indirect-controlled charging through voluntary TOU rates, smart or controlled charging, and V2B applications, all capable of mitigating negative impacts of electric load growth and saving money for EV owners and operators.

Additionally, various pilot project results suggest that grid-interactive vehicles have the potential to serve as regulation and storage resources for wholesale electricity markets. EVs are well suited for participation in the Ancillary Service Markets, particularly as frequency regulation resources. EVs are able to provide near-instantaneous balancing of load and generation and have successfully participated in wholesale market pilot programs as regulation resources. EVs also have the potential to participate in DR programs, as spinning reserves, as energy imbalance resources, and in providing voltage control.

This section identifies and discusses the gaps that serve as barriers to EVs participating in the State's retail and wholesale electricity markets.

3.1 A Common Framework

Although there appears to be a general understanding of the grid-interactive vehicle concept among stakeholders in New York State, there is not a common framework describing the various use cases for grid-interactive vehicles in the State. To understand the market opportunities at both the retail and wholesale levels, a common framework should be developed that allows stakeholders to communicate efficiently. The literature suggests that V1G is used to describe EVs serving as interruptible load, either through on/off charging or modulating the rate of charge; some have also referred to it as "V2G half."[9] At the utility or distribution level, smart charging or controlled charging is a more commonly used

[9] F. Tuffner, and M. Kintner-Meyer, *Using Electric Vehicles to Meet Balancing Requirements Associated with Wind Power*. (Pacific Northwest National Laboratory, 2011). http://energyenvironment.pnnl.gov/pdf/PNNL-20501_Renewables_Integration_Report_Final_7_8_2011.pdf

terminology. Alternatively, V2G or "V2G full" involves discharging the batteries to either a building (V2B) or the local distribution circuit (V2G) if power flows from the vehicle are greater than the energy used at the building premises. The California Public Utility Commission developed a common framework for describing what they call Vehicle Grid Integration (VGI) that is organized around three dimensions:

- Direction of power flow at the point of the EV's interconnection.
- Coordination of objectives of actors that control devices necessary to complete a transaction for grid services.
- Number of resources included within a transaction for grid services.[10]

Developing a common framework or adapting an existing framework will help facilitate dialogue and a shared understanding of grid-interactive vehicle opportunities among EV stakeholders in New York. Furthermore, this common framework will help to facilitate consumer understanding and acceptance of the grid-interactive vehicle opportunity in New York. The approach developed in California highlights and brings clarity to the issues regarding potential conflicting objectives among participants in the EV supply chain. For example, the owner of a public charging station may have different objectives than the EV owner using the equipment to charge the vehicle. Thus, initial grid-interactive vehicle systems will likely be adopted first by residential customers and private EVSE owners, for example EV fleet operators. EV stakeholders in New York will benefit from a deeper understanding of the objectives of the different participants with an interest in seeing the development of a grid-interactive vehicle architecture; this is particularly important when developing new business model designs to quantify the monetary value of EVs as grid resources.

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[10] Adam Langton and Noel Crisostomo, *Vehicle-Grid Integration: A Vision for Zero-Emission Transportation Interconnected throughout California's Electricity System*. (California Public Utilities Commission, Energy Division, 2013). http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M081/K975/81975482.pdf

3.2 Economic Analysis

The literature suggests that grid-interactive vehicles can provide value at the retail level to both distribution utilities and to EV owners beyond the transportation services. The DOE/EPRI 2013 Electricity Storage Handbook describes this value as distribution infrastructure services (distribution system upgrade deferral and voltage support) and customer energy management services (power quality management, power reliability, retail energy time shift, and demand charge management) that distributed energy storage systems can provide.[11] This report refers to all of these, collectively, as retail services.

Currently, there is limited economic data regarding the costs and benefits affecting each stakeholder group by using EVs as energy storage resources. For example, the costs associated with the necessary distribution-level safety requirements, control and metering technology, as well as the costs of establishing and administering grid-interactive EV programs will all need to be considered. In addition, there is no cost-benefit analysis of the system-wide benefits of off-peak or dynamic charging of EVs in New York. These calculations are essential to the development of appropriate off-peak EV charging rates, to justify infrastructure investments, and to identify customer incentives necessary for direct-controlled charging.

An economic analysis is necessary to determine whether the potential benefits to the bulk power system outweigh the costs (including infrastructure investments) of enabling EVs to serve as grid resources at the wholesale level. First and foremost, EVs must meet customer expectations and requirements for transportation services, which places potential constraints on the use of EVs providing grid services at the wholesale level.

More broadly, EVs benefit all New York residents by reducing emissions from the transportation sector. Although past studies have analyzed potential emission-reduction benefits, it is not clear how these benefits can be monetized and used to guide public policy. One potential gap identified in research is the need for a statewide, holistic assessment of the energy and non-energy benefits of EV adoption in New York.

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[11] Abbas A. Akhil et al. *DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA*. (Sandia National Laboratories, 2013). http://www.emnrd.state.nm.us/ECMD/RenewableEnergy/documents/SNL-ElectricityStorageHandbook2013.pdf

3.3 NYISO Market Rules

The New York Independent System Operator (NYISO) is a national leader in developing market rules and innovative programs that allow loads and limited energy storage resources (LESR) to participate as grid resources through specific market- and reliability-based programs (see this project's Preliminary Research Report). It is necessary to evaluate these programs to better understand the challenges and opportunities for EV participation in these programs. There is a lack of understanding whether or not EVs can cost-effectively meet the specific technical and programmatic requirements, settlement processes, and signal and messaging processes necessary to qualify for NYISO's DR and LESR programs. EVs hold the potential to present a new form of load with latent energy storage capacity creating unique opportunities and challenges for vehicles to serve as grid resources at the wholesale level. Requirements for participation, notification and dispatch approaches, settlement requirements, and issues around metering and telemetry need to be evaluated and potential realignment strategies proposed to better accommodate grid-interactive vehicles if warranted.

One major barrier to overcome to enable EV participation in wholesale electricity markets is the small capacity of individual EV batteries coupled with the substantial minimum resource size required for participation in NYISO markets. Whereas other regional grid operators, CAISO and PJM for example, require a 500 kW minimum resource size, NYISO markets require twice that amount for participation in certain programs. Based on the average power rating of EVs currently on the market, it would take over 300 EVs to meet a 1-MW minimum resource size for participation in NYISO's demand side ancillary services program. If NYISO found value in having grid-interactive vehicles serve as a resource in the wholesale electricity market, one step NYISO could take to enable this would be to lower the minimum resource size for markets in which EVs could participate.

3.4 Business Model Development

As previously discussed, the divergence of potential interests along the EV value chain (EV owner, EVSE owner, distribution utility, etc.) is a barrier to monetizing the value of EVs as grid resources. Business models need to be developed that identify and align the economic interests of varied stakeholders to create a profitable pathway to grid-interactive vehicle use. There are a number of companies serving as DR or curtailment service providers, delivering aggregated individual curtailable loads to wholesale power markets. Large individual customers often participate directly in DR programs while smaller customers can participate through a curtailment service provider. These customers agree to a pre-specified amount of demand reduction; this provides grid operators with resources to call on during peak load events, to maintain capacity reserve margin, thus protecting grid reliability. The payment for these services should benefit both the customer and the overall grid. From a resource adequacy perspective, DR payments are generally more economical than the investment in extra generation capacity to cover the peak hours. For companies providing curtailment services, any loss in production or inconvenience in operations due to curtailing energy must cost less than the payments they receive.

This model is not necessarily appropriate for the use of EVs as a grid service. To qualify as a DR resource, loads must first be established as consuming power during peak demand hours. The amount of curtailable load is determined using a baseline of what the customer would ordinarily be consuming during peak load hours. As previously discussed and in this project's Preliminary Research Report, the most economical approach to EV charging would be to avoid these high demand periods, with incentives in the form of TOU rates or payments to allow for direct load control. Distribution companies and load serving entities have the most to gain from direct load control programs. These companies could serve this function or a new business opportunity could emerge for entities to provide direct load control management services.

In the future, given a significant amount of economical V2G resources available in the State, new business models will be needed to aggregate individual DERs for participation in wholesale power markets. To date, there are no examples of companies aggregating distributed generation or storage resources for participation in energy markets. Ultimately, a successful business model can only be realized if the benefits of providing such services outweigh the costs; as discussed above there is currently no empirical evidence to support this notion.

One element of this business model will be the aggregation of EVs or EVSE to meet minimum market resource sizes. As discussed in the Preliminary Research Report, even if NYISO lowers their minimum resource size, aggregation of vehicles will still be necessary for market participation. Aggregation to meet a minimum resource size can take the form of the aggregation of the EVs themselves or the aggregation of charging stations (EVSE). If EVs are aggregated, the vehicles will communicate with the aggregator; the location of charging will not be a factor. If EVSE are aggregated, the aggregator dispatches the equipment, and the specific vehicle connected is less relevant. This distinction is important because it largely determines where the intelligence (controls and communication technology) needs to be located. In either case, technology will be needed to combine the multiple resources (either EVs or EVSE) into what will serve as a single resource to the ISO.

Additionally, questions regarding cost-effectiveness of various technology options and adoption of best practices should be considered in a business model that incorporates both regulation and market forces.

3.5 Information on Charging and Driving Behaviors

Data on EV use and charging behaviors provides necessary information for the development of New York's grid-interactive vehicle infrastructure. Basic information is needed on how long EV owners are connected to an EVSE, and what percentage of the time the vehicle is actually charging. In addition, driving behaviors must be more fully understood. NYSERDA and ConEd have begun to collect this data on a limited basis; these efforts should be expanded and EV stakeholders should be given access to these data sets for planning purposes.

The largest data set on EV driving and charging behaviors was developed through the U.S. Department of Energy's EV Project program, the nation's largest EV deployment and monitoring program. With thousands of EV charging events recorded, data from the EV Project shows that the EVSE infrastructure is underused. Between 35 and 50 percent of home Level 2 chargers are not being used during evening hours and 87 to 97 percent of away-from-home Level 2 chargers are not being used during daytime hours.[12] Given an opportunity to generate revenue by providing grid services, EV owners would have an incentive to connect to the grid through an EVSE whenever possible, thereby increasing the utilization of the charging infrastructure. The EV Project also found that EVs are connected to chargers much longer than it takes to fully charge the vehicles. In one location, EVs were connected to a charger 32 percent of the time but drawing power only 7 percent of the time.

At this time, the EV Project data is rather dated and may not reflect consumer driving and charging behaviors of New York EV owners. NYSERDA has been collecting similar data for the past two years on approximately 450 EVSE units, albeit a smaller number of EVSE units than the EV Project. Additionally, NYSERDA's data collection to date has been limited to EVSE in public, workplace, and multifamily locations; no data on single-family residential charging behavior has been collected. The ConEd EV pilot project is very limited with approximately 50 EV owners participating. The pilot program is focused on testing the ability of metering technology to separately meter EV load in single-family residential premises and is evaluating participants' responsiveness to peak demand information.

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12 S. Letendre, K. Gowri, M. Kintner-Meyer, and R. Pratt. *Intelligent vehicle charging benefits assessment using EV Project data*. (Pacific Northwest National Laboratory, 2013). http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-23031.pdf

This pilot project is also collecting valuable consumer behavior data, but again from a very limited set of participants. The limited amount of EV owner driving and charging behavior data is a barrier to more fully analyzing grid-interactive vehicle opportunities. In addition, developing a mechanism for utility notification of EV registrations would enable better data collection and understanding of residential charging behaviors. In sum, a coordinated effort in New York is necessary to build valid data sets that characterize EV owners' driving and charging behaviors, which should be made available to EV stakeholders.

4 Policy/Regulatory Gaps

Much could be written about policies and regulations that would support the expansion of EVs and EV infrastructure in New York. One could speak of tax incentives, cash incentives, financing options, air quality standards, low carbon fuel standards, carbon taxes, and vehicle registration waivers, among other mechanisms to grow the EV market. However, as with the previous task's Preliminary Research Report, this gap analysis makes the assumption that the EV market will continue to grow, EV infrastructure will continue to expand, and EV adoption will reach a point of providing a significant potential resource for grid storage. With this assumption in mind, this analysis focuses on regulatory and policy gaps that can be addressed to facilitate grid-interactive vehicle infrastructure in a streamlined and efficient manner.

From an energy policy perspective, there is a lot going on in New York right now. The New York State Public Service Commission (PSC) issued its Track 1 Order in the Reforming the Energy Vision (REV) proceeding. The Commission's Track 2 Order is expected as the next step in the proceeding. Meanwhile, the Clean Energy Fund (CEF) Proposal cites "accelerated electrification of the transportation sector" as one of its Strategic Priorities and Target Areas to reaching advanced Sustainable Transportation goals. The New York State Energy Research and Development Authority's (NYSERDA's) Clean Energy Fund proposal states:

> By highly leveraging the CEF with other available State and Federal funding, NYSERDA will support the development, validation, and commercialization of products and services that provide sustainable energy improvements. Target areas include: electric transportation including rail and plug-in vehicle infrastructure, H2, electric and hybrid heavy duty vehicles, idle reduction, freight transport efficiency, and transportation demand management.[13]

Electric transportation could help offset the 40% of State greenhouse gas emissions that come from the transportation sector. It could also present a new and important source of revenue for electric utilities. The outcome of current State energy proceedings and policy topics in this section will impact the future role of EVs in the State.

[13] Clean Energy Fund Proposal to the New York Public Service Commission, (New York State Energy Research and Development Authority. 2014, page 83). http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BDABF6A8A-17A5-441F-AC44-48587105CF6D%7D

4.1 Communication and Metering

As introduced in Section 2, the necessary technology for communication and metering of grid-interactive vehicle programs exists, but it is unclear which mechanisms will enable the most efficient integration of EVs with the grid. These mechanisms and devices—including AMI, smart charging enabled EVSE, direct communication with EVs, and other measurement and control solutions—are all available in the marketplace but may not meet utility revenue grade standards. To advance grid-interactive vehicles in New York, control and metering technologies and mechanisms will need to be tested and verified as meeting the functional requirements expected of revenue grade meters.

4.2 Dynamic Pricing Rates

An early step in the process of EV adoption in the State is the basic need to mitigate EV charging's impact on the grid. An important mechanism at the State level is regulation by the PSC to ensure that EV owners/operators have access to appropriate dynamic pricing and TOU rates that adequately incentivize off-peak charging while limiting additional expenses such as separate meter fees, which erode the financial benefits of off-peak charging. Without such charge-control mechanisms, EVs have the potential to, for example, contribute to summer peak load if EV owners arrive home with their vehicles at 6:00 p.m. and commence charging.

In addition to the expanded use of controlled charging equipment (as discussed earlier in this report), complementary rate structures are needed to incentivize charging during off peak times. M.J. Bradley & Associates'[14] identified and reviewed plug-in electric vehicle tariffs in other states including California, Michigan, and Virginia. The report concludes that New York utilities and PSC should pursue pilot offerings through both TOU rates and off-peak charging rebate programs. Information collected from these pilot programs will help determine which rate structures and incentives are most effective at encouraging off-peak EV charging. As EV penetration in the State reaches numbers where their potential as storage is viable, well-designed rate structures and incentives will facilitate EV's role as DERs.

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14 M.J. Bradley & Associates LLC, *Electricity Pricing Strategies to Reduce Grid Impacts from Plug-in Electric Vehicle Charging in ew York State*. June, 2015. Prepared for New York State Energy Research and Development Authority. http://www.mjbradley.com/sites/default/files/NYSERDA-EV-Pricing.pdf

4.3 Distribution-Level Planning

As EV use grows, it will be important to ensure that the local distribution system is able to support additional load from EV charging, particularly when DC fast charging is involved. In an *Electric Energy* article, author Scott Lang cites a 2010 Electric Power Research Institute (EPRI) study that suggests "if two customers on the same transformer plugged in 6.6 kW charging stations during a peak time, their charging load, in addition to existing load, may exceed the emergency rating of roughly 40 percent of today's distribution transformers."[15]

DC fast charging, in particular, may present such challenges to the distribution infrastructure. One vehicle using DC fast charging adds load equivalent to 43 vehicles charging via Level 1 chargers or the household usage of 45 houses.[16] It is unlikely that residential customers will install DC fast chargers, due to higher purchase costs and the typical practice of overnight rather than quick recharging. However, distribution utilities will need to work closely with EVSE installers to ensure that DC fast charging infrastructure will not have a negative impact on distribution transformers or other elements of the grid.

Similar to methods used to measure the effects of DERs, evaluation protocols of distribution level impacts of EV adoption and potential storage integration need to be assessed, selected, and implemented.

4.4 Land Use Planning

Policy-based land use planning that includes charging stations and addresses distribution-level grid upgrades will be important to the realization of a grid-interactive vehicle infrastructure. For example, when new construction is undertaken, the installation of EVSE adjacent to parking spaces or in garages requires additional planning. Municipalities currently either mandate EVSE deployment or rely on market forces to provide opportunities. Given the low market share of EVs, policies that require EV charging infrastructure (like that recently adopted in New York City requiring that 20 percent of new off-street parking spaces be EVSE-ready) are intended to accelerate EVSE build-out over relying on market growth only.

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[15] Scott Lang, "Electric Vehicles and the Smart Grid: Charging Forward!" http://www.electricenergyonline.com/show_article.php?mag=&article=542

[16] John Gartner, "DC Charging Could Accelerate Grid Impact," *plugincars*, October 11, 2010. http://www.plugincars.com

4.5 Storage Requirements

New York's Public Service Law commits to the conservation of energy through the development of alternate energy production facilities, among other mechanisms. Within its definition of alternate energy production facility New York statute includes battery storage: [17]

> The term 'alternate energy production facility,' when used in this chapter, includes any solar, wind turbine, fuel cell, tidal, wave energy, waste management resource recovery, refuse-derived fuel, wood burning facility, or energy storage device utilizing batteries, flow batteries, flywheels or compressed air, together with any related facilities located at the same project site, with an electric generating capacity of up to eighty megawatts, which produces electricity, gas or useful thermal energy.

The Statute goes on to reference the State Energy Plan for additional policy guidance. There are currently no procurement targets or storage requirements in New York Statute. The lack of statutory storage requirements or battery storage procurement targets at the State level suggests a policy approach with limited accountability. In 2013, the California Public Utility Commission adopted a storage procurement mandate that requires the three large investor-owned utilities to add 1.3 gigawatts of energy storage to California's grid by 2020.[18] The lack of storage procurement targets in New York may not necessarily be a gap, but the lack of regulatory incentives does not facilitate grid-interactive vehicle infrastructure.

4.6 Distribution of Benefits

Section 2 addressed the need to measure the energy exchanged in grid-interactive vehicle programs. Section 3 addressed the need to accurately value the benefits provided by grid-interactive vehicles. This section focuses on the gaps that exist in determining how the benefit created is distributed along the EV value chain.

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[17] New York State Energy Law § 21-106: New York Code – Section 21-106: Co-generation, small hydro and alternate energy production facilities, 1.b. http://codes.lp.findlaw.com/nycode/ENG/21/21-106

[18] Jeff St. John, "California Passes Huge Grid Energy Storage Mandate," *Greentechgrid, October 17, 2013.* http://www.greentechmedia.com/articles/read/california-passes-huge-grid-energy-storage-mandate

The value generated by grid-interactive vehicles introduces questions not currently addressed in State policy or utility regulation. For example, an EV owner participating in the wholesale regulation market would simultaneously fill the roles of both a retail customer and a wholesale market resource; how the EV owner would be charged and compensated for these services has yet to be determined. Similarly, an EV could potentially provide multiple benefits to the grid, but current regulations preclude this, which limits the full benefits from being realized and captured. The value of the benefits created by EVs can vary by location; how to capture this variation in value is an important question that must be addressed to appropriately distribute the benefits of grid-interactive vehicles. Additionally, the State's net metering program does not include energy storage devices. Some challenges are evident in the idea of allowing energy storage devices to net meter.[19] Of primary concern is a situation in which customers could receive net-metered credits for energy not produced by an on-site renewable generator. This situation could arguably undermine a key policy intent of net metering: increasing the use of renewable energy.

Understanding and accounting for these dynamics are important elements of appropriate compensation. Ultimately, these questions must be addressed to determine how to most fairly and appropriately compensate each participant, including EV owners, EVSE owners, distribution utilities, and the grid operator.

4.7 EV Integration as Part of REV

Any regulatory analysis in New York would be incomplete without mention of the REV proceeding. The development of broad, statewide energy and transportation policy as part of the REV proceeding would facilitate the adoption of grid-interactive vehicles in New York. The REV proceeding is a closely watched, highly public, regulatory initiative to promote energy efficiency, expansion of renewables, a more distributed and resilient grid, and increased customer engagement. The REV straw proposal cites two-way power flows and advanced communications as criteria of a distributed grid for New York.[20]

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19 Sky Stanfield and Amanda Vanega, *Deploying Distributed Energy Storage: Near-term Regulatory Considerations to Maximize Benefits*. (Interstate Renewable Energy Council, 2015). http://www.irecusa.org/2015/03/deploying-distributed-energy-storage-near-term-regulatory-considerations-to-maximize-benefits/

20 "Developing the REV Market in New York: DPS Staff Straw Proposal on Track One Issues" (State of New York Department of Public Service proposal to New York Public Service Commission, 2014, page 13). http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BCA26764A-09C8-46BF-9CF6-F5215F63EF62%7D

In addition, REV proposes two models for the incorporation of DERs into retail and wholesale markets. One option is direct incorporation of DERs with wholesale markets (through NYISO) and the other is through distribution utilities that already bid into the wholesale markets.[21] In the second scenario, the utility could bid load and aggregated resources into the NYISO markets.[22] Active engagement by EV owners with their distribution utility will be critical to wide scale adoption of EVs without adding to peak load and to developing potential storage opportunities.

If properly managed, the adoption of EVs in the State has the potential to contribute to each of the six objectives for REV:

- Enhanced customer knowledge and tools that will support effective management of the total energy bill.
- Market animation and leverage of customer contributions.
- System wide efficiency.
- Fuel and resource diversity.
- System reliability and resiliency.
- Reduction of carbon emissions.[23]

As referenced in the REV Track 1 Order, the U.S. DOE identified potential risks associated with poorly managed EV deployment: “As mentioned above, achievement of carbon reduction goals will likely require electrifying transportation, including a substantial shift to electric vehicles. A large penetration of electric vehicles has potential to strain distribution infrastructure, as recharging may occur during evening hours which are already a summer peak time on many residential distribution circuits.”[24]

However, the REV Track 1 Order also identifies the potential of EVs to support the grid and serve as a storage resource: [25]

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21 Developing the REV Market in New York, page 17.

22 Developing the REV Market in New York, page 20.

23 *Order Adopting Regulatory Policy Framework and Implementation Plan*, State of New York Public Service Commission, 2015, page 4. http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b0B599D87-445B-4197-9815-24C27623A6A0%7d

24 Order Adopting Regulatory Policy Framework and Implementation Plan, page 24.

25 Order Adopting Regulatory Policy Framework and Implementation Plan, page 27.

> DSP [distributed system platform] markets can assist a transition to electric vehicles by turning what could be a strain on distribution systems into a valued asset. Electric vehicles present great opportunity if coordinated with grid functions to provide storage and voltage support. Electric vehicles can also increase utility sales and reduce rate pressure caused by infrastructure needs.

The first two objectives of the REV proceeding involve customer engagement, an area in which EV owners are particularly strong. A whitepaper published by the Edison Foundation and the Institute for Electric Efficiency found that EV owners were disproportionately engaged electric customers: [26]

> Interestingly, our analysis also revealed that the strategy with the potential to return the greatest financial benefit to utilities and customers alike is to focus on accelerating the adoption of EVs. Households that have EVs, which represented only about 1.25 to 1.5 percent (12,500 to 15,000) of the hypothetical 1 million customers in a service territory, created a disproportionately high share of the overall consumer-driven savings, indicating that even modest increases in EV adoption will have a large impact on benefits.

In summary, the policy and regulatory decisions that are made now will affect the degree to which the electrification of transportation in the State will serve as a grid asset through DR, storage, and load flattening.

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[26] Faruqui et al., "The Costs and Benefits of Smart Meters for Residential Customers," The Edison Foundation Institute for Electric Efficiency, 2011). http://www.edisonfoundation.net/iei/Documents/IEE_BenefitsofSmartMeters_Final.pdf

5 Conclusion

This analysis has identified gaps in standards and technologies, gaps in EV participation in retail and wholesale electricity markets, and gaps in the policy and regulation landscape. While the technologies necessary for grid-interactive vehicles currently exist, they have not been demonstrated at scale. In order to implement broad adoption of grid-interactive vehicles, gaps in technologies, standards, policies, and regulations will need to be addressed. Addressing these gaps early and building a policy and regulatory framework that anticipates and addresses potential barriers will help facilitate widespread, commercially viable applications of vehicle energy storage to build a stronger, more resilient electric grid in New York State.

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