



Mary Krayeske
Associate Counsel
Law Department

June 8, 2018

Honorable Kathleen Burgess
Secretary
State of New York Public Service Commission
Three Empire State Plaza
Albany, NY 12223-1350

Re: **Case 14-M-0101 – Proceeding on Motion of the Commission in Regard to Reforming Energy Vision (“REV Proceeding”) - Demonstration Projects**

Dear Secretary Burgess:

Pursuant to the Public Service Commission’s February 26, 2015 *Order Adopting Regulatory Policy Framework and Implementation Plan* in the above-referenced proceeding, Consolidated Edison Company of New York, Inc. submits the attached REV Demonstration Project Outline: Electric School Bus V2G.

If there are any questions, please contact me.

Sincerely,

/s/ Mary Krayeske

Mary Krayeske

Attachment



REV Demonstration Project Outline

Electric School Bus V2G

June 8, 2018

1 EXECUTIVE SUMMARY

School buses are an untapped market segment for vehicle electrification with the potential for significant system and societal benefits. First, the buses daily driving schedule enables charging during predominately off-peak hours, which can improve network efficiency and increase system load factor. Second, their seasonal schedule provides for the ability to function as summertime energy storage, serving the grid at peak periods, and potentially reducing the need for system upgrades. Third, the use of electric buses reduces air pollution exposure to children, a particularly vulnerable population segment.

In this demonstration project, Consolidated Edison Company of New York, Inc., (Con Edison or the Company) and its third-party partners seek to test a new business model for electric school buses. The bus operator, National Express, will operate five electric school buses in White Plains during the school year. During the summer months, when the buses are not used for transportation purposes, they will serve as grid-connected energy storage assets. The bus operator will forego the ability to operate these buses during that period. Con Edison will retrofit the buses to enable vehicle-to-grid (V2G) capability.¹ This demonstration will answer both economic and technical questions, including whether the vehicle batteries are durable and capable of maintaining storage capacity and vehicle range despite the additional utility charge/discharge cycles over the summer. If successful, the project may help to reduce customer concerns about electric buses, the risks of using their transportation assets for grid services, and create a new revenue stream that improves owners' total cost of ownership (TCO). It will also help to prove the operational viability of electric school buses, which are in limited deployment but gaining interest across the country.

This demonstration will include a partnership among (1) Con Edison, (2) National Express, (3) Lion Electric (bus manufacturer),² (4) First Priority Green-Fleet³ (project lead) and (5) the New York State Energy Research and Development Authority (NYSERDA).

The five buses will serve the White Plains public school district. During the school year, these buses will park and charge overnight. From June 15 through August 31 (buses' summer period), the buses will park at National Express's Northern White Plains depot and be used as grid-connected energy storage assets over six hours at an aggregate 75 kW (15 kW per bus). The buses are expected to discharge for V2G purposes for three summers (2019-2021).

¹ A vehicle to grid (V2G) asset is an electric vehicle that can discharge power from its battery to the power grid on command.

² Lion has 150 e-buses operating in North America. Most are in Canada, but 40 operate in California and several in Massachusetts as well.

³ First Priority Green Fleet is the North American dealer for Lion Electric.

The demonstration of shared assets between Con Edison and the bus operator is unique. This project is possible because the seasonal electric system peak demand during the summer cooling season generally aligns with the off-season for school bus operators. As energy storage resources available during the peak system demand, electric buses can provide grid value and thereby generate an additional revenue stream for the bus operator. This additional revenue stream would improve the TCO for the bus operator, which may support increased e-bus adoption and may foster a larger, long-term supply of energy storage for the grid.

Under the demonstration project, Con Edison would pay approximately 25 percent of the purchase cost of buses, 25 percent of the cost of chargers, and all of the V2G costs. The federally funded New York Truck – Voucher Incentive Program (NYT-VIP), run by NYSERDA in New York, would contribute to buying down a large portion of the vehicle cost.⁴ If this demonstration project is successful, and the preconditions listed in section 3.2 are met, a broader transition to electric school buses could provide material load relief and pollution reduction across Con Edison’s service territory. More than 8,000 school buses currently operate in Westchester County and New York City. According to Eric Goldstein, CEO of New York City School Support Services, 70 percent of the New York City’s available school buses are unused during summertime. If fully electrified, those unused buses could provide approximately 450 MWh of energy storage, potentially adding between 85-112 MW of peak shaving capability. Furthermore, because buses are mobile, these storage assets could be deployed to areas of system need for the summer period.

Completely transitioning the school bus fleet from diesel fuel to electricity could eliminate 185,000 tons of CO₂ annually and would reduce ground-level emissions of harmful diesel pollutants such as particulates and NO_x.⁵ These outcomes would advance the State’s public policy goals, including reaching the Zero Emissions Vehicle mandate, and achieving the goal to deploy 1,500 MW of energy storage by 2025.

2 BUSINESS MODEL OVERVIEW

2.1 PROBLEM/ MARKET OPPORTUNITY

This project seeks to address the impediments to the adoption of both electric school buses and V2G technology.

Bus operators have been slow to adopt electric school buses, because of their cost. Moreover, operators have little experience purchasing, operating, and maintaining electric models, leading them to discount

⁴ As noted in the Company’s cover letter, the NYT-VIP program expires on June 30, 2018. As funding available through this program is critical to the project’s success, the Company respectfully requests expedited review of this filing so that program funds can be applied for and used.

⁵ This assumes 80 kWh usable battery capacity.

the benefits of lower fuel and maintenance costs. This demonstration project and the transparent results it will provide could demonstrate the viability of additional revenue streams and reduce the customer uncertainty that is currently inhibiting the uptake of this new technology.

V2G deployment has also been slow. To date, the majority of V2G tests have not focused on customer willingness. Studies have analyzed how V2G might create revenue, but there have been no market tests of a scalable business model in the New York metropolitan area. This demonstration project will help to test the benefits of grid-connected energy storage including local resiliency, improved system utilization, and the potential to defer traditional infrastructure upgrades.

The slow uptake of these technologies means that harmful tailpipe emissions from diesel buses continue despite a viable alternative technology, a problem in its own right. Conventional school buses are diesel-fueled, often old vehicles. In the New York metropolitan area, school buses have an average lifespan of a little over fourteen years. The local pollution effects are particularly harmful for children and bus drivers and can lead to a higher propensity of asthma and respiratory ailments.⁶ Electric school buses, however, fully eliminate ground-level tailpipe pollution and reduce climate change impacts.

2.2 SOLUTION

Con Edison proposes an electric school bus vehicle-to-grid (V2G) project to demonstrate viable operations of electric school buses as both transportation and energy storage assets. The hypothesis is that the shared use of electric school buses makes this new technology more affordable for the bus operator and the utility. The project will:

- Increase one bus operator's experience with electric bus models and lower customer barriers to adoption
- Create a revenue stream for bus operators that improves electric school bus TCO
- Develop grid energy storage assets

Bus operators may find using their vehicles for V2G attractive because of the potential to increase revenue without conflicting with their core transportation business. In the New York metropolitan area, most buses are unused in the summer months, which is the time of the highest demands for electricity and, therefore, the highest values of energy storage. Given these complementary usage profiles, electric school buses offer the potential to serve both transportation and grid needs. By sharing an asset, Con Edison and the bus operator can improve economics of this new technology.

Numerous pilots have used vehicles as energy storage devices, powering either a building (i.e., V2B) or feeding into the grid (i.e., V2G). This functionality requires grid communication and bidirectional power flow. However, the primary reason past pilots have not scaled is the lack of an addressable market. Because of the relatively high capacity market prices in New York City, coupled with the potential future

⁶ Adar, S. D., D'Souza, J., *Adopting Clean Fuels and Technologies on School Buses. Pollution and Health Impacts in Children*. American Journal of Respiratory and Critical Care Medicine (June 2015).

opportunity to contribute to distributed energy resource markets and Non-Wires Solutions projects in Con Edison's service territory, wider-scale adoption of these resources in New York City and Westchester County may create more benefits than in other areas of the country. This project would provide valuable information on how the business model of V2G systems could benefit bus operators, bus riders, utility customers, and the public in New York City and Westchester County.

2.2.1 BUSINESS MODEL OVERVIEW

National Express, a school bus fleet operator in the greater New York metropolitan area, will purchase five electric buses from Lion Electric, the bus manufacturer. National Express will be the owner and operator of the school buses. These buses will operate out of National Express' North White Plains depot.

First Priority GreenFleet (First Priority), the V2G provider for the project, will manage the project. First Priority has previously implemented several EV and V2G pilots for entities including the Air Force, Army, UPS, and FedEx.

First Priority will manage three project elements:

- The eLion PEV battery electric Type C school buses, which are equipped with bi-directional DC components and 100 kWh of battery capacity per bus
- BTCPower's upgraded charging stations, which will be equipped with UL-certified inverters to provide AC power back to the grid
- EV Connect's open platform, a cloud-based service for smart charging and power management for load balancing in a three-phase power environment, real-time analysis of electricity usage, and V2G scheduling capability

Con Edison will pay the costs of bus modifications for bidirectional charging and discharging and will cover one quarter of the charging infrastructure costs. Con Edison will operate the buses as a V2G asset between June 15 through August 31 each year, during which time National Express will forego the ability to use the buses. The buses will remain at National Express's Northern White Plains bus yard, plugged into the installed V2G hardware, which will be operated and maintained by First Priority.

2.2.2 PROJECT MODEL VS. ANTICIPATED FUTURE MARKET MODEL

In the project model, National Express will forego all use of the buses during the summer months. The vehicles would remain on National Express's property, plugged in to the V2G grid connection, and programmed to send power back into the grid daily from 1pm-7pm, and charge between the hours of 11pm-5am. The National Express' bus depot located in Con Edison's White Plains network, peaks between 2-6 pm. While this area of the distribution system does not currently experience constraints, the batteries will provide incremental load relief on a demonstration-basis that could be extended in the future to areas of the system with greater need. The bus batteries could support various system needs should they arise. Con Edison and First Priority will adjust the discharging window as needed, to include evening discharge.

The future market model could remain the same or be modified. One possibility is that the V2G could provide additional grid services other than distribution load relief, for example, as participants in NYISO

markets. Markets for energy storage are still developing. Another possibility is that the buses could provide grid services year-round when not in transit. Such changes could include:

- Con Edison modifications:
 - Relocating buses to, or targeting bus fleets in, areas of larger grid need. 26% of New York City contracted school buses are in current locational system relief value (LSRV) networks.⁷ In those areas, a single school bus could provide nearly \$40,000 of net present locational distribution capacity value⁸
 - Allowing the operator to use buses throughout the summer, but reserving the rights to use the buses on call for demand management
 - Expanding the program size and number of participating bus operators
 - Testing different V2G technology
 - Using different size batteries, or coupling the bus batteries with other storage or generation resources onsite to better manage coincident charging demand on the system
 - Changing the hours of discharging into the system
 - Increasing the amount of power and energy discharged per bus

- Operator modifications:
 - Potential to participate in additional NYISO markets, *e.g.* ancillary services
 - Using a portion of the bus batteries for building peak shaving
 - Testing V2G discharging during seasons other than summer

⁷ New York City Open Data

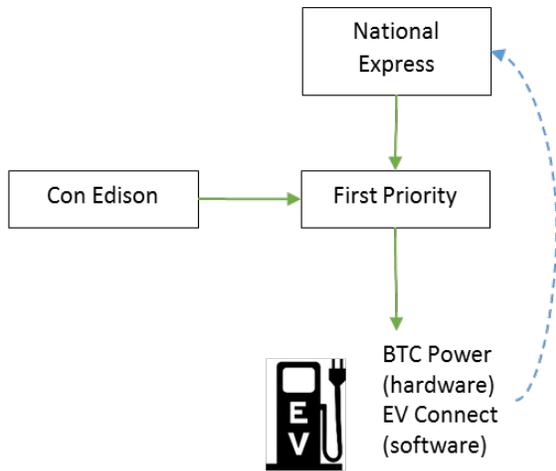
⁸ NPV of LSRV values only, 8% discount rate
https://www.coned.com/_external/cerates/documents/elecPSC10/StatVDER-CRED-7.pdf

2.2.3 COST AND REVENUE SHARING

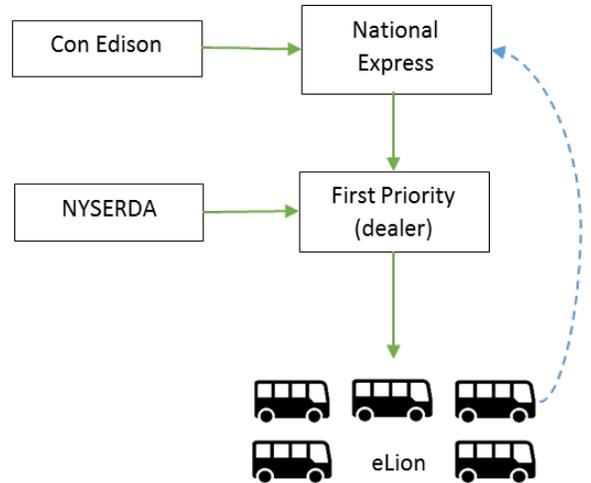
Con Edison will work with several partners to finance the project components.

Exhibit 1: Financing and procurement relationships

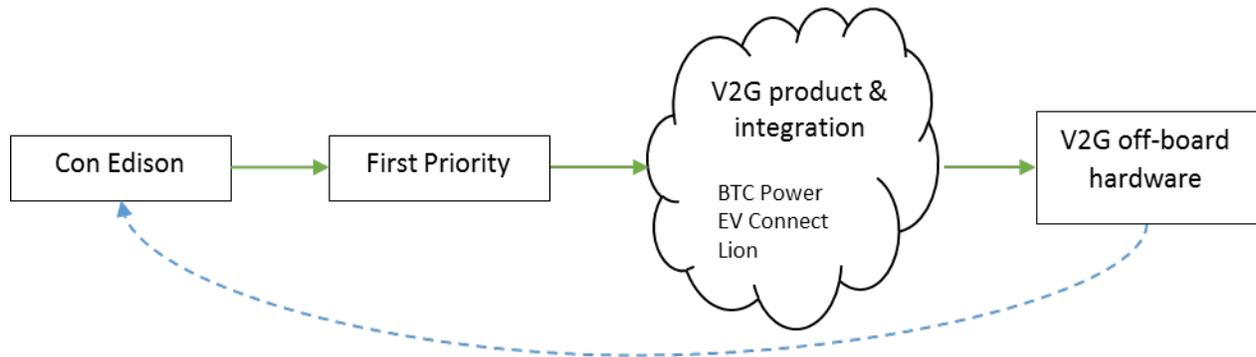
National Express pays for 75% of chargers, Con Edison pays 25%



74% of bus funding supplied by National Express & NYSERDA



Con Edison pays for V2G implementation



* Green arrows denote financial flows; blue dashed arrows show asset transfers

Con Edison will pay one quarter of the costs for the buses and vehicle chargers. This is commensurate with use of the buses and chargers – Con Edison will have sole usage rights for nearly 25 percent of the year (i.e., the summer, plus various mid-year testing), while National Express will use the buses for the

rest of the year. National Express and NYSERDA will pay 75 percent of the costs of purchasing the vehicles and installing the chargers.

Con Edison will also pay for the V2G costs, which include modifying the buses, managing the discharge, and purchasing the off-board inverters. Con Edison will be responsible for energy costs during the summer period when it is using the buses exclusively to charge and discharge. Those costs include supply, demand, taxes, and meter fees.

National Express will pay all energy costs during the school year. Con Edison will pay National Express over three years for the rights to operate the buses as a V2G asset. Con Edison will pay First Priority to manage the V2G.

National Express will retain all revenue generated by the operation of the buses for transportation services. All revenue generated by the operation of the buses for grid purposes during the summer period, including arbitrage of wholesale market prices, and any other energy or capacity related services will be retained by Con Edison. Future revenues may also be generated through revised tariffs under the Value of Distributed Energy Resources proceeding, which may include a revenue stream intended to capture avoided emissions. Section 5.1 below details the expected project revenues.

Exhibit 2: Cost Share

	Con Edison	National Express	NYSERDA
Capital Expenses			
Vehicles (Lion)	26%*	35%	39%
Chargers (BTC Power)	25%	75%	-
V2G hardware	100%	-	-
Ongoing Expenses			
V2G Project Management (First Priority, EV Connect)	100%		
Energy Costs	100% of Summertime Costs	100% of School Year Costs	
Maintenance & Operating Costs (EV Connect)		100%	

* Paid for over 4 periods: upfront and after each summer V2G period

2.2.4 HYPOTHESIS TO TEST

- 1. A school bus with V2G technology can function as a dual-use asset—transporting children during the school year and functioning as a grid asset over the summer, without extensive impacts to asset life or maintenance**

This hypothesis has not been tested in New York City or Westchester County. Using these resources as dual-use assets is a question of both business viability and technical feasibility. To validate the use of buses for transporting children during the school year and as a grid asset in the summer, satisfaction surveys will be given to the bus operators. Surveys will be issued to other bus operators to gauge their interest and willingness to participate in a similar program. On-site monitoring through the connected system will validate that the bus is grid connected and ready to be used during summer periods. Bus battery and asset health will be monitored during the term of the pilot.

- 2. Electric buses paired with V2G technology can create a positive business case for bus operators, through lower operating costs and additional grid-based revenue streams**

First Priority will convene and survey bus fleets on EV interest and various V2G models to assess how much impact energy revenue has on purchasing decisions. The company will also provide a study, including analysis of potential project benefits and costs.

- The value of the V2G technology will be assessed by tracking the power output of the buses over each season. The vehicle range will also be monitored seasonally to track the overall battery performance of the buses. Regressions of range based on weather and temperature will show if V2G affected battery life
- The project administrator for the V2G, First Priority, will also provide performance reports that include details on vehicle uptime, miles per kWh, and driving performance
- First Priority will provide performance reports that include details on vehicle, and chargers: uptime, miles per kWh, maintenance events, labor hours and parts required. First Priority will compare fuel and maintenance costs between the electric buses and comparable conventional ones
- National Express will analyze its other routes and release a study describing its ability to convert more vehicles

A comparison of the value of the power, cost of the battery degradation (i.e., potentially shortened life), and other costs and benefits will help to validate this hypothesis.

3. V2G technology can provide reliable power

The demonstration project will test the effectiveness of the buses as storage resources. Buses will be monitored in real-time to determine the batteries responsiveness to commands, output level, power quality, and output duration. The Company will also test whether the buses have the technical ability to provide other battery services, such as frequency regulation.

4. Bus service purchasers, such as school boards and municipalities are willing to pay more for service provided by electric vehicles

First Priority will do in-person surveys of school districts and operators to learn what electric bus benefits they most value, including reduced local pollution, climate impacts, rider and driver comfort, and fuel costs. Surveys will also assess districts’ willingness to pay for these attributes.

2.3 LINKAGES TO DEMO PRINCIPLES

Principle	Proposed Measure
Partnership between utility and third-party service provider; goal of third-party capital contribution	The partnership responsibilities and cost sharing arrangements are described in exhibit 1. National Express and NYSEDA are contributing more than 75% of the bus and charger capital costs.
Utility to identify problems and market should respond with solutions	This project seeks to address the impediments to electric school bus adoption and V2G technology. First Priority responded to a Con Edison RFI to use school buses as batteries.
Clear delineation of how generated economic value is divided between the customer, utility, and third-party service provider; proposal for how much capital expense should go into the rate-bases versus competitive markets	Con Edison receives value of the using the vehicles as peak shaving assets during the summertime period. National Express receives payment from Con Edison in exchange for forgoing the use of the vehicles during the summer. Con Edison pays First Priority to implement and manage the project.
Market for grid services should be competitive	Con Edison will not own the battery asset – it is paying a third party for the rights to use its asset.

Principle	Proposed Measure
<p>Propose rules that will help create subsequently competitive markets; establish regulatory proposals to ensure safety, reliability, and consumer protection</p>	<p>The V2G test will inform future V2G interconnection and dispatch guidelines so that V2G assets can participate in competitive markets. The reliability of the assets can be assessed based on their performance during the demo, which will help for future reliability and safety criteria.</p>
<p>Utilities should explore opportunities in their demonstration to work with and include various residential, commercial, institutional, and industrial customer participants</p>	<p>The proposed demo enables participation in energy storage by a different customer group, school bus operators.</p>

3 MARKET ATTRACTIVENESS

3.1 UNIQUE VALUE PROPOSITION

3.1.1 PARTICIPATING CUSTOMER

The solution proposed enables joint utilization of energy storage / transportation assets by Con Edison and National Express. The payments from Con Edison provide better economics for the bus operator.⁹

Currently, electric buses cost approximately \$250,000 more than a conventional diesel school bus. However, benefits of operating an electric bus fleet rather than a conventional diesel school bus include:

- Potential energy storage revenue stream
- Lower annual fuel costs, reduction of maintenance, and elimination of oil changes and exhaust system costs accounting for savings in excess of \$10,000 per year
- A competitive advantage with health and environmentally conscious municipal and school customers
- Improved driver satisfaction -- increasing vehicle acceleration, reduced engine noise and vibration and eliminated tailpipe pollution improves driver work quality. This may translate into greater worker interest and employee retention

⁹ Con Edison will pay national Express after each summer of usage. This reduces the risk to Con Edison that the already paid for asset is unavailable.

3.1.2 PARTNER/ 3RD PARTY

There are several partners and third parties involved in this project:

- NYSERDA and the New York State Department of Transportation (“NYSDOT”) have developed a program utilizing federal funding to increase the adoption of alternative fuel vehicles. This program, the New York Truck – Voucher Incentive Program (NYT-VIP), exists, “to promote clean air and a sustainable future for New York’s transportation system [and] aims to accelerate the integration of advanced vehicle technologies in the commercial truck and bus sectors.”¹⁰ The federal program ends on June 30, 2018 and NYSERDA must provide documentation requesting funding prior to that date to have the project qualify for the funding. At this time, the Company has no reason to believe that the federal program will be extended beyond June 30, 2018
- Lion Electric Company is an all-electric bus and truck manufacturer founded in 2008. It has produced over 150 electric school buses for North America. This project will provide Lion with an opportunity to enter the New York metropolitan area school bus market
- First Priority will be the project implementer so that V2G technology can provide reliable, grid quality power that does not interfere with National Express’s operational needs. First Priority gains further expertise as a V2G operator

First Priority will license the EV Connect software platform for the demonstration period to monitor charge/discharge and BTC Power, V2G-compatible chargers. National Express has the potential to use the hardware for new revenue for discharging during the non-summer period.

3.1.3 LOCAL MUNICIPALITIES AND SCHOOL DISTRICTS

Municipalities and other customers can use this demonstration to determine whether e-buses are appropriate for their students and communities. In particular, schools that contract for bus services can use the demo results as a basis to request or favor e-buses in future solicitations. The vast majority of school bus routes in the Con Edison service territory are contracted. New York City contracts all its routes, and an internal New York Power Authority (NYPA) member survey shows an approximately even split between contracting and ownership. While both models can work for e-buses, municipalities that contract with third parties have a direct path to adopting e-buses.

3.1.4 OTHER BUS FLEETS

Other fleets will benefit from information gained from the deployment of the first full-sized electric school buses in the state. The operational experience will provide actual local data on electric school bus performance and operational costs.

3.1.5 UTILITY

Con Edison benefits from this demonstration pilot through increased V2G technical experience and potentially by increasing customer demand for e-busses. At the conclusion of this demonstration

¹⁰ <https://truck-vip.ny.gov/>

project, Con Edison will be able to review results and data and, if successful, could craft an offering for school bus operators throughout its service territory.

Initially, Con Edison will gain knowledge about how well buses can perform as batteries in terms of reliability, longevity, and safety. Experience with power quality, V2G uptime, grid interconnection, and bus availability will enable Con Edison to potentially incorporate this new type of asset into its programs. Deploying the first e-buses in the local market may also address operator uncertainty and catalyze upstream customer demand from schools and municipalities. Wider adoption of electric school buses could positively affect all its customers by reducing local air pollution and climate change emissions. Increasing electric vehicle adoption would help meet demand management, DER utilization, and climate change goals.

Vehicles are also mobile. While the ability to create grid compatible AC power is not a bus-based feature today, several bus manufacturers, including most recently Proterra, have announced the feature. On board V2G would enable e-buses to serve as emergency power during outages or be more easily transported to high need networks.

3.1.6 SYSTEM

Electric school buses have the potential to improve Con Edison's system utilization and increase the supply of energy storage. Each electric school bus would add an average of 7.2 MWh of load per school year. Buses can charge overnight and would create predominately off-peak load.

Electric buses can also expand the market supply of energy storage. Relatively little energy storage exists in the Con Edison service territory. The challenges include permitting, customer interest, and available space. Creating a new supply of energy storage from vehicles would make adding grid-connected, customer-sited storage easier.

3.2 ABILITY TO SCALE

The demonstration has the potential to demonstrate the viability of using an off-season electric school bus for grid-connected storage and can be scaled up. There are three important considerations to this ability to scale:

First, electric school buses currently cost approximately 3.5 times as much as a conventional diesel bus. Moreover, Lion is currently the only mass-market producer of full-sized Type C buses, which are greater than 20' in length and carry more than 60 passengers. However, other manufacturers are introducing electric Type C buses and it is hoped that competition coupled with declining component costs will ultimately reduce the price point of electric buses. Blue Bird, for example, one of the country's biggest bus manufacturers, is releasing an e-bus in 2018.¹¹ Thomas and IC Bus, the other major manufacturers,

¹¹ <https://www.businesswire.com/news/home/20180407005037/en/Blue-Bird-Electric-School-Buses-Road-Orders>

have also announced e-bus plans. States also have the option to use funding from the nearly \$3 billion Volkswagen diesel trust fund to purchase electric school buses.¹²

Second, school districts and local governments that have stated a desire for electric buses have to make purchasing commitments. A current New York City Council bill would require that school buses contracted by New York City either have advanced pollution controls or be electric¹³. NYPA has also surveyed its customers and found that 25% of municipalities were very or extremely interested in electric buses. That interest has to translate into firmer commitments to enable the market. This demo may encourage customers to require that they be served by at least some electric buses. Sixty-one firms operate New York City's 8,000 plus bus routes.¹⁴ Converting just five percent of those routes would result in hundreds of e-school buses and over 30 MWh of storage capacity. And, while costs would have to be managed, the City's current pupil transportation budget of over \$1.1 billion may enable EVs to be purchased at low overall budget impact.¹⁵

Finally, the value of network support to Con Edison may change over time – especially as bus depots in constrained areas transition to e-buses. This could add or subtract value from the summer-season revenue stream. Decrease in value of load relief may be offset by other revenue streams, such as wholesale market revenues. Other projects are testing the ability for batteries to participate in multiple energy markets. Section 7.2 identifies how battery revenue can impact overall school bus economics.

4 DEMONSTRATION PLAN

4.1 METRICS FOR SUCCESS

1. Ability to schedule and dispatch resources
2. High customer satisfaction
 - a. surveys indicating that National Express's customers are likely or very likely to require e-buses in future contracts
 - b. National Express commitment to buy additional e-buses
3. Expected levels of battery degradation - battery retains greater than 92 percent of initial range
4. 95 percent V2G uptime
5. Lower vehicle maintenance costs, as compared to benchmark conventional vehicles in National Express's fleet

¹² <https://www.epa.gov/cleandiesel/volkswagen-vw-settlement-dera-option>

¹³ <http://legistar.council.nyc.gov/LegislationDetail.aspx?ID=3343761&GUID=AB4AE61B-4A4D-47CB-BEBF-A5D7E6BEE6E0>

¹⁴ <https://data.cityofnewyork.us/Transportation/Routes/8yac-vygm>

¹⁵ <https://cbcny.org/research/citys-fourth-extension-school-bus-grant-program-should-be-rejected>

4.2 TIMELINES, MILESTONES, AND DATA COLLECTION

Phase	Key Elements	Milestones
Delivery of vehicles, and installation of chargers Q3/Q4 2018	Electrical relay added to buses to allow battery to output DC power, which occurs prior to delivery to National National takes delivery of buses EVSE hardware installed on site Management platform software connected to charger hardware V2G software module added to management software	Successful vehicle registration and inspection Electrical work permitted and approved by Westchester County Charger operation Scheduling of chargers based on load or time of day
V2G Commissioning September 2018	Beta testing components, system integration, V2G software control	Measured V2G at desired kW levels Appropriate power quality levels Shutoff in response to de-energized grid supply (as per UL standards)
Market Participation June 2019-September 2021	Daily V2G dispatch during summer period Scheduling by Con Edison or First Priority through web portal Validation that vendor adhering to company security standards	Vetting of cybersecurity procedures In-parameter battery degradation Output with minimal efficiency losses Fewer than five unplanned periods of resource unavailability

4.2.1 POLLUTION

First Priority will calculate GHG and NO_x reduction based on the power consumed during recharging phase and by weekly mileage reporting. The fuel efficiency (i.e., miles per kWh or kWh consumed per route) will be compared to several school bus benchmarks to determine avoided particulates and NO_x compared with normal school bus operations.

4.2.2 BATTERY PERFORMANCE

The EV Connect power management software will allow all the project parties to collect data on the life of the electric school buses and battery health. In the summer period, the EV Connect system will allow First Priority, under Con Edison's guidance, to control each individual charging station.

4.3 PARTICIPATION

National Express will operate 5 eLion type C buses from its depot at 14 Fisher Lane, North White Plains. National will use the buses for 5 of the depot's approximately 70 routes. These buses will likely serve the adjacent City of White Plains.

4.4 OUTREACH TO TARGETED COMMUNITIES

Con Edison will collaborate with National Express to raise awareness of the buses through:

- a. School bus branding
- b. Meetings – Con Edison will raise awareness with local schools and municipalities about the vehicles before, during, and after the test. Outreach will include Westchester County and New York City
- c. Fliers – the project partners will create handout material for interested parties, and for the bus drivers to distribute
- d. Technology demonstrations – the vehicles will be brought to local events, such as community street fairs, town halls, county fairs, and parades
- e. Industry showcases – the vehicles will be available for energy conferences, bus schedule permitting
- f. Environmental events – environmental events offer an opportunity to showcase the buses to interested parties
- g. Social and earned media – the company will use its channels to tell the story of the buses, both in terms of the grid benefits created, and pollution avoided

4.5 CONDITIONS/BARRIERS

Electric buses are a nascent market. Currently, Lion is the only provider of a full-sized Type C school bus. The buses themselves are approximately \$250,000 more expensive than conventional diesel buses.

4.5.1 RISK/MITIGATION STRATEGIES

RISKS	MITIGATION	Probability of Risk. Max: 100%	Severity of Risk. Max: 100%
<p>1. V2G hardware will not function properly</p>	<p>Responsible party: First Priority</p> <ul style="list-style-type: none"> • Utilizing off-board inverter to simplify system and use mature technology • Conduct root cause analysis and implement appropriate design or mechanical corrections • Partnership with the manufacturer to support troubleshooting 	5%	80%
<p>2. Power output, such as harmonics, not optimized for the grid</p>	<p>Responsible party: Con Edison</p> <ul style="list-style-type: none"> • Dedicated service and interconnection point to electric buses reduces risk of electrical interference from other building load • UL-certified inverter creates high quality AC power signal • Utilize Con Edison DER interconnection expertise and power quality team to formulate solution 	5%	70%
<p>3. Conflict among vendors/stakeholders on core deliverables</p>	<ul style="list-style-type: none"> • First Priority to reiterate project charter, clarify deliverables and facilitate resolution • Con Edison to withhold funds if deliverables not provided 	10%	20%
<p>4. Vehicles are damaged and become unable to perform V2G functionality</p>	<p>Responsible party: National Express</p> <ul style="list-style-type: none"> • National carries adequate insurance to replace and repair vehicles • Con Edison pays for V2G functionality after each summer. For example, the Company would pay National in the fall of 2019, 2020, and 2021. This reduces some financial exposure 	25%	70%

RISKS	MITIGATION	Probability of Risk. Max: 100%	Severity of Risk. Max: 100%
5. National Express unable to keep vehicles plugged in for bus V2G operations	Responsible party: National Express <ul style="list-style-type: none"> • Site bus chargers so they do not interfere with summertime school lot operations • Provide supplemental training and one-on-one briefings to increase level of comprehension before V2G period • Reiterate that payment is based on availability 	10%	10%
6. Hardware technology components are not interoperable as discovered during testing phase	Responsible party: BTC Power <ul style="list-style-type: none"> • Initiate corrections to ensure secure interface • Utilize fall 2018 and spring 2019 to address any commissioning challenges before summer 2019 V2G period • Test prior to summertime, including during school breaks and on weekends 	40%	50%
7. Technology components have security vulnerabilities	Responsible party: First Priority / EV Connect <ul style="list-style-type: none"> • Implement re-engineering to address vulnerabilities • Replace or reconfigure components • Electrically disconnect V2G components until vulnerabilities resolved • Maintain resource separation from the company's SCADA system 	20%	50%
8. Technology components exhibit lack of stability	Responsible party: First Priority <ul style="list-style-type: none"> • First Priority implement re-engineering to reduce possibility of failure • Begin testing as early as possible in 2018 to ensure stability by 2019 	20%	25%

RISKS	MITIGATION	Probability of Risk. Max: 100%	Severity of Risk. Max: 100%
9. Critical V2G systems malfunction or go down	Responsible party: First Priority <ul style="list-style-type: none"> • Conduct root cause analysis and implement appropriate design or mechanical corrections 	20%	25%
10. Batteries malfunction	<ul style="list-style-type: none"> • LG Chem batteries have thermal management systems to prevent overheating • Utilize warranty coverage for batteries, which covers both operations and V2G to get replacement batteries 	10%	15%

5 FINANCIALS

5.1 UTILITY REVENUE STREAMS

The system benefits from use of distributed energy storage assets represent the value proposition to the utility from the V2G demonstration. For the demonstration period, Con Edison will use the energy storage assets to support the local distribution grid. The proposed charge-discharge pattern generates minor value from energy arbitrage and reduced installed capacity (ICAP) requirements.

The long-term market value of bus V2G depends on how much revenue it can create and how little it interferes with the operator’s primary transportation purpose. The energy value could be derived from distribution system and/or wholesale markets. Those include:

- Value of Distributed Energy Resource (VDER) payments
- demand response
- facility demand reduction
- demand management,¹⁶ or as a
- non-wires solution

¹⁶ The 2019 Demand Management Program offers customers \$1,350/kW for on call 2-6 pm load reduction from batteries and requires a ten-year asset commitment. If they participated in this program e-buses would need to meet a similar time commitment.

As an illustration, the net present value (NPV) of VDER payments in a high value LSRV location would be approximately \$38,000 for an e-school bus. The system-wide Demand Management Program provides \$1,350 per kW, or a potential \$27,000 per bus. These are just two programs, but batteries can be monetized in other ways.

Several programs and demonstrations, such as Con Edison's "Commercial Battery Storage" and "Storage on Demand," are testing and honing the revenue streams for stationary and mobile battery energy storage. Electric school buses have the potential to function within those structures and leverage similar value stacks.

Finally, as with all electric vehicles, company customers may benefit from increased energy sales during off-peak periods. The utility will also receive approximately \$14,000 per year, per vehicle in increased delivery revenues from National Express charging the vehicles.¹⁷ If EV market scales and the vehicles charge off-peak they can put downward pressure on rates.

5.2 INVESTMENTS

The proposed Budget assumes the following costs to Con Edison:

- Payment for rights to use the vehicle as a grid asset
- 1/4th of the charge of EVSE equipment and related charges
- 100 percent of the EVSE upgrade cost for V2G
- Analysis and reporting fees
- Project management and administration

Total cost to Con Edison is **\$1,084,250** payable over four periods as follows:

1. By Q3 2018 \$480,800
2. Summer 2018 \$126,400
3. Summer 2019 \$233,900
4. Summer 2020 \$209,100
5. Summer 2021 \$34,000

6 REPORTING

Con Edison will report to the Commission every quarter on key demonstration metrics, which will allow Con Edison and the Commission to track the progress of the Project. All key metrics will be reported for the quarter, for the calendar year, and from the initiation of the demonstration project. Such data will be reported on an absolute and relative (i.e., to plan/budget) basis, and will include:

¹⁷ SC 9 Rate III, Voluntary Large Time of Day provides the lowest demand and delivery for overnight power during the bus operation period.

- Project costs
- Installation progress
- Energy consumption, energy used to power vehicle, energy discharged to the grid, and the availability of the vehicles to operate as a grid resource
- Avoided CO₂e
- Vehicle range, vehicle uptime, miles per kWh, energy consumed by propulsion and HVAC, and driving performance
- Total miles driven
- Reports on the discharging activities will include analysis of the savings achieved and potential revenue
- Lessons learned against key hypotheses
- Milestones achieved
- Recommendations for potential future programs

7 CONCLUSION

7.1 POST-DEMONSTRATION BENEFITS

7.1.1 QUALITATIVE

School bus operators have not yet embraced electric school buses. Customer uncertainty is high and the total cost of ownership is greater than conventional diesel school buses, despite significant environmental benefits. This demonstration will show potential electric school bus buyers how the vehicles function and reduce their uncertainty. It will also provide Con Edison with experience in sharing an asset that serves both transportation and grid functions. If successful, it may foster a new market for electric vehicles and potential additional grid assets for Con Edison. It also furthers collaboration and cost sharing between the state, the utility, and the private sector.

7.1.2 QUANTITATIVE

The project represents a major innovation to serve dual purposes, both to provide electric school buses new revenue and allow Con Edison to test using buses as storage devices. Con Edison will spend approximately \$1,009,200 for 75 kW of distributed resources and vehicle to grid deployment.

7.2 PLANS TO SCALE

Con Edison believes that given the declining cost curve for batteries, the operating cost advantage of electric drivetrains as compared to diesel ones, and the potential for V2G, the business model of dual-use vehicle battery assets may represent a sustainable, creative, and low-cost investment that can benefit all partners. In an analysis of e-bus economics, Con Edison compared potential incremental value streams available to the electric bus over its useful life to the incremental capital cost of an electric bus. Our analysis considers the declining cost premium of the electric bus as battery and balance-of-vehicle costs decline over time. The below table indicates the year electric school buses may become

economically viable compared to conventional diesel buses. The year in which NPV is positive indicates when to expect electric bus deployment to be economically viable and the V2G business model to scale.

Scenario	Potential Battery Revenue Streams			NYSERDA Subsidy	Value of an e-bus relative to a diesel bus	
	DRV	LSRV	NYISO Capacity		Year NPV Positive	NPV
Baseline	Bus without any battery revenue or vehicle subsidy				2022	\$2,400
1	✓			✓	2018/ 2020	\$7,000/ \$22,000
2	✓	✓	✓		2021	\$9,000
3	✓	✓			2021	\$5,000
4	✓		✓		2022	\$28,000
5	✓				2022	\$24,000

Con Edison’s modeling indicates that V2G hastens e-school bus economic viability and appreciably increases NPV.¹⁸ Absent incremental revenue streams or government subsidy, the value of the e-bus is in net avoided fuel and maintenance costs, and the e-bus is competitive with a diesel bus on a TCO basis starting in 2022.¹⁹ Scenarios one through five indicate that revenue streams enabled by the e-bus can make them competitive with diesel vehicles up to two years earlier than under the baseline case, and increase their overall value.²⁰

Con Edison will launch the project in 2018 and the demonstration period will span through 2021. If the project is successful, the Company anticipates that this demonstration could bridge to a larger scale program that generates grid benefits and an electric school bus market that benefits the entire state.

¹⁸ Based on a 14 year bus lifetime.

¹⁹ Vehicle projections from Bloomberg New Energy Finance 2018 Electric Vehicle Outlook. Fuel and maintenance savings based on current diesel prices, elimination of motor fluid and pollution control systems, and reduction in brake pad replacements.

²⁰ Distributed Resource Value (DRV) and LSRV derived from 6/1/2018 Con Edison VDER value stack credit statement. Capacity based on 5/2/2018 DPS ICAP cost projections.

7.3 ADVANTAGES

The REV initiative's goals include changing the energy system to incorporate a more distributed and resilient architecture, engage customers, increase system utilization, further positive electrification, and create new business models to enable utilities and third parties to successfully and profitably build and operate this new system. The proposed project is consistent with the intent and criteria of REV and will advance the evolution of the grid, through the deployment of a significant energy storage asset that can serve multiple uses, and the advancement of a new business model.