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REV Demonstration Project:  
Electric School Bus V2G  
2019 4Q Quarterly Progress Report

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Dated: January 31, 2020

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## **1.0 EXECUTIVE SUMMARY**

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Consolidated Edison Company of New York, Inc. (“Con Edison” or the “Company”) submits this 4th quarterly report for 2019 on the progress of the Electric School Bus V2G REV Demonstration Project (the “Project”) it is implementing as part of the Reforming the Energy Vision (“REV”) proceeding, as required by the Order Adopting Regulatory Policy Framework and Implementation Plan, issued by the New York State Public Service Commission (“Commission”) on February 26, 2015.<sup>1</sup>

### **1.1 PROGRAM ACHIEVEMENTS**

On June 8, 2018, Con Edison submitted the Project for approval by Department of Public Service Staff (“DPS Staff”). On June 20, 2018, DPS Staff approved the Project. Con Edison filed an implementation plan for the Project with the Commission on November 13, 2018. In Q4 2019, the Company continued to focus on the implementation of the Project, specifically integration of vehicle to grid technology.

### **1.2 CYBERSECURITY AND PERSONALLY-IDENTIFIABLE INFORMATION PROTECTION**

Consistent with Commission policy related to cybersecurity and the protection of personally-identifiable information (“PII”), each partner agreement executed for the implementation of the Project includes, where applicable, specific protections related to cybersecurity and PII. This protection is critical in encouraging customers to sign up with new and innovative services offered by utilities.

### **1.3 ACCOUNTING PROCEDURE ESTABLISHED**

On February 16, 2016, in Case 15-E-0229, Con Edison filed an accounting procedure for the accounting and recovery of all REV demonstration project costs.<sup>2</sup> This accounting procedure establishes a standardized framework that will govern how the Company categorizes and allocates the costs of the REV demonstration projects and will facilitate analyzing each project to determine the overall financial benefits of the program to customers.

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<sup>1</sup> Case 14-M-0101, *Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision*, Order Adopting Regulatory Policy Framework and Implementation Plan (issued February 26, 2015).

<sup>2</sup> Case 15-E-0299, *Petition of Consolidated Edison Company of New York, Inc. for Implementation of Projects and Programs that Support Reforming the Energy Vision*, General Accounting Procedure.

## **1.4 COSTS, BENEFITS, AND OPERATIONAL SAVINGS**

Budget information for all of the Company's REV demonstration projects is being filed confidentially with the Commission, concurrently with the filing of this document. All costs filed are incremental costs needed to implement the projects. To reduce overall project costs Con Edison worked closely with NYSERDA to take advantage of an expiring grant program.<sup>3</sup>

## **1.5 ELECTRIC SCHOOL BUS V2G**

The Project is designed to examine the technical and operational viability of using school buses as both a grid resource and transportation asset. Key tests include determining whether electric school buses function well for transportation purposes, are reliable as grid assets, and whether their use as grid assets does not cause excessive wear and tear on the equipment. Con Edison has partnered with First Priority Green Fleet ("First Priority"), who is responsible for Project management, design and construction of vehicle and site hardware, and vehicle to grid ("V2G") operations and analysis.

In Q4 2019, Con Edison, First Priority, Nuvve Corp ("Nuvve") and Lion Electric ("Lion") continued to make progress on V2G implementation, overcoming several technical setbacks. The first V2G bus has been retrofitted with the V2G hardware. Software issues that are preventing the two way inverter from charging are being isolated by Nuvve, Lion and the inverter supplier. Pending the completion of several tests, the first bus will return to service and discharge power onto the grid. It is expected that the remaining buses will be retrofitted over an upcoming school holiday.

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<sup>3</sup> The federally funded NYT-VIP program.

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## **2.0 ELECTRIC SCHOOL BUS V2G – QUARTERLY PROGRESS**

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### **2.1 DEMONSTRATION HIGHLIGHTS**

#### **2.1.1 Q4 2019- Major Task Completion**

- Project Planning:
  - All major Project planning complete
- Phase 1: Electric Bus Operations & Analysis:
  - Buses operational for 332 school days (2018-2019)
- Phase 2: Design and Construction of Charging & V2G Infrastructure
  - All V2G site hardware completed
  - V2G retrofit of first bus primarily complete

#### **2.1.2 Activities Overview**

##### **Phase 1: Electric Bus Operations and Analysis**

The electric school buses performed their primary student transportation function well. This was the key Phase 1 goal. The V2G bus retrofit took one bus out of service for five weeks. The remaining four buses had an uptime of 95% in Q3 and Q4 of 2019.

Reliability has been stable and excellent. The drivers that used to operate the non-electric school buses have continued to operate the electric vehicles and continue to report high vehicle satisfaction, according to the quarterly survey of National Express performed by First Priority.

In late 2018, First Priority successfully installed cellular data loggers that are intended to capture miles travelled, energy per trip, state of charge (SoC), and energy per mile. These data help detail the cost of operating an electric vehicle and the range in real world driving and weather conditions. The data loggers are accurately reporting miles travelled and vehicle location but do not currently calculate energy metrics accurately. This issue has been identified by First Priority and Lion and will be addressed after the V2G integration is completed. In the interim, National Express has shared their additional electric costs determine financial impacts of bus charging.

## **Phase 2: Design and Construction of Charging and V2G Infrastructure**

The development of V2G is ongoing. The Project partners are using an on-board alternating current inverter that has required additional development from Lion and Nuvve. Despite the downsides of new engineering, on-board V2G offers several advantages. In comparison to on-board V2G, one on-board inverter replaces the work of two inverters (one is utilized on the vehicle for charging, and one is utilized off the vehicle for discharging). At scale this solution reduces fundamental cost and on-site space requirements. During Q4 2019, the Project team researched pathways for on-board V2G to become a scalable solution, including ways to gain Underwriter Laboratories (UL) and state interconnection (SIR) certification. The technical pathway for V2G became clearer—UL certification would lead to more, more economic deployment options..

During Q4 2019, Lion created new wire harnesses to install the new inverter on its vehicles. Its technicians completed the hardware retrofit of the first bus in White Plains prior to January 2020. The Project team intended to install software on the bus to allow it to perform with V2G in December 2019. However, the software behaved unexpectedly, and did not properly respond to charge signals. Working closely with the inverter manufacturer, Nuvve has continued to test new software versions, Lion and Nuvve will perform tests of charge and discharge behavior before installing the software on the bus in White Plains. After the software is installed, the Project will begin its testing phase. The site construction is complete and Lion estimates it will take 2-3 days to retrofit the remaining buses.

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### **2.1.3 Key Metrics**










The following data supports the Phase 1 goals of reliability and bus performance.

- E-school bus days of operation: 332
- Vehicle failures due to out of specification range: 0
- Misleading range data provided to driver: 0




### **2.1.4 Next Quarter Forecast**

In Q1 2020, the Project team aims to complete V2G commissioning, including operating a V2G test vehicle on site and having the buses be fully upfitted. The necessary V2G hours for the test will be preserved by discharging during school vacation and weekends.

## 2.1.5 Checkpoints/Milestone Progress

Checkpoint/Milestone	Timing*	Status
Buses Perform as Expected as Transportation	Phase 1 Midpoint / End	  
Network integration and System testing	Phase 2 Midpoint / End	  
Battery and vehicle impacts evaluated and documented	Phase 3 Midpoint / End	  

### Legend

 On Schedule	 Delayed w/out Major Impact	 Delayed or Stopped – Project Goals Impacted
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## 2.1.6 Planned Activities

### 2.1.6.1 Customer Acquisition

**Status:** **Green**

**Expected Target by Phase 1 Midpoint:** No vehicle failures due to below specification range or misleading data provided to driver.<sup>4</sup>

**Actual by Phase 1 Midpoint:** No vehicle failures due to below specification range or misleading data provided to driver.

**Solutions/strategies in case of results below expectations:** Use diagnostic data to determine cause of failures. Work with customer (National Express) to pursue any out of specification vehicle failures with manufacturer.

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<sup>4</sup> Maximum range for these vehicles is 80 miles per charge. Use of heating, air-conditioning and regenerative braking are all factors that can affect range. An example of misleading data provided to the driver would be the bus reporting 40 miles of driving range when in fact only 20 is available. This would make the vehicle unreliable from the driver's perspective.

### **2.1.6.2 Construction/Commissioning and Integration**

Status: **Yellow**

**Expected Target by Phase 2 Midpoint:** Inverter hardware works 100% of the time after pre-summer V2G period diagnostic testing. Software responds to all communication signals and control V2G discharge.

**Actual by Phase 2 Midpoint:** N/A

**Solutions/strategies in case of results below expectations:** Software troubleshooting methodology from past V2G projects, onsite testing, and potential hardware replacement. Testing of onsite hardware separate from vehicle integration to isolate problem.

### **2.1.6.3 Battery and vehicle impacts evaluated and documented**

Status: **Green**

**Expected Target by Phase 3 Midpoint:** V2G use expected to have little quantitative or perceived impact on the vehicle's primary transportation asset value. Performance targets are .3%-2% per season.

**Actual by Phase 3 Midpoint:** N/A

**Solutions/strategies in case of results below expectations:** Reduce depth of discharge and peak state of charge to see if battery wear impacts can be reduced to expected parameters. Explore cell temperature controls.

## **2.2 CHANGES TO THE PROJECT DESIGN**

Nuvve's use of on-board invertors as opposed to off-board invertors has required site design changes, including the addition of a relay and contactor common in CHP distributed generation.



## 2.3 WORK PLAN & BUDGET REVIEW

### 2.3.1 Phase Review

The Project team has completed its Project Planning and made progress on Phase 1 (Bus Operations and Analysis) and on Phase 2 (Design and Construction of Hardware and V2G Infrastructure).

### *Phase Progress*

#### 2.3.2 Work Plan

Phase 1 – Electric Bus Operations and Analysis (Completed)

	Activity	Description	Responsibility			
			FPGF	Con Ed	Lion	Nuvve
<b>Timeframe: April 1, 2018 – December 31, 2018</b>						
1.1	Delivery of buses to FPGF/NJ	Sales transaction completed; full payment rendered by NELLC; buses shipped from The Lion Electric Company in Montreal	X		X	
1.2	Pre-inspection and preparation	Buses pre-inspected, customized, detailed and prepared for delivery	X		X	
1.3	Bus delivery to White Plains Bus Company (“WPBC”)	Buses arrive at WPBC and pass inspection by DMV	X		X	
1.4	Training	FPBS provides operational and technical training to WPBC personnel	X		X	
1.5	Buses operational	Buses deployed on designated routes and fully functional	X		X	
1.6	Performance analytics	Initial data collected from charging stations, bus telematics, and data loggers	X			
1.7	Quarterly reports initiated	Initial performance data analyzed, findings produced and reported	X	X		

*Phase 2 – Design and Implementation of Charging and V2G Infrastructure (Underway)*

	Activity	Description	Responsibility			
			FPGF	Con Ed	Lion	Nuvve
<b>Timeframe: July 1, 2018 – May 31, 2019</b>						
2.1	Pre-installation Engineering plan	Site assessments, engineering drawings	X			
2.2	Electrical service request	Con Ed receives service request from FPGF	X			
2.3	Service plan	Assessment by Con Edison, issuance of service upgrade plan		X		
2.4	EVSE installation plan	Assessment by Healy Electricity, issuance of EVSE site plan	X			
2.5	Equipment ordering	EV Connect orders BTCPower hardware/equipment	X			
2.6	EVSE installation	BTCPower charging stations installed without V2G capability or smart charging capability	X			
2.7	EVSE testing	Testing on “BTCPower dumb chargers” to ensure charging functionality	X			
2.8	Chargers operational and networked	Chargers able to charge buses and connected to ChargePoint Energy Management Platform (EMP)	X			
2.9	Commissioning and training	EV Connect and ChargePoint provide training on charger operations to WPBC personnel	X			
<b>Timeframe: June 1, 2019 – September 30, 2019</b>						
2.10	Charging station swap	Nuvve orders and delivers 5 PowerPort charging stations to WPBC in place of BTCPower chargers	X			X
2.11	Charging station swap	FPGF contracts Healy Electric to replace BTCPower chargers with Nuvve units, relays and disconnects.	X			X
2.12	Activation and Training	Nuvve confirms that charges are fully functional and commissions “charging only” functionality				X
2.13	Bus modifications	Lion NRE design and development: Lion completes schematics, wire selections, harness assemblies, enclosures and connectors			X	
2.14	Bus modifications	Lion decommissions existing onboard charger			X	
2.15	Bus modifications	Lion purchases and installs new inverters and CurrentWays onboard chargers			X	
2.16	Bus modifications	Lion creates new interface program to enable power rates and V2G charging schedules			X	X
2.17	Bus modifications	New Lion configuration retrofitted on all buses			X	
2.18	Bus modifications	Road testing successfully completed all buses			X	
2.19	Bus modifications	Repair of data logger connections			X	
2.20	Bus modifications	Nuvve configures and places Nuvve VSL onboard Lion vehicle			X	X
2.21	Bus modifications	Nuvve develops and configures required CAN messages between VSL, charger, and vehicle systems			X	X

	Activity	Description	Responsibility			
			FPGF	Con Ed	Lion	Nuvve
2.22	Commissioning	Nuvve charging stations commissioned to communicate with Nuvve platform in place of ChargePoint EMP				X
2.23	Bench Test	Bench test of V2G discharge at Lion facility by August 2019			X	X
2.24	Commissioning	Nuvve configures WPBC buses on Nuvve aggregator for grid services				X
2.25	Integration full fleet	Complete installation of equipment and commission five buses			X	X
2.26	Commissioning and training	Nuvve and Lion test charging and discharging, conduct troubleshooting and ensure V2G full functionality; provide training to WPBC			X	X

*Phase 3 Activities, Deliverables and Timeframe:*

	Activity	Description	Responsibility			
			FPGF	Con Ed	Lion	Nuvve
<b>Timeframe: October 1, 2019 – September 30, 2021</b>						
3.1	V2G commissioning and launch	Fall 2019 full launch of V2G	X	X	X	X
3.2	V2G baseline	Summer 1 2019 battery baseline established with assistance from ChargePoint	X			X
3.3	V2G analysis 1	Fall 2019; data collected from Nuvve platform, buses and charging stations compiled, analyzed and findings reported	X			X
3.4	V2G continues Summer 2	Summer 2020 V2G deployed for second evaluation period	X	X	X	X
3.5	V2G analysis 2	Fall 2020; data collected from Nuvve platform, buses and charging stations compiled, analyzed and findings reported	X			X
3.6	V2G continues Summer 3	Summer 2021 V2G deployed for third evaluation period	X	X	X	X
3.7	V2G analysis 3	Fall 2021 data collected from Nuvve platform, buses and charging stations compiled, analyzed and findings reported	X			X

### 2.3.3 Updated Budget

Budget information is being filed confidentially with the Commission.

## **2.4 CONCLUSION**

### **2.4.1 Lessons Learned**

Phase 1's primary goal was to determine whether the electric buses function well in providing transportation. The buses are meeting expectations. Phase 2 has demonstrated that the V2G can be compatible with the SIR process, using either off-board invertors, the original plan, or on-board invertors, the revised plan.

### **2.4.2 Recommendations**

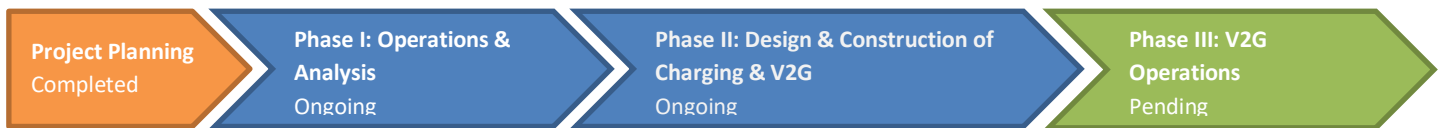
None at this time.

## Electric School Bus V2G REV Demo Project

The **School Bus V2G** (vehicle to grid) demonstration project (the "Project") is designed to examine the technical and operational viability of using school buses as both a grid resource and transportation asset. Key tests include proving that electric school buses function well for transportation purposes, are reliable as grid assets, and that using them as grid assets does not cause excessive wear and tear on the equipment.

The buses have been performing as transportation since September 2018. Project partners make progress towards implementing a scalable V2G model.

Project Inception: June 2018  
 Project Launch: September 2018  
 Project End Date: September 2020  
 Budget: \$1.08M  
 Q4 2019 Spend: *Filed confidentially*  
 Cumulative Spend: *Filed confidentially (on budget)*



### Lessons Learned: Customers (bus operator)

- Success requires embracing operational changes for maintenance staff and drivers
- The buses have succeeded because they have been reliable, with a minimum of fit & finish issues
- The Company hopes to use e-buses as a competitive advantage

### Lessons Learned: Market Partner

- Con Edison is one of the first test markets of V2G and they are uncertain of national demand
- Locally, NY-area operators need an e-bus provider that can provide the transportation, electrical infrastructure, and any V2G integration

### Lessons Learned: Utility

- V2G, as designed in this Project, can go through existing DG interconnect processes
- UL has a standard for on-board AC V2G that may be able to be revised expeditiously

**Application of Lessons Learned:** *The Company is working to operationalize V2G and reduce deployment costs.*

**Issues Identified:** The subcontractor required to provide the charger hardware and communication chips to enable V2G was replaced with Nuvve. This delayed the first summer discharge period. Project partners have been managing the problem and have an alternative that maintains the Project's fundamentals.

**Recent Milestones:** *a) No vehicle failures from technical causes or otherwise b) 332 days of school bus operations c) software incompatibility identified and addressed*

**Upcoming Milestones:** *Upfit existing school buses, initiate school bus discharge.*