Beneficial Electrification School Bus Vehicle-to-Grid (V2G) Pilot Evaluation Executive Summary

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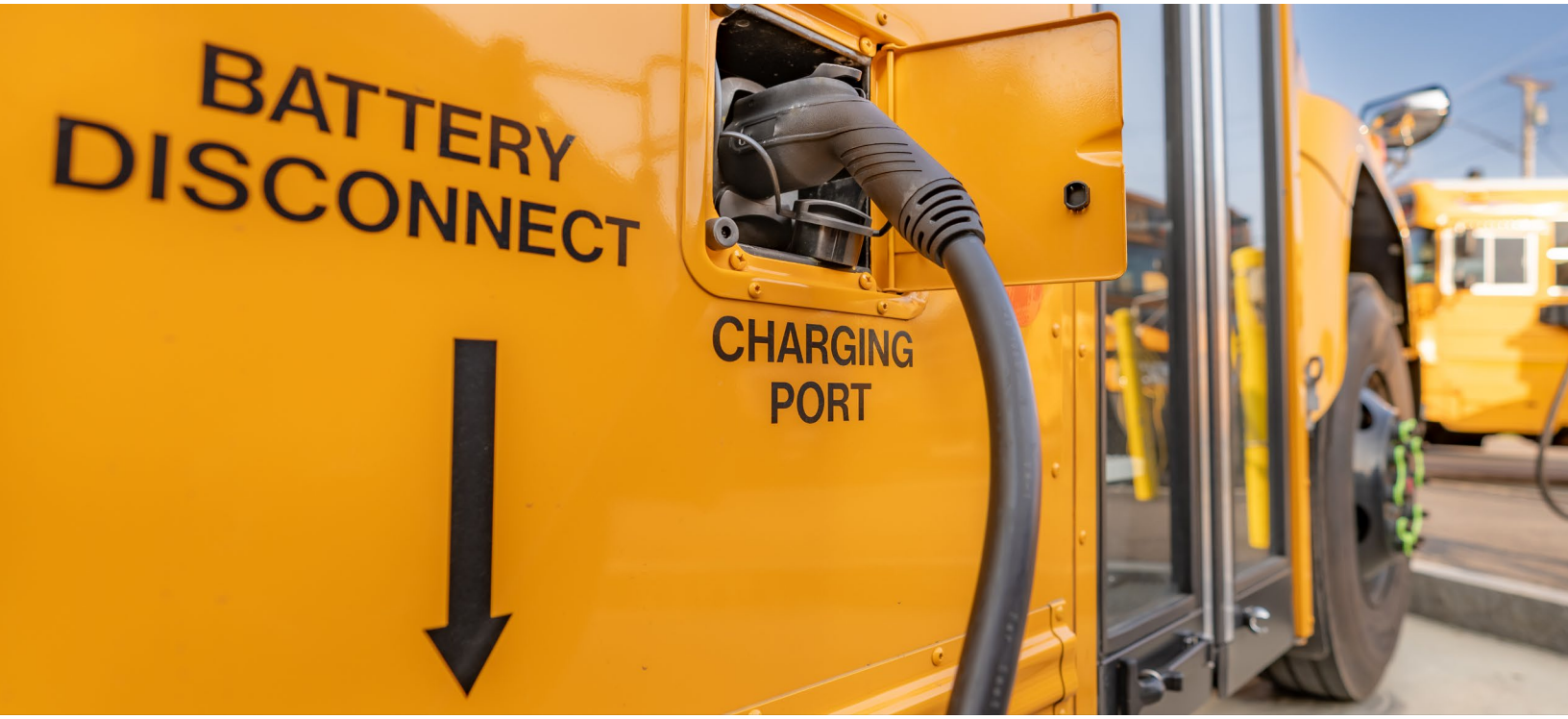

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Executive Summary

This report evaluates the performance and scalability of vehicle-to-grid (V2G) technology in electric school bus (ESB) fleets for ComEd's Beneficial Electrification School Bus V2G Pilot. ESBs offer traditional EV benefits while enabling grid services through V2G. Because school buses spend long periods parked at depots when not in service, they can connect to the grid and provide valuable support. Their predictable schedules and large battery capacities make them ideal for these services, strengthening their role as candidates for grid integration.

The Pilot included four ESBs across three school districts: River Trails SD 26, Troy CCSD 30C, and Wauconda CUSD 118. Table 1-1 provides an overview of the four ESBs enrolled in the Pilot. Each site is equipped with Tellus Power Green chargers.

Table 1-1. Vehicle and battery characteristics for participating sites

Site	Model	Bus Quantity	Battery Capacity	SOC Operating Range	Deployment Date
River Trails	Blue Bird Gen 2	1	155 kWh	10% - 97%	03/31/2024
Troy	Micro Bird G5	1	88 kWh	20% - 75%	03/19/2025
Wauconda	Blue Bird Gen 2	2	155 kWh	10% - 97%	01/09/2023

V2G testing was conducted at these sites over a five-month period from June 2025 to October 2025. This enabled a comparison of V2G operations during the summer, when buses were largely parked and not regularly used for transportation, and the fall, after the academic year began, when buses were regularly completing routes.

The Pilot tested two event types: maximum duration events and maximum power events. For maximum duration events, power was requested at the highest sustainable output for the full event period to assess consistent energy delivery, safe battery use, and alignment with longer grid needs. For maximum power events, power was requested at the chargers' full output for as long as possible to evaluate power capability, rapid response, and capacity services.

Key Findings

Reliability and Power Delivery. Across 231 scheduled V2G events, the pilot achieved an overall participation success rate of 82%, with success defined as events where discharging occurred. Participation was higher during summer events(93%) than during in-school events (73%). Lower participation was mainly due to technical issues (firmware updates and equipment parts replacements), operational constraints (buses unplugged for inspection or cleaning and low battery charge after routes), and communication problems (bus-to-charger or charger-to-command-platform connectivity issues).

The average power ratio, which indicates the percentage of requested power delivered during charging and discharging, generally remained above 90% at all sites, reflecting strong capability to meet grid demands. Notable exceptions occurred at Wauconda, where technical malfunctions temporarily reduced discharged power to just below 40% during the early phase of the pilot.

Communication reliability was critical to V2G operations. While charging and discharging sessions were mostly successful once initiated, variability in plug-in success (the ability of the charger and bus to establish communication at the start of a session) was largely due to inconsistent system readiness (plugged ESBs, correct firmware, acceptable SOC range for V2G) and communication protocols.

Performance during maximum duration events was generally more consistent, with buses sustaining power delivery close to expected levels for nearly the full scheduled period. In contrast, maximum power events showed greater variability, especially during the school year, with shorter event durations and reduced energy delivery often resulting from lower initial state-of-charge and battery voltage constraints.

Operational Efficiency and Availability. Vehicle uptime was high across sites, with River Trails and Wauconda buses fully available for charging and driving throughout the pilot. Troy's bus had approximately 90% up time due to a 12-day battery repair period. Similarly, charger uptime was high across all events and sites, with one charger offline for two days due to repairs, preventing V2G participation. Bus energy efficiency averaged 1 to 2 kWh per mile across all vehicles, with Troy's bus showing the lowest energy consumption per mile, indicating longer or more efficient routes. V2G participation did not significantly affect driving efficiency. During the pilot, buses completed the equivalent of up to 55 full charge–discharge cycles, well below typical battery life ratings, indicating that V2G participation imposed only a modest cycling burden.

Participation and Community Impact. Limited segments of the bus routes passed along borders of Environmental Justice (EJ) and low-income (LI) communities as they commonly align with major roadways, but the buses did not enter any EJ, LI, or Restore, Reinvest, and Renew (R3) zones. The routes indicate that the buses are not fully accessible to the targeted communities, thereby limiting their direct impact. Since vehicle emissions are most concentrated along high-traffic routes, adjacent communities may still experience some improvements in air quality from ESB service.

Stakeholder Engagement. Stakeholder perspectives on V2G technology were gathered through surveys to assess perceived benefits, concerns, and adoption barriers. Respondents included both pilot participants and non-participants, representing roles from district leadership to fleet operations staff. Financial considerations emerged as the most consistent theme, with schools expressing strong interest in understanding potential costs and benefits. Technical concerns followed, particularly regarding ESB battery degradation, V2G reliability, and site compatibility.

Recommendations

The Pilot provided critical insights into the performance of V2G technology in ESB fleets, marking significant progress from proof of concept to large-scale deployment across ComEd territory. The evaluation assessed the feasibility of V2G operations while identifying opportunities for further testing, stakeholder engagement, and research. Recommendations include expanding technical evaluation across different settings and contexts, providing additional support to school districts and their fleet operations teams, and assessing the battery health impacts and financial implications of discharging energy back into the grid.

Table 1-2. Summary of pilot findings and recommendations

Pilot Findings	Recommendations
Future V2G Pilot Testing	
V2G testing for the Pilot was conducted from June 2025 to October 2025, allowing for a comparison of V2G operations during summer break and the academic year.	Extend V2G testing to capture seasonal performance impacts, particularly winter conditions when cold temperatures can reduce battery efficiency and slow charging and discharging speeds.
Pilot events involved only a single bus discharging at each site. A feeder load-flow analysis was conducted for the participating sites to assess the effect of increasing V2G penetration on the electric grid and to identify potential thermal or voltage violations.	Conduct tests with multiple buses discharging simultaneously at a site to better assess site-level scalability. These tests should be carefully planned with consideration of site conditions to avoid infrastructure overloads.
The Pilot involved a limited number of buses. At scale, simultaneous battery discharges at a single site may impact grid power quality.	Evaluate power quality during energy discharge to the grid and identify potential harmonics issues. Assess how ESBs respond to voltage fluctuations or feeder disturbances to determine impact on reliable performance.
Pilot sites were limited to school districts in suburban communities. Due to the constrained pilot timeline, sites were selected based on site readiness and technical compatibility.	Expand site enrollment to include a broader mix of communities – urban areas, small towns, and rural areas. Testing in diverse community types will help inform V2G scalability due to differences in route lengths and infrastructure.
During the Pilot, some telematics data was unavailable for an extended period, requiring manual recovery and highlighting the need for improved reliability.	Implement an independent, backup data collection system to ensure consistent data availability.
Stakeholder Engagement	
Survey responses from school district stakeholders revealed varying levels of interest in V2G technology and participation in a school bus V2G pilot.	Strengthen engagement with fleet operations teams, whose daily operation and management of equipment is critical to V2G participation. Building trust and rapport with these in-field members is essential for successful adoption.
Several scheduled V2G events were unable to proceed as the buses were unplugged for various reasons. In one instance, staff were unsure whether a bus could be reconnected to the charger after washing to participate in an event.	Provide best practices, clear guidance, and training to minimize non-technical operational issues impacting V2G participation.

Pilot Findings	Recommendations
A pilot orientation meeting with the participating school districts was held in August 2025, two months after V2G testing began.	Enhance planning and communication by conducting customer orientation and alignment before V2G testing to set expectations and improve event participation.
Equity Initiatives	
The routes traveled by the buses enrolled in the Pilot did not pass through any DAC or R3 zones. They occasionally traveled along major roadways bordering ACS block boundaries.	Emphasize the importance of ensuring equitable access to ESBs for students and extending the benefits of V2G to underserved communities. Collaborate with stakeholders at school districts to develop strategies that advance equity. Consider additional incentives to improve ESB and V2G accessibility for ComEd's targeted communities.
Additional Research Areas	
The Pilot considered a battery degradation study using one Wauconda bus as a non-participating control, but both buses had noticeable participation in V2G events. Combined with limitations in the testing period and data availability, this made comprehensive analysis impractical. Stakeholders have expressed strong interest in this topic.	Conduct a battery degradation analysis to assess how V2G discharging affects ESB battery health.
Financial considerations around V2G technology surfaced repeatedly in the survey responses, with stakeholders heavily interested in the potential benefits and associated costs.	Perform a financial modeling analysis to evaluate the financial implications, including total cost of ownership (TCO) of V2G technology and the revenue potential for discharged energy. Investigate potential methods of compensating participants for discharged energy.