Best Practices for EV Fleet Operators
Looking to Deploy Vehicle to Grid (V2G)
Technology - Aug 27, 2020
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<td>Webinar Kickoff, Topic Introduction (Mike Heumann)</td>
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<td>Rhombus Presentation (Rick Sander, CEO)</td>
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<td>Panel Question #1 (1-min question; 2 minutes response per vendor)</td>
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Webinar Topic Introduction

Mike Heumann, VP of Sales and Marketing
Rhombus Energy Solutions
Panelists

Rick Sander
CEO and Co-Founder
www.rhombusenergy.com

Albert Burleigh
Executive Director of Sales
www.blue-bird.com

Gregory Poilasne
Chairman and CEO
www.nuvve.com

Mike Heumann
Vice President, Sales and Marketing
www.rhombusenergy.com
What is Vehicle to Grid (V2G)?

• V2G utilizes the energy stored in the batteries of electric vehicles (EVs) to augment the electrical grid during peak load hours
  • EVs return to fleet vehicle yard with some energy left in their batteries, where they connect to a bi-directional charger
  • The charging infrastructure communicates with the grid operator, and puts power back into the grid (if needed) at a premium
  • The EVs then recharge in the night during super-off-peak load hours at a lower per-watt-hour price
• This significantly reduces EV fleet energy cost
Why is V2G Compelling for EV Fleets?

- An EV auto with 85kWh battery can store nearly 3 days of the power consumed by an average US home.
- An 155kWh EV school bus can store over 5 days of the power consumed by an average US home.
- A long-distance EV transit bus can store up to nearly 23 days of the power consumed by a US home.

This battery capacity can represent “money in the bank”
Bi-Directional Charging for EV Fleets

Rick Sander, CEO
Rhombus Energy Solutions
www.rhombusenergy.com
The Attraction of Vehicle To Grid (V2G)

- V2G is an incredibly smart idea for EV fleets
  - V2G can help stabilize the grid during peak demand hours
  - V2G can help offset intermittent renewable supply
  - V2G can significantly reduce EV fleet energy costs
  - V2G provides a source of emergency backup

- V2G is not new... an idea that originated at UoD in 1997

- Why has V2G not been readily available until now?
  - It is complicated! Lot’s of elements to the system
  - EV are finally becoming popular. (Performance ✨ $ Reducing)
  - Depending on the Use Case, the economics are now compelling

- V2G is gaining traction with EV fleets as bi-directional “smart” chargers are deployed and the arbitrage economics are proven out.
Why Are V2G Implementations Challenging?

- There are many participants in V2G operation:
  - EV Owner
  - EV OEM
  - EVSE OEM
  - Software Aggregator
  - Grid operators / utilities
    - Utility DSO (Distribution System Operator)
    - Utility TSO (Transmission System Operator)
  - “Standards” groups.

- These groups and industries must work and communicate with one another other for V2G be truly successful.
How Do We Accelerate Vehicle To Grid?

- To gain wide scale commercialization, we need improved (and ideally simplified) industry standards:
  - Grid communication
  - Grid Interconnect (for bi-directional power flow)
  - EV to charger communication
  - EV charger standards
  - Aggregator software/service providers
  - Safety and Security
- In the interim, large fleet deployments will drive forward using semi-custom installations while trying to “future proof”
Requirements for a V2G Charger

“Smart” bidirectional charger provides the gateway to the utility grid connection

- The charger system controls power flow and direction while and communicates to aggregator, grid and EV user.

- V2G chargers must have multiple communication paths
  - Measuring, Monitoring, and Metering requirements for demand energy or behind the meter factory demands
  - Advanced electric vehicle communication link (ISO15118)
  - Aggregator platform and back-end service provider connections

- V2G chargers must meet a significant number of certification standards
  - Eg: UL 1741-SA, IEEE1547, UL 2202, UL 2231, UL 9741…

Other Requirements:

- Industrial rated design to reliably operate at full power continuously day and night
- Easily maintained and serviced if problems occur.
- Remote diagnostics/prognostics to reduce downtime and prevent issues before they happen.
Who is Rhombus Energy Solutions?

- Rhombus is an industry leader in advanced power conversion, providing solutions to:
  - AC-DC Systems for Transportation Electrification
  - Energy Storage Systems For Charging Support / Power Load Leveling
  - Microgrids, w/ Integrated Command / Control energy management

- Rhombus is headquartered in San Diego with a high-power testing lab and manufacturing in Dearborn as well as a India design center.

- Our expertise is developing bidirectional high-power inverters for renewables, energy storage and microgrids… enabling V2G charging

- Our products are easily customized for specific EV OEMs and fleet requirements

- Rhombus has deployed over 820 systems worldwide

Rhombus is the expert in V2G charging systems for EV fleets
We Make Electric Vehicles Greener
Nuvve Overview

• The world’s only platform enabling profitable deployment of EV fleets globally
• University of Delaware Spin Off
• HQ in San Diego, CA
• Offices in Copenhagen, London, Newark (DE), Paris
• 33 Employees
• Core IP: 15 patents filed or pending
• Projects on 5 continents
• 3+ years of full commercial operation in Denmark on FR markets
• Corporate investors
  o EDF Renewable Energy
  o Toyota Tsusho
• Joint Venture

Awards:

EDF
Toyota Tsusho
dreev

V2G Operations
Our Mission

To lower the cost of electric vehicle (EV) ownership while supporting the integration of renewable energy for scalable and sustainable green society.

Wind/PV share (global capacity)

2018: 15%
2040: 52%

EV share (new global sales)

2018: 2%
2040: 57%

Source: BNEF
<table>
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<tr>
<th>Nuvve’s Platform And Services</th>
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<td><strong>Transforms electric vehicles from unreliable resources into reliable, dispatchable and monetizable assets.</strong></td>
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<tr>
<td><strong>Stabilizes the grid</strong></td>
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<td><strong>Enables increased renewable penetration</strong></td>
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<td><strong>Reduces the cost of EV ownership, encourages EV adoption</strong></td>
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<td><strong>Guarantees vehicle use for transportation</strong></td>
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<td><strong>Optimizes and protects the vehicle battery</strong></td>
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V2G / VGI

Barcelona, Spain
Newark, Delaware
Manila, Philippines
Nagoya, Japan
Corsica, France
London, UK
Culver City, CA
UCSD, San Diego CA
Nagoya, Japan

CDG Airport, Paris
Windhoek, Namibia
San Jose, CA
Nice, France
Frederiksborg, Denmark
Torrance, CA
El Cajon, San Diego CA
V2G Services Delivered at all Grid Levels

Building Energy Optimization

- School bus demonstration at Torrance school district
- Demonstrated $5,000 of energy bill saving per bus per year based on 20kW

Utility & Distribution Services

- Negotiating different programs with multiple utilities across the US
- Value up to $21,000 per year per bus.

System Wide Grid Services

- Possible participation in some ISO/RTO markets today
- Working on a project to roll-out ancillary service and wholesale market access in California
- Collaboration with NSI to shape up the regulatory environment
Nuvve GIVe Platform

HIGH LEVEL OF CONTROL
- Integrates variable sized resources (KWh)
- Independent control of each asset (EV)
- Second-by-second control

VERSATILE INTEGRATION
- Third party integrations with existing systems including EVSEs, OEMs, and utilities
- Secure REST API available
- Support for multiple communication protocols

MOBILE MANAGEMENT
- Set charge levels and enable last-minute charging remotely
- Available as a mobile app and web interface

PERFORMANCE INSIGHTS
- 24/7 dashboard view of EV usage and charging
- Live energy delivery performance reporting
- Custom reports

Drivers can adjust charge needs on the go
Monitor your entire fleet with the Nuvve dashboard
Customer Offer

Free DC Charging Stations for Electric School Buses Enabled by V2G

NuVve Corporation, the global leader in vehicle-to-grid (V2G) technology based in San Diego, and Blue Bird have teamed up to deliver cost-competitive electric school buses with turnkey charging solutions.

By using NuVve's V2G platform, the large battery inside the bus is able to discharge energy back to the electric grid at high-demand times while still ensuring the bus always has the energy needed to drive its routes every day. This breakthrough technology allows NuVve to generate extra revenue by participating in energy markets to pay for the cost of the charging infrastructure.

**HIGH-POWERED CHARGING**

NuVve's powerful 65kW DC bidirectional V2G charger can charge any vehicle with a CCS-1 (universal) plug and fully charge a bus in about 3 hours.

**FLEET MANAGEMENT**

Drivers and fleet managers can remotely monitor and control the charging of their buses in real-time via a mobile application.

**V2G-CAPABLE BUSES**

NuVve’s V2G services are compatible with Blue Bird Vision (Type C) and All-American (Type D) buses.

**BATTERY HEALTH**

NuVve’s technology ensures charging and discharging does not harm the bus battery, and can even help maintain battery health when the bus is idle.

No Cost Infrastructure Solution

By leveraging V2G technology and Low Carbon Credits (California, Oregon), Blue Bird and NuVve are able to offer:

- **FREE** DC charging station ($55,000 value) per vehicle
- Up to $20,000 toward installation costs
- 12 years maintenance for the charging station

Custom solutions are available based on your specific needs. Blue Bird, its dealers, and NuVve can provide guidance on the best combination of DC and AC charging options to optimize energy use on your site.

How V2G Works

Blue Bird and NuVve provide a free V2G-compatible charger with the electric bus. This charger is connected to the internet and links up to NuVve’s central system. NuVve will then remotely control the charge and discharge rates of the charger and ensure that the energy is being used in the most efficient manner.

Learn about Blue Bird electric buses

GET STARTED WITH NUOLVE V2G SOLUTIONS
Thank You

Contacts:

V2G interest email: evse@nuvve.com

V2G charging solutions: https://nuvve.com/chargers/
How did Blue Bird get started in electric?

- Blue Bird was a pioneer and first school bus OEM to embrace EV technology

- 1994 - Collaborated with Westinghouse Electronic Systems to develop first battery-powered school bus

- 1996 - Collaborated with Electrosource, Inc. to produce transit style electric shuttle buses for the Atlanta Summer Olympics
Where are we today?

2016
- Blue Bird signed exclusive relationship with ADOMANI and Efficient Drivetrains, Inc. (EDI)
- Blue Bird received a $4.9MM grant from US Department of Energy (US DOE) for development and commercialization of high power V2G school buses.

2017
- Blue Bird Launched our current iteration of the Blue Bird electric bus at the STN Expo

2018
- Blue Bird delivered its first electric-powered school buses to customers in California
- Cummins bought EDI and rebranded the powertrain under the Cummins PowerDrive 7000 System

2020
- Only manufacturer to have produced and deployed electric school buses in Type A, Type C, and Type D
- Only manufacturer to offer standard CCS1 to allow for either AC Level 2 or DC Fast Charging
- V2G now standard on all buses with DC Fast Charging
How are EV sales?

1 to 100 – in just 20 months!
Sales have now exceeded 250 units!
Where have we sold our EV buses?
Major EV System Components

- **1. Electric Propulsion Motor**
- **2. Connectivity Module and Electronic Drive Mode Selector**
- **3. Air Compressor**
- **4. Power Steering Pump**
- **5. System Control Module and Low-Voltage Junction Box**
- **6. High-Voltage Junction Box**
- **7. Energy Storage System**
- **8. Thermal Management System**
Legislate Passes Electric School Bus Mandate; Montgomery Looks into Testing

Grants expected to offset some of the additional costs, estimated to be in the millions.

By Catherine Festz (Daily News Staff; published 2019-04-10 12:32)

A bill that passed in the final hours of the state legislature requiring all new Maryland school buses be "zero-emission" vehicles would save costs the Montgomery school system an estimated $1.1 million, but a last-minute addition of a grant program will affect the expected price tag.

House Bill 1129, sponsored by District 16 delegate David Lever-Hillega, mandates all new school vehicles be "zero-emission" vehicles.

Vermont launches electric school bus pilot with Volkswagen settlement funds

Incorporated Aug 2019

Vermont launches electric school bus pilot with Volkswagen settlement funds

Incorporated Aug 2019

State To Help Purchase Electric Buses With Volkswagen Money

With the electric buses, children's exposure to harmful diesel exhaust fumes "drops to zero."

Zealand school district getting electric buses

Electric school buses are coming to the Grange Market...
Why Electric School Buses?

We are seeing more and more districts interested in purchasing EV school buses. Why?

- **ZERO EMISSIONS**
  Cleaner air for our children

- **REDUCED MAINTENANCE COSTS**
  Less parts = less maintenance

- **TEMPERATURE CONTROL**
  Performance in various weather conditions

- **VEHICLE TO GRID TECHNOLOGY**
  V2G technology allows the sale of energy back into the grid

- **SERVICE & SUPPORT**
  Extensive North American dealer channel

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Zero-Emissions, Viable Total Cost of Ownership Solution
Why are School Bus Fleets attractive Partners for Utilities?

• A great source of distributed energy because their usage patterns are predictable.

• They are idle at precisely the times when energy demand is at its peak — midday and during the hottest summer months.

• By storing or drawing energy from a fleet of parked school buses, utilities can avoid wasting surplus energy from renewables or cranking up a natural gas power plant, for example.

• Night time charging provides favorable utility rates.
Maintenance Savings

The Cummins PowerDrive electric motor is maintenance free, eliminating downtime and costs associated with maintenance.

- No engine oil changes
- No engine air filter changes
- No smog check/testing
- No spark plugs, glow plugs or coil replacements
- No degradation of the air intake/vacuum system
- No fluid check or change associated with a transmission
- Brake pad change interval gets much longer
- Fewer coolant changes needed

Approximately 80% Reduction in Maintenance Costs
What’s our outlook for the EV school bus market?

Interest in EV will continue to increase as the TCO equation becomes even more favorable as:

- Battery prices continue to fall
- Battery efficiency improves
- V2G projects become a reality

- Even more choices in bus sizes and capacities as optional battery pack sizes with varying ranges become available which will meet more customer’s needs

- Improvements in EV cold-weather performance to improve range and charging will increase appeal of EV school buses to a broader base of customers

- While available grant funding will likely decrease, expected increases in funding from utilities

- Turn key solutions to include financing, infrastructure, vehicle deployment, and maintenance to allow ease of conversion to electric
Thank You!
Panel Questions and Audience Surveys
Panel Question #1

• How important will V2G be for EV fleets now and in the future?
  • Blue Bird
  • Nuvve
  • Rhombus
Panel Question #2

• How much of a cost delta does V2G have versus unidirectional chargers, and does it impact EV battery life?
  • Rhombus
  • Blue Bird
  • Nuvve
Panel Question #3

• What are the 2-3 best practices that you would suggest to a company considering deploying V2G for their EV fleet?
  • Nuvve
  • Rhombus
  • Blue Bird
Want More Information on V2G?

- Rhombus: news@rhombusenergy.com
- Nuvve: evse@nuvve.com
- Blue Bird: www.electricdreambus.com