ZEV School Buses – They’re Here & There Is Funding for Purchasing

V2G Electric School Bus Initiative

April 10, 2018
Session Outline

• Introduction
  • Kevin Matthews, V2G Electric School Bus Initiative

• Blue Bird’s zero-emission school buses
  • Jim Johnson, Blue Bird Corporation

• Public funding programs
  • Danielle Chambers, California Air Resources Board

• The V2G total-cost-of-ownership opportunity
  • Steve Crolius, V2G Electric School Bus Initiative

• Q & A
Blue Bird Electric School Bus

James Johnson
Regional Sales Manager - West
How does Electric Benefit School Districts?

- School Districts
  - Communities, Parents, Schools, and Local Government Agencies are on the path to reduce emissions
  - Electric buses allow them to:
    - Generate ZERO emissions
    - Reduce maintenance costs
  - School Districts easily qualify for Grants
  - Reducing Fuel costs up to 90%

School Districts can Take Advantage of Grant Funding
When discussing any electric vehicle, there are common points that may be brought up against the product. It is important to know how to address common misconceptions regarding electric vehicles. In the following slides, we will review each piece and show how a discussion can lead to positive reception of the product. Some common points made are:

- The buses are very expensive.
- These buses have a lot of batteries- and they are expensive to replace.
- Electric buses do not have sufficient range.
While it is true that the Blue Bird electric bus will be more costly than a traditionally-fueled bus, there are many ways to add an electric bus to your fleet – affordably!

- **Grants**
  - Many states have their own alternative fuel grants, some specifically for electric-vehicle applications
  - The Volkswagen Settlement Funding is a potential avenue to help pay for an electric bus
    - Even important to speak to your state representative to encourage them to use some of this funding towards **electric school buses**

- **Maintenance Cost Savings**
  - Electric buses simply do not need a majority of the parts that traditional buses require, and the parts on an electric bus tend to last longer than parts on a traditionally-fueled bus
  - Electric buses produce ZERO emissions- providing cleaner air for our children

**YES- You Can Afford an Electric Bus!**
Blue Bird Electric buses utilize two complete sets of battery packs, with up to 160 kWh capacity. These batteries are safely housed between our robust frame rails.

- Batteries are Lithium Ion NMC (Nickel-Manganese-Cobalt)
  - This type of battery offers a longer lasting battery density and provides a better Total Cost of Ownership due to its considerable lifespan when compared to other battery technologies

- 5 year warranty (Blue Bird will also offer an extended warranty option)

- Up to 160 kWh onboard capacity to provide up to 120 mile range on a single charge
The range of the Blue Bird Electric bus designed to provide up to 120 miles on a single charge, which covers in excess of 80% of school bus daily routes in the U.S. The bus will charge overnight, so you are ready to go the very next day! By performing a mid-day charge, approximately 90% of school bus routes in the U.S. would be covered.
Type D Electric Bus Layout

Built By Blue Bird Powered By Adomani
In pure electric vehicles the Drivetrain replaces the entire drive system including the engine and the transmission assemblies. The entire engine based system is responsible for transferring power from the batteries to the drive motor.

Components that make up the drivetrain are the motor, controller, driveshaft, and differential. The EV drivetrain provides the same horsepower & torque performance of the original OEM vehicle.
Batteries produce large amounts of heat, enough to damage other components in the vehicle along with itself and reduce the flow of power output.

The cooling system will sense when the batteries are getting warm and keep them at optimal temperatures that allow maximum power transfer with no risk of failure.

The cooling system doesn't cool the batteries, it actually cools the motor, controller, onboard chargers, DC inverter that is used to heat the batteries in warm climates, along with being used in parallel with cabin heater.

The system is cooled by an onboard A/C compressor that cools the battery packs during operation. The battery management system or BMS controls both heating and cooling requirements.
Vehicle Control

Onboard software is used to support electric vehicle configurations or modes distinctive to its properties and provide the driver with information.

This software includes management and control of complete drivetrains (motors, battery systems, charging systems, clutches, etc.), and interfaces to critical vehicle systems. It also includes important fault detection and the related management features.

The software is telematics based and can be used to track vehicle route, location, start and stop time and performance.
For EV there are Hill, ECO-EV, and Regenerative modes. Each mode ensures the maximum efficiency given the driving situation (i.e. city, highway, elevated, etc.)

**Hill Mode:**
Hill Mode demands larger amounts of power from the batteries which is achieved by using the HV system to ensure safe travel up steep inclines.

**ECO-EV Mode:**
ECO-EV Mode is the standard mode used for everyday driving being the most efficient of the modes with the least wear and tear on the components.

**Regenerative Mode:**
Regenerative Mode is initiated when applying the breaks allowing some power to be resupplied to the batteries.

As soon as you lift off the accelerator, the regenerative braking starts and is increased when applying the brakes similar to a retarder.
Charging of the vehicle uses the industry standard SAE J1172 Level 2 connector. A full charge can be accomplished overnight but can also take advantage of opportunity charging during the day.

Additionally regenerative breaking provides some energy to extend range capability and limit energy loss for special terrain such as hills or stop...
Two sets of battery packs, that include 7 strings that run in parallel and are controlled by individual BDU's so if one pack goes down the second pack continues powering motor.
# Specifications

## Body Specifications

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Multiple floor plans available with passenger seating up to 81</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior Width</td>
<td>96”</td>
</tr>
<tr>
<td>Interior Width</td>
<td>90 3/4”</td>
</tr>
<tr>
<td>Aisle Width</td>
<td>Varies by Floor plan</td>
</tr>
<tr>
<td>Skirt Length</td>
<td>19 3/4” , 25 3/4”</td>
</tr>
<tr>
<td>Interior Height</td>
<td>77”</td>
</tr>
<tr>
<td>Overall Height</td>
<td>122” - 128” depending on options</td>
</tr>
<tr>
<td>Wheelbase</td>
<td>245”/259”/273”</td>
</tr>
<tr>
<td>Front Overhang</td>
<td>95” with standard steel bumper</td>
</tr>
<tr>
<td>Rear Overhang</td>
<td>122” with standard steel bumper</td>
</tr>
<tr>
<td>Brakes</td>
<td>4-wheel air drum and air disc brakes with 4-channel anti-lock brake system</td>
</tr>
<tr>
<td>Suspension</td>
<td>Soft ride front leaf spring suspension; Two-stage steel leaf rear spring suspension system (ratings varies by capacity); Air Suspension available</td>
</tr>
<tr>
<td>Steering</td>
<td>Tilt &amp; telescoping steering column</td>
</tr>
<tr>
<td>GVWR</td>
<td>Up to 36,200 lbs.</td>
</tr>
</tbody>
</table>

## EV Specifications

<table>
<thead>
<tr>
<th>Battery Type</th>
<th>Lithium Ion NMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery Capacity</td>
<td>160 kwh</td>
</tr>
<tr>
<td>Miles Per Charge</td>
<td>Up to 120 miles, dependent on drive Cycle, driver behavior, and accessory usage</td>
</tr>
<tr>
<td>Recharge Time</td>
<td>Function of charger - for level 2, less than 8 hours</td>
</tr>
<tr>
<td>Rated Power</td>
<td>Approximately 220 HP</td>
</tr>
<tr>
<td>Rated Torque</td>
<td>Approximately 520 ft-lbs.</td>
</tr>
<tr>
<td>Emissions Certification</td>
<td>EPA and CARB</td>
</tr>
</tbody>
</table>
Questions

James Johnson
478-302-6131
james.johnson@blue-bird.com
State Funding for California ZEV School Buses

Danielle Chambers
Air Pollution Specialist
CA Air Resources Board

April 10, 2018
Since 2001, CARB and local air districts have used more than $500M to cleanup school buses

- Objective: reduce kids’ exposure to toxic diesel exhaust and reduce air pollution by replacing the oldest school buses
- New funding sources allow for continued opportunities to replace California’s aging school bus fleet with ZEV School Buses
Funding Sources For School Buses

• State Funding
  – Hybrid Voucher Incentive Program (HVIP)
  – Rural School Bus Pilot Project
  – Carl Moyer Program
  – AB 617: Community Air Protection Funds
  – Volkswagen Mitigation
  – Prop 39: School Bus Replacement Program

• Local Funding
  – Vehicle registration fees (AB 923, AB 2766)
Hybrid Voucher Incentive Program (HVIP)

- $133M for FY 2017-2018
  - First come, first served
- Covers incremental cost of ZEV School Buses
  - Up to $220K per school bus
  - Additional $15K per school bus in disadvantaged community
- School districts can apply for a voucher through HVIP-approved dealership
- [www.californiahvip.org/](http://www.californiahvip.org/)
Rural School Bus Pilot Project

• Administered by North Coast Unified Air Quality Management District
  – Part of California Climate Investments
  – Funded by proceeds from California Cap-and-Trade Program

• Project must demonstrate GHG and black carbon reduction
  – Priority given to rural schools in small air districts & oldest buses with most miles
  – $400K for zero emission technology, additional $5K for charging infrastructure
  – $165K for hybrid/internal combustion (IC) engines using renewable fuels
Rural School Bus Pilot Project

- $10M for 2016-2017
  - Program amended to include additional $5M
  - Funded 30 electric school buses, 7 hybrid/IC engines using renewable fuels
  - Buses are currently being delivered
- $10M available for FY 2018-2019
  - Open solicitation Spring 2018
Carl Moyer Program

• Partnership between CARB and local air districts
  – CARB sets guidelines, provides oversight
  – Air districts select projects to meet local needs
• Grant amounts are based on the amount of pollution reduced
• 2017 Guideline changes allow greater flexibility for school bus projects
• Early or extra emission reductions required, beyond regulatory requirements
• Apply through local air district
**AB 617 Community Air Protection Funds**

- $250M to reduce toxics and NOx in communities most affected by air pollution
- Immediate reductions through the Carl Moyer Program
  - School bus replacements are eligible
- 95% of funds will go to three largest air districts
- Public process:
  - Workshops conducted February 2018
  - Moyer Community Air Protection Supplement Guidelines will be proposed at CARB Board Meeting April 2018
- [www.arb.ca.gov/msprog/cap/capfunds.htm](http://www.arb.ca.gov/msprog/cap/capfunds.htm)
Volkswagen Mitigation (Appendix D)

- Court-ordered $3 billion national Trust; $423 million allocated to California to offset oxides of nitrogen (NOx) emissions violations
- School bus replacements are an eligible project type
- Public process
  - Comment docket currently open
  - CARB Board Meeting: May 2018
- [www.arb.ca.gov/msprog/vw_info/vsi/vw-mititrust/vw-mititrust.htm](http://www.arb.ca.gov/msprog/vw_info/vsi/vw-mititrust/vw-mititrust.htm)
Prop 39: School Bus Replacement Program

• Administered through California Energy Commission

• $75M allocated to school buses through SB 110
  – Priority given to;
    • oldest school buses
    • school buses operating in disadvantaged communities, and
    • to schools that have a majority of students eligible for free or reduced-priced meals
  – ZEV charging infrastructure & workforce training/development

• Public Process
  – Public workshops to discuss proposed design concept February 2018
  – Proposed solicitation release May-June 2018

• energy.ca.gov/transportation/schoolbus/index.html
Local Funding Opportunities

• Local air districts can use local funds to fund school bus projects
• Contact your local air district for district specific information
• Example:
  – South Coast AQMD used vehicle registration fees to match HVIP funding
  – 18 school districts, 33 ZEV buses & infrastructure in environmental justice communities
    • Delivery by September 2018
UPCOMING! School Bus Fleet Webinar

• April 20, 2018 @ 10:30 AM
• Topics include:
  – Regulatory Requirements for School Buses and White Fleet Vehicles
  – State and Local Funding for replacement School Buses and Infrastructure
  – Electric School Bus Overview
  – Case Studies: Zero Emission School Buses in Use
  – Q&A
• Register online at:
  – https://attendee.gotowebinar.com/register/4186541545415807746
Danielle Chambers
danielle.chambers@arb.ca.gov
916.323.0027
ZEV School Buses – They’re Here & There Is Funding for Purchasing

V2G Electric School Bus Initiative
April 10, 2018
The V2G total-cost-of-ownership opportunity
The V2G TCO Opportunity: Overview

• Absent public subsidies, it will be hard for ZEV school buses to compete economically with fossil-fueled school buses
• The State of California has been generous with subsidies, spending ~$500 million of tax- and ratepayer dollars on school buses since 2001
• However, converting the state’s entire school bus fleet to ZEV technology would require ~$5 billion in subsidies
  • At historical rates of investment, the conversion will play out over 170 years
• V2G is a game-changing proposition: it can generate explicit and implicit cash flows substantial enough to allow ZEV school buses to compete without subsidies
Phase 1 V2G Project Parameters

- Project host: Torrance Unified School District
- Two type C V2G school buses
- Deployment at school bus yard / maintenance facility
- Effective power capacity (both directions): 46 kW per bus
- “Behind the meter V2G” = vehicle-to-building
  - Demand peak shaving
  - Time-of-day rates arbitrage
Phase 1 V2G Economic Impacts

- Factor 1: Higher electricity bill but elimination of petroleum fuel costs
  - Incremental cost of electricity, including rate shift: $900
  - Elimination of fuel cost: ($9,000)
  - Net impact: ($8,100)

- Factor 2: Impact on the facility’s electric bill
  - Demand charge reduction year-round: ($2,800)
  - Energy charge reduction during the summer: ($1,100)
  - Energy charge reduction in other periods: ($200)
  - Net impact: ($4,100)

V2G functionality helps ensure that the monthly demand peak does not go up with increase in kWh

V2G functionality enables the execution of arbitrage and peak-shaving techniques

<table>
<thead>
<tr>
<th>Category</th>
<th>Annual Savings</th>
<th>Per Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>$8,100</td>
<td>$4,050</td>
</tr>
<tr>
<td>Step 2</td>
<td>$4,100</td>
<td>$2,050</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$12,200</strong></td>
<td><strong>$6,100</strong></td>
</tr>
</tbody>
</table>
Phase 2 V2G Project Parameters

- Project host: Rialto Unified School District
- Eight type C V2G school buses
- Deployed at new pupil transportation facility (currently under construction)
- Effective power capacity (both directions): 200 kW per bus
- “Full-strength V2G” = participate in wholesale ancillary services market
  - Frequency regulation, both “Reg Up” and “Reg Down”
  - May also provide vehicle-to-building services
## Phase 2 V2G Economic Modeling Results

<table>
<thead>
<tr>
<th></th>
<th>GROSS REVENUES AND COST OF ELECTRICITY LOSSES BY MONTH</th>
<th>ANNUAL PROFIT &amp; LOSS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reg Down</td>
<td>Reg Up</td>
</tr>
<tr>
<td>Dec-16</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$698</td>
<td>$804</td>
</tr>
<tr>
<td>Jan-17</td>
<td>$593</td>
<td>$715</td>
</tr>
<tr>
<td>Feb-17</td>
<td>$510</td>
<td>$604</td>
</tr>
<tr>
<td>Mar-17</td>
<td>$592</td>
<td>$711</td>
</tr>
<tr>
<td>Apr-17</td>
<td>$476</td>
<td>$559</td>
</tr>
<tr>
<td>May-17</td>
<td>$548</td>
<td>$672</td>
</tr>
<tr>
<td>Jun-17</td>
<td>$960</td>
<td>$1,032</td>
</tr>
<tr>
<td>Jul-17</td>
<td>$992</td>
<td>$1,066</td>
</tr>
<tr>
<td>Aug-17</td>
<td>$377</td>
<td>$1,331</td>
</tr>
<tr>
<td>Sep-17</td>
<td>$288</td>
<td>$1,331</td>
</tr>
<tr>
<td>Oct-17</td>
<td>$385</td>
<td>$1,302</td>
</tr>
<tr>
<td>Nov-17</td>
<td>$594</td>
<td>$1,205</td>
</tr>
<tr>
<td>Total</td>
<td>$7,014</td>
<td>$11,333</td>
</tr>
<tr>
<td>Net</td>
<td>$18,346</td>
<td></td>
</tr>
</tbody>
</table>

**ANNUAL PROFIT & LOSS**

<table>
<thead>
<tr>
<th></th>
<th>Per Bus</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Revenues</td>
<td>$18,346</td>
<td>$146,770</td>
</tr>
<tr>
<td>Cost of Losses</td>
<td>($10,346)</td>
<td>($82,771)</td>
</tr>
<tr>
<td>Monthly Costs</td>
<td>($1,950)</td>
<td>($15,600)</td>
</tr>
<tr>
<td><strong>Profit</strong></td>
<td>$6,050</td>
<td>$48,399</td>
</tr>
</tbody>
</table>
# EV School Bus TCO without V2G

All parameter values derived from conditions in 2Q18

<table>
<thead>
<tr>
<th></th>
<th>Diesel</th>
<th>EV</th>
<th>Key Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial Vehicle Price</strong></td>
<td>$110,000</td>
<td>$210,000</td>
<td>Projected price of EV type C bus after ~1,000 vehicles; includes per-bus cost of charging infrastructure</td>
</tr>
<tr>
<td><strong>Annual Expense for</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel</td>
<td>$5,958</td>
<td>$2,592</td>
<td>12K miles/year; diesel at $3.23/gal; electricity at $0.18/kWh</td>
</tr>
<tr>
<td>Propulsion System Maintenance</td>
<td>$2,341</td>
<td>$745</td>
<td>Oil change, brake replenishment major drivers of cost</td>
</tr>
<tr>
<td>Accrual for Battery Replacement</td>
<td>--</td>
<td>$0</td>
<td></td>
</tr>
<tr>
<td><strong>Years to Breakeven</strong></td>
<td></td>
<td>&gt;20</td>
<td></td>
</tr>
</tbody>
</table>

Source: Financial model developed by PJM Interconnection and the V2G Electric School Bus Initiative
# EV School Bus TCO with V2G

All parameter values derived from conditions in 2Q18

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<tr>
<td>Annual Expense for Fuel</td>
<td>$5,958</td>
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<td>$745</td>
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</tr>
<tr>
<td>Accrual for Battery Replacement</td>
<td>--</td>
<td>$2,128</td>
<td>$300/kWh to start; 3% annual rate of cost decrease</td>
</tr>
<tr>
<td>Annual V2G Revenues</td>
<td>--</td>
<td>$6,100</td>
<td>Based on actual electric market parameters</td>
</tr>
<tr>
<td>Years to Breakeven</td>
<td>14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Financial model developed by PJM Interconnection and V2G EV School Bus Initiative
V2G School Bus Outlook

• Basic electric school buses are conceptually simple: just like regular school buses except you plug them in
• V2G school buses are less simple: you need lots of “systems” to make them work
• Yet, once standard selling, commissioning, and operating procedures have been established, V2G school buses will be match EV school buses in simplicity for school districts as (complexity will be handled by vendors and/or automated)
• V2G EV School Bus Initiative mission: promote and facilitate the process of establishing standard systems and procedures – over the next five years
• Success will create benefits for school children, local communities, taxpayers, and the climate
Questions?
Steve Crolius
scrolius@alliancecg.com
(401) 792-3671
Appendix
Phase 2 V2G Economic Modeling Approach

- Modeling performed using:
  - Actual CAISO clearing prices for Reg Up and Reg Down, 12/1/16 – 11/30/17
  - PJM frequency regulation 40-minute test signal
- Key assumptions:
  - Bid hours chosen to avoid interfering with pupil transportation mission
  - Receive award for 100% of hours bid at the market clearing price
  - 20% round-trip energy loss
  - Lost electricity paid for at retail rate per kWh, net of demand charge
  - Fixed monthly charges incurred at the same rate as LA Air Force Base demonstration project
Economic modeling provides a valid indication of the potential cash flows that could be generated by V2G school buses.

However:

- The indication is only as good as the assumptions within the model, and several key assumptions are still speculative at this time.
- The modeling is based on participation in CAISO’s frequency regulation market; this market is relatively small and its clearing prices could change significantly should new resources enter en masse.
- It is also the case that V2G school buses will have the ability to generate economic value for their owners in other markets and other use cases.
  - E.g., proxy demand response, microgrid integration.