Beyond the Pilot

Depot Considerations for a Transition to 100% ZEB Fleet

Cliff Henke, Senior Analyst, Transit and Rail
WSP USA, Los Angeles
Outline

- Current Projects
- Approach Strategies
- Challenges
- Lessons Learned
- Q&A
Recent experience with similar challenges
ABQRIDE Transit Electric Bus Facility Impact Study

Challenge FACILITY MODIFICATION
- Integrating into existing Ops & with existing diesel / CNG fleet

Challenge POWER
- Discussions w ABQ utilities
- Primary vs Secondary Service
MBTA North Cambridge Pilot – Configuration & Fleet Size: Phased Approach

- Existing (28) Electric Trolley Buses replaced by New (35) Battery Electric Buses
North Cambridge Pilot – Charging Infrastructure

- Infrastructure to support DC Automatic Overhead Plug-In Charging

Diagram showing the layout of the charging infrastructure, including DC conduit run, conduit support rack, motorized cord retractor, switchgear, charging cord, charging gun, transformer, dispensers, switch, charging stations, and by-pass lanes.
North Cambridge Pilot – Electrical Service

- 35-bus configuration
- 1:1 ratio = 36 chargers @ 150 kW
- 5,250 kVA total capacity needed
- Electrical yard
  - 2 @5000 kVA transformers and switches
  - 8 low voltage switchgear cabinets
North Cambridge Pilot – Charging Technology

DC Automatic Overhead Plug-In Charging System

- 1:1 Charger per Bus
- 150 kW Charging Cabinet
- 3.2 Hours for full charge
- (assume zero SOC)
- Could also support overhead pantograph
- CCSI SAE Level 2 / 3 J1772 plug / port standard
- Multi BEB OEM & Mnuf’s
North Cambridge – Charge Cord Management

Infrastructure to support DC Automatic Overhead Plug-In Charging
Facility Schedule, Strategy for Metro Divisions 8 & 9

- Optimized Parking Layout
- ZEB Charging Connection
- Capital Costs Utility Back-Up
- Sustainability Options

LA Metro Bus Division 8
- ALABAMA AVE
- CANOGA AVE
- NORDHOFF ST
- OPS
- MAINTENANCE
- WASH
- CNG
- BUS PARKING

LA Metro Bus Division 9
- CNG
- OPS
- SANTA ANA AVE
- NORDHOFF ST
- MAINTENANCE
- CAR PARKING
- TRACK BUS PARKING
- BUS PARKING
- FUEL
- WASH
- SAN BERNARDINO FWY
Scalability Increases Complexity Exponentially

Examples of needed technical analyses:

- Technology assessments
- Current & planned route evaluation
- Facilities assessment
- Disposal & recycling, tailpipe emissions, utility emissions and noise
- Equity considerations
- Benefit-cost analysis
- Budgetary and funding analysis
- Replacement scenarios and sensitivity tests

<table>
<thead>
<tr>
<th></th>
<th>King County Metro (largest to date)</th>
<th>LA County Metro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fleet</td>
<td>~ 1,200</td>
<td>~2,400</td>
</tr>
<tr>
<td>Make</td>
<td>New Flyer, Gillig, Proterra</td>
<td>NABI, New Flyer, El Dorado Nat., BYD</td>
</tr>
<tr>
<td>Bus Engine</td>
<td>Diesel, Hybrid, Electric, BEB</td>
<td>CNG, rCNG, BEB</td>
</tr>
<tr>
<td>Bus sizes</td>
<td>30’, 35’, 40’ 60’</td>
<td>40’, 45’, 60’</td>
</tr>
<tr>
<td>Garages</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Utilities</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Energy Sources</td>
<td>hydroelectric, coal</td>
<td>natural gas, other renewables</td>
</tr>
<tr>
<td>Other Electric Transit</td>
<td>light rail, streetcar, monorail, trolleybus</td>
<td>heavy rail, light rail</td>
</tr>
</tbody>
</table>
Thank You
Potential Q&A Slides
Battery-Electric Bus Infrastructure

- Flexibility in Charge Equipment

<table>
<thead>
<tr>
<th></th>
<th>Charger (HxWxD)</th>
<th>Charger Weight</th>
<th>Dispenser (HxWxD)</th>
<th>Max Dist Charger to Dispenser</th>
<th>Max Dist Dispenser to Gun</th>
<th>Dispensers per Charger</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABB 150 kW</td>
<td>80&quot; x 46.1&quot; x 30.4&quot;</td>
<td>2948 lbs</td>
<td>31.5&quot; x 23.7&quot; x 8.3&quot;</td>
<td>492'</td>
<td>22.9'</td>
<td>1:1 thru 1:3</td>
</tr>
<tr>
<td>ChargePoint 156 kW</td>
<td>43&quot; x 40&quot; x 75&quot;</td>
<td>860 lbs</td>
<td>20&quot; x 10&quot; x 16&quot;</td>
<td>330'</td>
<td>30'</td>
<td>1:1 thru 1:2</td>
</tr>
<tr>
<td>Proterra 125 kW</td>
<td>72&quot; x 40&quot; x 23.6&quot;</td>
<td>2,500 lbs</td>
<td>26.5&quot; x 15.75&quot; x 8.5&quot;</td>
<td>492'</td>
<td>25'</td>
<td>1:01</td>
</tr>
</tbody>
</table>

Denotes worst case scenario

- Flexibility in Charger Use

Charging Port on BEB
Charging Gun on end of Dispenser Cord

Depot overhead pantograph
Bus roof mounted charging bar
Systems Integration

**Infrastructure Needs**
- Facility Upgrades
- Power Upgrades
- Charging Strategies
- Space Constraints
- Regulations
- Staging
- Energy Capacity
- Right of Way

**Maintenance Needs**
- Training
- Transition Plans
- Best Industry Practices
- Fleet Conversion
- Back Shop
- Re-purpose
- Maintenance Practices
- Parts Inventory

**Operations Needs**
- Route Changes
- Passenger Capacity
- Travel Distance
- Modeling
- Contingency Plans
- Performance
- Training
- Reliability
- Availability
How to be aggressive in the face of challenges?

Leveraging experience

Partnering with suppliers and stakeholders

Anticipating the unknowns
Modeling Capabilities

Example 2

<table>
<thead>
<tr>
<th>Block #</th>
<th>Routes Involved</th>
<th>Block Length (KM/ Miles)</th>
<th>Start Time</th>
<th>End Time</th>
<th>Bus OEM</th>
<th>Battery (kWh)</th>
<th>End SOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>C43-255</td>
<td>43</td>
<td>115/71.5</td>
<td>4:44 AM</td>
<td>8:33 PM</td>
<td>Proterra</td>
<td>550</td>
<td>9.9%</td>
</tr>
</tbody>
</table>

Bus OEM: Proterra
Battery Size: 550 kWh
Example 4

**Modeling Capabilities**

**ON-ROUTE charge on Grid (considering battery working ability)**

- **Bus:** BYD-1
- **Battery:** BYD-1
- **Season:** Summer
- **AC:** YES
- **HEAT:** NO

**Energy usage on Fleet (considering battery working ability)**

- **Bus:** BYD-1
- **Battery:** BYD-1
- **Season:** Summer
- **AC:** YES
- **HEAT:** NO
U.S TRANSIT BUSES: A UNIQUE “BUILD TO ORDER” MARKET

- Buy America and Altoona Requirements Unique in the World
- Rapid Pace of Change
- Each order custom
  - Pilot bus
  - Wiring scheme different
  - Major components evolve lot by lot
- Time to market now 2-3 years
- Big reason why OEMs are financially fragile

“And now you want what?”
VEHICLE PARTNERSHIP APPROACH

- Tailored Design Criteria that Meet the T’s Service Needs
- Healthy Skepticism of Advanced Propulsion Technology
- Specification and Procurement Milestones
- Design Reviews and Testing
- Delivery Scheduling
- Manufacturing Partnerships but with Oversight
- Inspections, Testing and Commissioning
- Do Not Forget Warranty and Field Service Requirements
Balancing Key CHALLENGES

INSTITUTIONAL
- Workforce Development
- Safety/Training
- Funding/Financing
- Other Initiatives

CHANGE MANAGEMENT
- Blended O&M Needs
- Future-Proofing Technology Development
- Dealing with Planned Program Changes

ASSETS
- Supply Chain
- Technology Phasing
- Systems Integration
- Procurement