Lima eBus
Project Overview

WSP Canada Inc.
Workshop Agenda

1. Project Background
2. Intro to WSP, Project Team & Stakeholders
3. Project Scope
4. Route Simulation & Analysis (BOLT)
5. eBus Selection & Charging Infrastructure
6. Lifecycle Assessment
7. Pilot eBus
   1. Vehicle Specification Development
   2. OEM Selection, Manufacture, Inspection & Commissioning
   3. Pilot Data Tracking
8. Project Next Steps
9. Session Wrap & Questions

Session 2
Project Overview
13:30pm to 15:00pm
Lima eBus Feasibility Study
Project Objectives

1. Help improve air quality in Lima by reducing fossil fuel powered diesel buses on the road
2. Assess feasibility of eBus operation in Lima’s transit network
3. Develop a Pilot eBus Strategy
4. Replicability Study for future eBus deployment
Pre-Feasibility Study (2017)

- Preliminary study on socioeconomic conditions, public transportation and legal aspects in Peru around eBuses
- Initial discussions with government authorities:
  - Energy and Mines
  - Environment
  - Transport & Communication
- Implementation Plan developed
- Global Sustainable Energy Partnership (GSEP) accepted pilot electrification project in Lima
Project Stakeholders

- Project management
- Manage project financing

- Local sponsors
- Project Facilitators & Promoters
- Universities

- Electric bus provider
- Supply charging & data mgmt. system

- Pre-feasibility study
- Feasibility study
- Pilot monitoring
Public Transit Overview

**Protransporte:** decentralized public agency of Metropolitan Municipality of Lima

- Daily Ridership 700,000 passengers (BRT)
- Daily Ridership 300,000 (feeder routes)

**El Metropolitano BRT Four operators:**

- Peru Masivo
- Lima Bus Internacional
- Lima Vias Express S.A. (LVESA)
- Transvial Lima SAC

- LVESA most advanced facility to support eBus pilot
- LVESA maintenance and general manager interviewed
- Taryet responsible for Route Scheduling
Public Transit Overview

**Allin Group**: operator along feeder routes Corredor Javier Prado
- Diesel and CNG bus fleet (total 210)
- Service includes Routes 201 and 209
- **Staff**: 25 mechanics, 7 electricians and 200 operators

**ETULSA**: operator along feeder routes Corredor Proceres-Abancay-Brasil (PAB)
- Diesel bus fleet (total 260) across 29 corridors
- Service includes Routes 201 and 209
- **Staff**: 57 mechanics, 6 electricians

Public transit operators involved to:
1. Benchmark existing fleet operating costs
2. Assess current fleet and facilities
3. Potential cooperation & support for eBus Pilot
Project Scope
Project Scope WSP

1. Assess eBus feasibility in Lima from vehicle operations and maintenance perspective
2. Condition of facilities, knowledge of local operators and mechanics
3. eBus Simulation (BOLT)
4. Identification of pilot eBus route
5. Develop eBus vehicle specifications
6. Assess OEM vehicle quality compliance to specifications
7. Pilot eBus Strategy and performance monitoring
BOLT Electric Vehicle Simulation Tool
BOLT - Electric Vehicle Simulation

**Key benefits**

Takes into account following parameters impact on range:

- **Battery Size**
- **Passenger load**
- **Parasitic Load (Lighting)**
- **HVAC**
- **Bus Weight**
- **Topography**
- **Charging Infrastructure**
Key Features of BOLT

- Model Vehicle Performance, State-of-Charge (SOC)
- On-Route & Depot Charging Scenarios
- Impact on Facility Energy Use
- Schedule Optimization
Example of a “Chain” multiple blocks chained sequentially over 24-hours showing State-of-Charge (SOC) drop
BOLT Visualizations: On-route

- Charger locations throughout transit network
- Energy used by on-route chargers throughout network
- Energy required to charge vehicle on-route
BOLT Visualizations: Facility

Number of vehicles charging in the depot throughout the day.

Energy required to charge vehicles in the depot.

Cumulative energy required to charge fleet.
BOLT Visualizations: Schedule Optimization

- Blocks cut into segments/rescheduled
- Allows feasibility for smaller battery sizes or without on-route charging
- Schedule Optimization can be used to achieve 100% electrification

**Before:** Red blocks cannot be completed with vehicle configuration (i.e. battery size)
BOLT Visualizations: Schedule Optimization

After: 100% completion based on schedule optimization

Two additional buses for the fleet to achieve 100% electrification with new schedule
Lima eBus Simulation
Lima eBus Simulations

- WSP on-site visitation to collect route data and passenger counting
  - On-board GPS route mapping technology
- Determine impact of:
  - Passenger load
  - Route Topography
  - Air Conditioning Load
- Output eBus performance (number of route loops)
- Routes Simulated:
  - Route 201
  - Route 209
  - Route 405
  - Route 412
  - BRT Route A
  - BRT Route B
  - BRT Expreso
  - Panamericana (Linea Amarillo)
- eBuses simulated:
  - BYD Andino 12m
  - BYD Andino 18m (BRT only)
## Route 201 Sample Output

### Outward Direction (West to East)

<table>
<thead>
<tr>
<th>Pattern 201.1</th>
<th>0% Loading</th>
<th>100% Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC On</td>
<td>20.5%</td>
<td>21.3%</td>
</tr>
<tr>
<td>AC Off</td>
<td>13.6%</td>
<td>14.4%</td>
</tr>
<tr>
<td>Impact of AC</td>
<td>6.9%</td>
<td>6.9%</td>
</tr>
</tbody>
</table>

### Return Direction (East to West)

<table>
<thead>
<tr>
<th>Pattern 201.2</th>
<th>0% Loading</th>
<th>100% Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC On</td>
<td>12.3%</td>
<td>12.5%</td>
</tr>
<tr>
<td>AC Off</td>
<td>5.4%</td>
<td>5.6%</td>
</tr>
<tr>
<td>Impact of AC</td>
<td>6.9%</td>
<td>6.9%</td>
</tr>
</tbody>
</table>
Panamericana Route Simulation

**MEASUREMENT** | **VALUE**
---|---
Total Measured Route Distance | 26.2 km
Elapsed Travel Time | 1 hour 52 minutes
Average Speed | 8.7 mph (14 km/h)
Max Speed | 39.8 mph (64 km/h)
Max Elevation | 845 ft (258 m)

ANDINO-12

| Manufacturer | BYD |
| Battery | 324 kWh iron-phosphate |
| Curb Side Weight (lbs) | 30,865 |
| Gross Vehicle Weight (lbs) | 42,659 |
| Seats | 36 |
| Passenger Capacity | 79 |
| Length | 12 metres |

Direction 1 Energy Loss  
Canta Callao to Javier Prado | 63.5 kWh  
Direction 2 Energy Loss  
Javier Prado to Canta Calllao | 57.4 kWh  
Total Energy Loss for Loop | 120.9 kWh  
Number of loops able to complete on a single charge | 2.1 loops
Diesel vs. eBus Lifecycle
Lifecycle Cost Comparison

Equivalent Annual Cost over 15 years:

- **Diesel**: $78,918
- **CNG**: $85,953
- **eBus**: $76,000
- **eBus**: $57,191*

*maintenance outsourced to eBus manufacturer BYD
**Total Lifecycle Cost**

- **Diesel:** $78,918 EAC  
  Lifecycle = $1.18 million

- **CNG:** $85,953 EAC  
  Lifecycle = $1.23 million

- **eBus:** $57,191 EAC  
  Lifecycle = $0.86 million
Lifecycle Cost Comparison

Estimated annual 60,000 km per bus

eBus reduction of tailpipe CO2 emissions:
  • 150 kg of CO2 compared to CNG bus
  • 226.8 kg of CO2 compared to Diesel Euro III bus
eBus Manufacture & Inspection
Market Scan of eBus Manufacturers

Reasons for BYD Selection:

1. eBus operations in several South American countries
   1. Campinas, Brazil
   2. Montevideo, Uruguay
   3. Santiago, Chile
2. Production facilities in Brazil and Columbia
3. BYD K9 high floor design, low mounted battery trays fit operating environment of Peru
4. Expansion plans in South America to open a factory in Argentina
5. Full service offering including maintenance and operator training
eBus Vehicle Specification

Specification Developed:
1. Protransporte specification for 12m transit bus
2. eBus performance and charging requirements

Specification Components:
1. Vehicle Dimensions
2. Traction Motor & Battery Performance
3. Operating Range
4. ViriCiti DataHub Installation
5. Internal/External Noise
6. Axles, Wheels and Tires
7. Chassis & Bodywork
8. Door Operation
9. Passenger Seats, Stanchions, Stop Request
10. Lighting
11. Driver’s Area
12. Windows & Mirrors
13. Ventilation
14. Electrical System
15. Fire Protection
16. Maintenance
17. Accessibility & Decals
eBus Build Verification

1. WSP Inspector on-site in China for quality assurance and verifying build to specifications (FAT)

2. Note defects from build:
   1. Loose or rubbing cables
   2. Paint scratches
   3. Fit and finish

3. Secondary WSP inspection in Peru after eBus shipped (PDI)

4. ViriCiti Data Hub installation
Defects Noted

- Paint scratch on battery access door
- Need to trim reflector tape over panel gap
- Loose electrical cables to be secured with zip ties
- High Voltage cable rubbing frame
eBus Implementation
Implementation Challenges

1. **Maintenance Familiarity & Supply Chain:**
   - Currently no BYD manufacturing in Peru
   - Spare parts would be delivered from Panama
   - BYD to provide servicing and maintenance for 2 year pilot
   - Need to train local mechanics

2. **Operator Familiarity:**
   - High torque electric motor differences in acceleration
   - Regenerative braking
   - BYD to provide driver training
   - Emergency response protocol

3. **Capacity for Charging:**
   - Existing electrical infrastructure upgrades
   - Overnight off peak charging to reduce grid impact and cost
Implementation Challenges

1. **Electrical Troubleshooting:**
   - Local staff need to develop knowledge on eBus systems
   - Reduced maintenance needs may initially be offset by troubleshooting time

2. **Road Conditions:**
   - eBus clearance (i.e. high floor design)
   - Avoid routes with potholes, gravel or uneven pavement
   - Increased battery weight can also impact road surface
ViriCiti Data Hub

1. Collect data on eBus performance, charging and energy consumption
2. Compare against OEM vehicle specifications
3. Monitor real time performance of the pilot eBus
4. Feed data into Replicability Study
eBus Pilot

Stage 1: Understanding
- User Group and Vehicle Needs (Operations & Maintenance)
- GHG Inventory of Fleet Assets
- GHG Reduction Targets

Stage 2: Exploratory
- Market Research on Alternative Propulsion Technologies and Trends
- Technology Impact on GHG Reduction, O&M Cost
- Grants and Funding Opportunities

Stage 3: Implementation
- Change Management Plan
- Maintenance & Facility Modifications
- Buy-in from Stakeholders & Senior Management

Stage 4: Execution & Monitoring
- Pilot Vehicle Program
- Establish KPIs for vehicles and Purchase/Lease Units
- Review of Pilot Data & User Feedback
- Wider Adoption Amongst User Groups

Currently in Stage 4
Thank you!

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