Operationalizing E-bus Fleets: Lessons Learned From China

ITDP
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1. The status of e-bus in China
2. The major driving force of e-bus development
3. E-bus operational data
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The Status of E-bus in China
Till 2019, the total bus fleet is 693,000, new energy buses (497,000) account for 59.1% of whole bus fleet.

New energy buses include: BEB, hybrid bus and fuel cell bus.

In new energy buses in China, the BEB account for 75%.
In the city of Shenzhen, Guangzhou, Zhengzhou, Changsha, new energy buses account for the largest proportion.
Promotion of New-Energy Buses in 36 Major Cities of China in 2018
The Status of E-bus in China

The Major Driving Force of E-bus Development
Four most important driven forces in promoting e-bus

- **Policy support** plays the most important role in promoting e-bus development in China since 2009.

- **E-bus industry**, cities with E-bus manufactures have the largest proportion of e-buses.

- **Environmental pressure**. National government set ambitious electrification target to regions have severe air pollution issue

- **Infrastructure** has to ensure efficient e-bus daily operation
National Policy

- Stage I (2009-2013): Pilot program get started
- Stage II (2013-2018): Gradual expansion
- Stage III (2018-2020): Nationwide promotion

2009.1
Notice on Launching Pilot Project of Demonstration and Promotion of New Energy Vehicles
Known as "ten cities and one thousand vehicles" project, each city will launch 1,000 new energy vehicles to carry out demonstration operation, and strive to make the operation scale of new energy vehicles nationwide and account for 10% of the automobile market share by 2012.

2012.6
Government should play a guiding role in procurement, and gradually expand the scale of purchasing energy-saving and new energy vehicles by public institutions. By 2020, the production capacity of new energy vehicles will reach 2 million vehicles, with a cumulative production and sales volume of more than 5 million vehicles.

2013.8
Notice on Continuing to Promote and Apply New Energy Vehicles
Government agencies, public institutions and other fields of vehicle procurement should be inclined to new energy vehicles, new or updated public transport, government official vehicles, logistics, sanitation vehicles in the proportion of new energy vehicles is not less than 30%

2014.7
Guiding Opinions of the General Office of the State Council on Accelerating the Promotion and Application of New Energy Vehicles
From 2014 to 2016, the proportion of new energy vehicles purchased by central government and pilot project cities will be no less than 30% of the total number of vehicles purchased in that year, and the application scale will be expanded year by year thereafter.

2014.11
Notice on Rewards for Construction of Charging Facilities for New Energy Vehicles
From 2013 to 2015, the Ministry of Finance will give awards in different degrees according to the annual number of new energy passenger car units promoted in cities (divided into three major urban agglomerations and two levels in other regions). The amount of awards will be increased year by year, with the range between 10 million and 120 million.

2015.3
Implementation Opinions on Accelerating the Promotion and Application of New Energy Vehicles in Transportation Industry
By 2020, the number of new energy vehicles in the public sector will reach 300,000 (200,000 buses, 100,000 taxis and urban logistics vehicles). The proportion of new or updated new energy vehicles in pilot cities will not be less than 30%, and that in Beijing, Tianjin and Hebei will not be less than 35%.
National Policy

- Stage I (2009-2013): Pilot program get started
- Stage II (2013-2018): Gradual expansion
- Stage III (2018-2020): Nationwide promotion
National subsidy for e-bus purchase (10,000RMB)
(Use bus length ≥ 10m as example)

E-bus sales number (unit)

National subsidy
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Indicators of subsidy quota</td>
<td>Vehicle Length; Driving Range; Energy Consumption per unit load;</td>
<td>Vehicle Length; Energy density of battery system; Efficiency of fast charging (Fast charging system for pure electric buses)</td>
<td>Vehicle Length; Energy density of battery system; Efficiency of fast charging (Fast charging system for pure electric buses) ; Energy Consumption per unit load;</td>
<td>aberage of total vehicle mass</td>
<td></td>
</tr>
<tr>
<td>Min/Max of indicators for subsidy</td>
<td>/</td>
<td>/</td>
<td>Driving Range; Energy Consumption per unit load; Energy density of battery system; Total battery system mass as a percentage of total vehicle mass</td>
<td>Driving Range; Energy Consumption per unit load; Energy density of battery system; Efficiency of fast charging</td>
<td>Driving Range; Energy Consumption per unit load; Energy density of battery system; Efficiency of fast charging</td>
</tr>
</tbody>
</table>
E-bus industry

The Top 10 NEV Bus Manufacturer and NEV Buses Share in Corresponding Cities

Sales of NEV Buses vs. Share of NEV Buses in Corresponding Cities

- Yutong/Zhengzhou
- BYD/Shenzhen
- BYD/Guangzhou
- Zhongtong/Jinan
- Yinlong/Zhuhai
- Zhongche/Changsha
- Jinlong/Xiamen
- Shenlong/Shanghai
- Haige/Suzhou
- Shenlong/Shanghai
‘Blue Sky’ Three Years Actions Key Zone and Core Cities
E-bus Operational Data
Average Driving Distance

Average driving distance for battery electric buses in 36 main Chinese cities.

Average range (km) per charge:

- 175 - 199
- 150 - 174
- 125 - 149
- 100 - 124
- 75 - 99
- 0 - 74
Operational data

**E-bus size**
- 50%: 6m < length ≤ 8m
- 37%: 8m < length ≤ 10m
- 13%: length > 10m

**E-bus average operational time (h)**
- 2017: 4.94
- 2018: 8.36

**Daily average mileage for different types of bus in each city (km)**
- Shenzhen: 250
- Beijing: 200
- Wuhan: 150
- Qingdao: 100
- Chongqing: 50

**Efficiency of the e-bus replacement ratio**
- Shenzhen: 1.7
- Beijing: 2
- Wuhan: 1.9
- Qingdao: 1.5
- Chongqing: 1.5

Legend:
- **Green**: fully-electric bus
- **Yellow**: traditional diesel bus
Energy Consumption
Operational Failure

- General Failure: 33%
- Battery Failure: 18%
- Electronic Control System Failure: 19%
- Battery Management System Failure: 9%
- Motor Failure: 17%
- Power System Failure: 4%
Charging infrastructure
Plug-in DC charge is most common and matured technology in China for e-bus.

<table>
<thead>
<tr>
<th>Type</th>
<th>Power</th>
<th>Pros</th>
<th>Cons</th>
<th>Location</th>
</tr>
</thead>
</table>
| Plug-in  | AC: 20-50Kw | • Lower initial cost  
• Low grid pressure  
• Charging at night, supporting the grid with ‘cutting peak and filling valley’ strategy  
• Cheaper operational cost | • Long charging time, not ideal for e-bus operation  
• Space requirement | Bus depot           |
|          | DC: 50-150Kw| • Fast charge in the daytime support flexible operation  
• Charging at night, supporting the grid with ‘cutting peak and filling valley’ strategy  
• Short charging time | • High pressure on grid  
• Space requirement |                      |
| Pantograph| 360Kw and above | • Fast charge support flexible operation  
• Installed along bus lines, less requirements on space | • High initial investment  
• High pressure on grid  
• Harmful to batteries life | Flexible, located along bus lines and depots |
Two demonstration pantograph charging stations installed in Shanghai.
The national subsidy has been shifted from bus procurement to infrastructure support from 2016.
Price for DC Charging Module

DC charging power module price (RMB/W)

- 2014: 2.1
- 2015: 1.6
- 2016: 1.2
- 2017: 0.6
- 2018: 0.5
- 2019: 0.4
National government, local government, bus company, bus industry should work together on:

- Establish testing, evaluation, monitoring and report mechanism on E-bus real world performance
- Establish e-bus monitoring platform to help to make better decision on e-bus procurement and operation

Charging infrastructure should be planned before e-bus procurement.

Optimized bus route plan and operational plan should be conducted before e-bus procurement.

Detailed operational plan should be based on different types of buses and charging infrastructures.
Start from a Pilot Project

Efficient e-bus system

- Fleet size
- Schedule
- Route planning
- Charging plan
- Charging units and location
- Grid capacity
- Battery Capacity
- Range
Data collection and analysis

- Power consumption, record changes in different temperature
- Driving range, driving range in different temperature
- Performance review for e-bus from different manufacturers
- Battery decay rate
- Charging pattern: including time and frequency
- Major operational failures
- Operational cost
- Monitor the bus performance and charging behaviors
- Benefits: energy saving, CO2 reduction, pollutant reduction
Overview:
The Development of New Energy Vehicles in Shenzhen

- **START**
  - 2009: Selected as an electric vehicle city pilot
  - Finished integration: several private bus operators into three large bus companies

- **2011**
  - Deployed 200 e-buses
  - Launched first fully electrified bus route, 2012

- **EXPLORE NEW BUSINESS MODEL**
  - 2015: Rent e-buses and batteries from manufacturers, which greatly ease the pressure of high upfront cost of e-buses

- **2017**
  - The number of new energy buses in Shenzhen reached 16359
  - The full electrification of buses

- **NOW**
Overview:
The Development of New Energy Vehicles in Shenzhen

Shenzhen E-buses Development History

- **New Energy buses**
- **Conventional Buses**
- **Proportion**

Overview:
The Development of New Energy Vehicles in Shenzhen

<table>
<thead>
<tr>
<th>Year</th>
<th>New Energy buses</th>
<th>Conventional Buses</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>0,0%</td>
<td>12,3%</td>
<td>0%</td>
</tr>
<tr>
<td>2010</td>
<td>0,0%</td>
<td>12,3%</td>
<td>0%</td>
</tr>
<tr>
<td>2011</td>
<td>0,0%</td>
<td>21,0%</td>
<td>21,0%</td>
</tr>
<tr>
<td>2012</td>
<td>21,0%</td>
<td>21,4%</td>
<td>42,4%</td>
</tr>
<tr>
<td>2013</td>
<td>21,4%</td>
<td>19,7%</td>
<td>41,1%</td>
</tr>
<tr>
<td>2014</td>
<td>19,7%</td>
<td>43,9%</td>
<td>63,6%</td>
</tr>
<tr>
<td>2015</td>
<td>43,9%</td>
<td>62,8%</td>
<td>100%</td>
</tr>
</tbody>
</table>

- 2016: 100%
- 2017: 100%
Governments at all levels attach great importance and issue various policies to support—

<table>
<thead>
<tr>
<th>Year</th>
<th>Name of policy and measures issued</th>
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<tbody>
<tr>
<td>2014</td>
<td>Shenzhen ‘13th Five-Year Plan’</td>
</tr>
<tr>
<td>2015</td>
<td>Working plan for developing new energy vehicle in Shenzhen</td>
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<tr>
<td></td>
<td>Policies and measures for promotion and application of new energy vehicles in Shenzhen</td>
</tr>
<tr>
<td></td>
<td>Implementation rules for record management for operators of charging facilities for new energy vehicles in Shenzhen.</td>
</tr>
<tr>
<td>2016</td>
<td>Methods for distributing stipend in operating new energy bus during promoting period.</td>
</tr>
<tr>
<td>2017</td>
<td>Method for distributing stipend for refined oil prices and operation of new energy buses in Shenzhen from 2015 to 2019 (trial)</td>
</tr>
<tr>
<td>2018</td>
<td>A sustainable action plan named &quot;Shenzhen blue&quot;</td>
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<td></td>
<td>Interim measures for the management of charging facilities for new energy vehicles in Shenzhen</td>
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Financial Support and Model Innovation—

Subsidy for e-bus procurement in Shenzhen
\((10,000\text{RMB}) \quad (L\geq10m)\)

- **National subsidy**
- **Local Subsidy**
adopted a system of integrating multiple parties to reduce the overall cost burden and market risks

innovates the financial model for e-bus procurement and operation, which is ‘financial leasing, separation of vehicle and battery, outsourcing of charging and maintenance’, to reduce the upfront cost, and encourage bus companies to speed up the transition.
Thanks!

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