International Experience with Electric and Zero Emission Buses

Ray Minjares

International Seminar

Electric Mobility in Public Bus Transport: Challenges, Benefits and Opportunities

9 May 2018

Ministry of Cities - Brazil
Buses are a visible entry point for cleaner fuels and vehicles
Old diesel technology can give the best BRT the worst image
INSISTEN EN DUDAS EXPRESADAS POR ENTES DE CONTROL, CONCEJALES Y AMBIENTALISTAS

Desde el Congreso piden revocar licitación para renovar buses de Transmilenio

Bogotá 18 Abr 2018 - 11:47 PM
Por: -Redacción Bogotá -bogota@elespectador.com

Senadores y representantes cuestionaron el proceso y pidieron una nueva convocatoria que incluya buses de tecnología limpia. Critican al alcalde Peñalosa porque en la licitación “prima el interés financiero bienestar de los bogotanos”.

Después de críticas, Peñalosa cambia puntos de licitación para nuevos buses de Transmilenio

Bogotá 24 Abr 2018 - 10:27 AM
Por: -Redacción Bogotá -bogota@elespectador.com

Quienes incluyan buses con tecnología Euro VI, una de las más limpias que se conocen en la actualidad, podrán tener hasta 400 puntos. En la primera propuesta presentada por el Distrito este ítem solo representaba 50 puntos.
9 out of 10 people breathe polluted air

Air pollution is a major environmental risk to health. By reducing air pollution levels, countries can reduce:

- Stroke
- Heart disease
- Lung cancer, and both chronic and acute respiratory diseases, including asthma

**Regional estimates according to WHO regional groupings:**

- **Over 2 million** deaths in South-East Asia Region
- **Over 2 million** deaths in Western Pacific Region
- **Nearly 1 million** deaths in Africa Region
- **About 500 000** deaths in Eastern Mediterranean Region
- **About 500 000** deaths in European Region
- **More than 300 000** deaths in the Region of the Americas

Clean Air for Health  #AirPollution

icct THE INTERNATIONAL COUNCIL ON Clean Transportation
But we also face a climate challenge

**Effect of current pledges and policies**

*Global greenhouse gas emissions*

- **Historical emissions**
- **Projections**
  - No climate policies: 4.1-4.8°C
  - Current policies: 3.1-3.7°C
  - Pledges: 2.6-3.2°C
  - 2°C Pathways
  - 1.5°C Pathways

Source: Carbon Action Tracker
Energy consumption of on-road diesel engines* has increased more than 400% since 1980

Based on IEA data from the World Energy Balances Data Service

*Diesel engines consume diesel fuel and biodiesel.
China Airpocalypse (2013 Jan)
60% of new buses in major cities must be NEVs

- Battery electric
- Plug-in Hybrid Electric
- Fuel Cell Electric

Figure 1. Vehicle population in China’s provinces and municipalities in 2014 (10,000 units)
China Industrial Policy: 48 Billion USD in NEV Subsidies since 2009

Chinese manufacturers dominate sales

**2015**

- Yutong: 15%
- BYD: 6%
- Zhongtong: 9%
- Nanjing: 10%
- Futian Ouhui: 3%
- Zhuhai Yinlong: 4%
- Others: 53%

**Total:** 50,000

**2016**

- Yutong: 19%
- BYD: 13%
- Zhongtong: 10%
- Nanjing: 7%
- Futian Ouhui: 4%
- Zhuhai Yinlong: 5%
- Others: 42%

**Total:** 116,000

*Source: Bloomberg New Energy Finance, OFweek*
California

Source: Frank Schulenburg, CC BY-SA 4.0,
California statewide goals

- Meet federal ozone air quality standards in 2023 and 2031
- 40% reduction in GHG emissions from 1990 by 2030
- 80% reduction in GHG emissions from 1990 by 2050
- 50% reduction in petroleum consumption by 2030

Requires maximum deployment of zero emission technologies
Battery and Fuel Cell Electric Buses in California
(107 in operation and 340 on order/awarded as of September 2017)

1 Buses in transit fleets and universities
California Statewide Fiscal Incentives

Approved Funding Plan - Vouchers

- Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) and Low NOx Engine Incentives
  - $188 million for FY 17-18
    - Increased voucher amounts
    - $35 million set aside for ZEBs
    - Rest is first come first served for ZE trucks, ZEBs, low-NOx engines, other

- Infrastructure voucher enhancement
  - Up to $30,000 per charger for BEB
  - Up to $100,000 per FCEB with purchase of 5 or more

<table>
<thead>
<tr>
<th>Category</th>
<th>Base Amount*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low NOx Engine (8.9 Liter)</td>
<td>$10,000</td>
</tr>
<tr>
<td>Zero Emission Bus (20 ft – 24 ft)</td>
<td>$80,000</td>
</tr>
<tr>
<td>Zero Emission Bus (25 ft – 29 ft)</td>
<td>$90,000</td>
</tr>
<tr>
<td>Zero Emission Bus (30 ft – 39 ft)</td>
<td>$120,000</td>
</tr>
<tr>
<td>Battery Electric Bus (40 ft – 59 ft)</td>
<td>$150,000</td>
</tr>
<tr>
<td>Battery Electric Bus (60 ft)</td>
<td>$175,000</td>
</tr>
<tr>
<td>Double Decker Bus (40 ft)</td>
<td>$175,000</td>
</tr>
<tr>
<td>Fuel Cell Electric Bus (≥ 40 ft)**</td>
<td>$300,000</td>
</tr>
</tbody>
</table>

* Up to $15,000 more for use in a disadvantaged community

Proposed FY 2017-18 Funding Plan [https://www.arb.ca.gov/msprog/agip/fundplan/proposed_1718_funding_plan_final.pdf](https://www.arb.ca.gov/msprog/agip/fundplan/proposed_1718_funding_plan_final.pdf)
Los Angeles
City of Los Angeles: 100% ZEB Goal by 2030

Metro Bus Fleet Transition to Zero Emission Buses (ZEB's)

- Total ZEB's
- Total CNG Buses

Graph showing the transition of the Metro bus fleet from 2017 to 2030, with an increase in ZEB's and a decrease in CNG buses over the years.
Challenges Transitioning to 100% Zero Emissions

1. Long-term **demand for equal or greater service** and operating performance
   1. 400+ km range in stop/go driving with 1.4 passenger load factor
   2. Less than 14,000 kg curb weight for 12m ZEB
   3. 400km range throughout the 12 year vehicle life
   4. 100km/h top speed; ability to sustain 10% grade

2. New Up Front **Investment in Charging Equipment** and Infrastructure

3. Known and unknown **technology risks**, particularly batteries

4. Additional **funding** needed to deploy 100% ZEB program.

Impacts to other capital and operating costs, deployment schedule and/or service levels and reliability. May require replacement on greater than 1:1 ratio.
Los Angeles – Two Phase Plan

Phase 1:
- Electrify 2 BRT lines
- Continue replacing existing fleet with low-NOx CNG engines (~ 200 per year)
- Develop ZEB Technology Assessment and Master Plan (2019-2020)

Phase 2:
- Implement ZEB Master Plan to deploy 100% zero emission buses.
Metro Orange Line – Project Details

- 40 New Flyer All Electric Buses 18m, and 5 BYD 18m buses
- 2 - Shop Chargers Installed at Division 8 in Chatsworth
- 8 - En-Route Opportunity Chargers Installed at MOL Terminals in Chatsworth, Canoga and North Hollywood
BEB ROUTE DESIGN FOR SANTIAGO PUBLIC TRANSPORT SYSTEM
Santiago Principle: Diesel Equivalent Operation

Routes with highest potential to meet the following:

- **Productivity**: the size of the fleet and the number of drivers must be the same with BEB, and TCO must not be much higher
- **Operation**: BEB must operate with same frequencies and regularity
- **Reliability**: System of buses and recharging solutions must run with similar reliability
Criteria for route selection

**Opportunity Charging**

- Data base (8 julio 2017)
  - 1. Route length (<20 km/one direction & <20 km/returning)
  - 2. Must run all week long
  - 3. Must run >11 hr/day
  - 4. Fleet > 15 buses

**Depot Charging**

- Data base (8 julio 2017)
  - 1. Route Length* (<180 km bus/day)
  - 2. Must run all week long
  - 3. Must run >11 hr/day
  - 4. Fleet > 15 buses
  - 5. Night operation

<%
- Ten routes selected for TCO analysis
- Final recommendations under development
Shenzhen, China: 16,359 electric buses

https://qz.com/1169690/shenzhen-in-china-has-16359-electric-buses-more-than-americas-biggest-citiess-conventional-bus-fleet/
## China City Targets for NEV Buses

<table>
<thead>
<tr>
<th>City</th>
<th>Target</th>
<th>Scope</th>
<th>Base Year</th>
<th>Target Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>60%</td>
<td>Existing fleet</td>
<td>2017</td>
<td>2020</td>
</tr>
<tr>
<td>Shaanxi</td>
<td>7000</td>
<td>Existing fleet</td>
<td></td>
<td>2020</td>
</tr>
<tr>
<td>Hainan</td>
<td>90%</td>
<td>New and replacement buses</td>
<td></td>
<td>2020</td>
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<tr>
<td>Guangdong</td>
<td>75%</td>
<td>Existing Fleet</td>
<td></td>
<td>2020</td>
</tr>
<tr>
<td>Pearl River Delta</td>
<td>90%</td>
<td>New and replacement</td>
<td></td>
<td>2019</td>
</tr>
<tr>
<td>Chongming Island</td>
<td>100%</td>
<td>Existing Fleet</td>
<td></td>
<td>2020</td>
</tr>
<tr>
<td>Harbin</td>
<td>80%</td>
<td>Existing Fleet</td>
<td></td>
<td>2020</td>
</tr>
<tr>
<td>Changsha</td>
<td>100%</td>
<td>Existing Fleet</td>
<td></td>
<td>2020</td>
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Conclusions: Dual Transition Strategy

<table>
<thead>
<tr>
<th>National Actions</th>
<th>Local Actions</th>
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<tbody>
<tr>
<td>Fiscal incentives</td>
<td>1. Demonstration</td>
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<tr>
<td>National targets</td>
<td>2. Route electrification</td>
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<td>Evaluation</td>
<td>3. ZEB Strategy</td>
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<tr>
<td></td>
<td>% ZEB Target</td>
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<td></td>
<td>Implementation Plan</td>
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