Electricity Bus and Public Transportation in Korea

Dec 15, 2016

Changhwan MO Ph.D.
Korea Transport Institute
Title: Electricity Buses and Public Transport in Korea

Presenter: Dr. Changhwan Mo(Research Fellow, Korea Transport Institute)

Abstract:
This study reviews the current status of technology development and operations of electric buses in Korea. It will analyze two types of electric buses which are operating in Korea: OLEV and a battery-swapping electric bus (BSEB). OLEV, On-line electric vehicle, is a wireless charging electric bus system and the battery-swapping system is an autonomous battery exchange electric bus. OLEV is operating in both Gumi and Sejong cities, while BSEB is operating in Pohang and Seoguipo city. It analyzes technology development, regulations, environmental impacts and economic feasibility of electric buses in Korea. It also provides policy directions of Korean electric buses from the perspective of public transportation.
OLEV
: On-Line Electric Vehicle
Korean road wirelessly recharges OLEV buses!
**Concept**

Ideal Goal: OLEV uses the electricity generated by sun or wind power with wireless recharging inverter, an induction system.

- Bus stops: Slow speed charging
- Transfer stations: Fast speed charging
- Garage and return stations: Fast speed charging

![Diagram of OLEV system components](image)

Construction of wireless charging spots: simultaneous charging 1 bus

Source: Kim, Jong Woo (2014)
# Preparation of legal system for commercial operations

<table>
<thead>
<tr>
<th>Classification</th>
<th>Process</th>
<th>Government</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Distribution of frequency (19<del>21kHz, 59</del>61kHz)</td>
<td>Ministry of Science, ICT, Future Planning</td>
</tr>
<tr>
<td>Road structure</td>
<td>Revision of transport law</td>
<td>Ministry of Land, Infrastructure and Transport</td>
</tr>
<tr>
<td>Electricity safety</td>
<td>Certification of electricity safety</td>
<td>Ministry of Trade, Industry, and Energy</td>
</tr>
<tr>
<td>Vehicle certification</td>
<td>Vehicle certification from government</td>
<td>Ministry of Land, Infrastructure and Transport</td>
</tr>
</tbody>
</table>

Start of commercial operation of OLEV

- City: Gumi city
- Route: 14km (one way, City hall-Gupyeng Yedaum Apt.)
- Frequency: 12 times per day (2 buses)
- Speed: 60-70 kmh
- Date: March 25, 2014
- Effect: Promotion of green city of Gumi
Sejong City

OLEV Bus in Sejong

Charging Facility in Sejong
Estimated Costs of OLEV

- Budget for wireless charging infrastructure: $762,000
  ① Garage (1 bus) = $143,000
  ② Bus stops = 2 stops × $143,000 = $286,000
  ③ Turning space = 1 place × $143,000 = $143,000
  ④ Operation system = $190,000

* Estimated budget for 1 OLEV bus

- Budget for OLEV bus purchase: $670,000

- Vehicle and Infrastructure System Engineering: $480,000

- Budget for one bus = $1,912,000: About 2 million dollars

Source: Kim, Jong Woo (2014)
Gumi City

- First commercial operation in the world by putting the wireless charging electric bus on the city bus route from Gumi Station to In-dong section (28km round trip) from March 25, 2014.

- Charged for about 20 minutes at the end point and the starting point using about 25% of the total battery capacity while operating one way.

- Introduced as part of an effort to transform the image of the gray industrial city into a green eco-friendly city.

- Environmentally friendly with no carbon gas and built as a low-floor bus that respects the transportation vulnerable

- Loved by many citizens and firmly established as a landmark of Gumi city.
Effects

- 38% lower fuel cost than the annual diesel and 33% lower than the CNG bus

- Same as that of planting 40,000 pine trees (30 years old) because there is no carbon emission during operation.

- Vibration was less and more quiet than the general bus

- High satisfaction of the passengers

Effects (continue)

- Added two wireless rechargeable electric buses in April, 2016 and operates four wireless rechargeable electric buses

- Taking the lead in establishing a green public transportation system by putting the electric bus in Gumi Station ~ Okgye 4 Industrial Complex (40km)

- Possible to offset the high cost of the car, comprehensively considering the efficiency of the operation, the improvement of the environment and the improvement of the urban image

☞ Gumi City judges that the added value of the environment improvement that can not be converted into simple economic value will further increase the value of the wireless charging electric bus.
### <Merits and Demerits of Wireless Charging Buses>

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Can be charged without stopping while driving → Real-time wireless charging</td>
<td>• Necessary to maintain the right distance between the electric line embedded in the road and the vehicle.</td>
</tr>
<tr>
<td>• Battery charging efficiency: 75~85%</td>
<td>• Waiting time for bus shift operation need → Charging time before route input 20 to 30 minutes</td>
</tr>
<tr>
<td>• Lower maintenance cost → Compared with gas and diesel buses: about 30% - 40%</td>
<td>• Expensive utility service is needed at the bottom of the road</td>
</tr>
<tr>
<td>• Automatically recharge buses with ease and safety</td>
<td>• High initial build costs(Gumi City Standard)</td>
</tr>
<tr>
<td>• Lighter weight of buses</td>
<td>• Flexible route can not be operated (Embedded power line at 5cm under the road)</td>
</tr>
<tr>
<td></td>
<td>• Possible to damage the electric wire during maintenance and repair of roads</td>
</tr>
<tr>
<td></td>
<td>• Safety issues by over-heating battery and charging facility</td>
</tr>
</tbody>
</table>
Battery Swapping Electric Bus (BSEB)
Battery Swapping Electric Bus

Battery Swapping Station

Concept and Structure

- Installed an upper exchangeable battery exchange facility at bus stops to compensate for the disadvantages of electric buses with short operating distances.

- Allows the batteries to be quickly replaced to meet the characteristics of public transport with short intervals and allows non-stop bus operation without waiting time.

- Not a system to charge and use the battery by plugging in the battery, but a system that can automatically replace the charged battery and used battery in a short time (about 2 to 4 minutes) equipped with battery detachable vehicle and automatic battery detachable system.
Electrical bus system composition

- Battery Swapping Station (BSS)
  - Constructed for the purpose of operating the BSSEB (Battery Swappable Smart e-Bus) and has the same form as a general bus stop
  - Automatically exchanges and recharges the battery mounted on the top of the BSSEB for about one minute during which the bus running on the designated route stops at the stop and the passengers get on and off
  - Systematically arranged so that up to 20 batteries can be loaded and operated and designed to accommodate several BSSEBs in congestion
- Battery Swappable Smart e-Bus (BSSEB)
  - Based on the large-scale CNG low-floor bus of the hwaiba Co., Ltd., it has similarly modified the general low-floor bus and its form and use.

<table>
<thead>
<tr>
<th>Name</th>
<th>Battery Swappable Smart e-Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body material</td>
<td>Lightweight carbon composite</td>
</tr>
<tr>
<td>Size(mm) [length×width×height]</td>
<td>11.055×2,485×3,490</td>
</tr>
<tr>
<td>Seat (person)</td>
<td>24+24+1</td>
</tr>
<tr>
<td>Weight(kg)[empty]</td>
<td>11,550</td>
</tr>
<tr>
<td>Weight(kg)[laden situation]</td>
<td>14,730</td>
</tr>
<tr>
<td>Tire form [front/rear]</td>
<td>275/70R 22.5-16PR(S)</td>
</tr>
<tr>
<td></td>
<td>275/70R 22.5-16PR(D)</td>
</tr>
<tr>
<td>Max. Speed (km/h)</td>
<td>72</td>
</tr>
<tr>
<td>Climbing ability (%)</td>
<td>5</td>
</tr>
</tbody>
</table>

- Battery of BSSEB (Battery Swappable Smart e-Bus)

  - Equipped with two batteries in the upper roof of the BSSEB, and consists of 1 exchangeable battery for continuous operation and 1 fixed battery for emergency operation.
  - Li-Ion-Polymer type, each capacity of 48.6kWh

<table>
<thead>
<tr>
<th></th>
<th>Li-Ion-Polymer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company(country)</td>
<td>LG CHEM(Korea)</td>
</tr>
<tr>
<td>Battery capacity</td>
<td>163kWh</td>
</tr>
<tr>
<td>Battery life</td>
<td>5,000Cycle</td>
</tr>
<tr>
<td>Charging time</td>
<td>39minutes [2C, SOC 80%]</td>
</tr>
<tr>
<td>Weight</td>
<td>1,400kg</td>
</tr>
<tr>
<td>Mileage per charging[SOC 80%]</td>
<td>100km</td>
</tr>
</tbody>
</table>

Pohang City
Benefit and Improvement point

- Require to install the BSSs at certain section so as to replace the local bus lines that repeatedly travel at an average distance of about 40 km

- Complement the weaknesses of electric vehicles and is expected to reduce carbon dioxide emissions in the public sector and create a bridgehead for green growth

- Around 80 seconds of battery charging and replacement time, which led to lowered vehicle and battery prices through battery sharing

- Solve the safety problem of charging the existing plug-in by automatic charging and switching system with unattended operation
Benefit and Improvement point (continue)

- Do not affect the peak power load when the battery is charged at light load time because power demand can be distributed

- Create value chain and new employment about traffic convergence charging infrastructure operation

- Operate at a proper dispensing interval regardless of the distance of the route by fast battery replacement during passenger
Expansion of BSEB

- Seguipo city in Jeju Island operates 23 BSEBs in 2016.
- 30 BSEBs will be operated on commercial routes since January, 2017.
### <Merits and Demerits of Battery Swapping Buses>

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Flexible route operation possible → No limit to spread application</td>
<td>• No institutional standards for installation and operation of battery replacement facilities</td>
</tr>
<tr>
<td>• Battery charging efficiency: 93~95%</td>
<td>• Land use density is limited to installing battery replacement facilities in the branch</td>
</tr>
<tr>
<td>• Charging time does not affect bus service</td>
<td>→ The height of the battery exchange facility is about 6.9m, which may interfere with the operation of the shop behind the installation</td>
</tr>
<tr>
<td>(Charge the discharged battery after replacing the battery)</td>
<td>• High cost of battery swapping facility</td>
</tr>
<tr>
<td>• Long operating distances</td>
<td>• Disadvantage in terms of cost capacity to purchase an extra battery</td>
</tr>
<tr>
<td>• Batteries can be quickly replaced to meet the demands of citizens with short intervals</td>
<td></td>
</tr>
</tbody>
</table>
EV and Public Transportation
• Build an eco-friendly public transportation system in which electric buses and hydrogen buses are mainly operating on the road

• Require market profitability to widely use in the bus industry

• Replace diesel and CNG buses if they have competitive prices and low infrastructure costs, compared with diesel and CNG buses

• Do not change the structure of urban transport system because they will just replace diesel and CNG buses in the transport market
- Work as a new public transit mode which replace ordinary buses

- Require to lower the prices of buses and the cost of charging facility by technology development.

- More promising for wireless charging bus system than the battery swapping bus system or a plug-in system since it can reduce the weight of buses and is easy and safe to recharge.

- Completely reduce vehicle emissions by E-buses, which will eventually replace all diesel and CNG buses.
Thank You!

coumo@koti.re.kr