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I. Electric Vehicle Initiative in Seoul
Seoul Overview

Seoul
(Area=605㎢, 10mill. 23.5%)

Capital Region
(Area=11,730㎢, 25mill. 49.4%)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pop.</td>
<td>5,536,169</td>
<td>10,286,503</td>
<td>10,575,447</td>
<td>2 times</td>
</tr>
<tr>
<td>Vehicles</td>
<td>60,442</td>
<td>778,940</td>
<td>2,981,400</td>
<td>50 times</td>
</tr>
</tbody>
</table>
Energy consumption and air pollution

- About 31% of energy is consumed by transportation sector
- About 58% of air pollutions come from mobile sources
- CO₂ intensity of auto is about 8 times higher than metro

### Energy consumption in Seoul (2011)

- **Total**: 16,958 (1,000 TOE)
  - Building: 9,876 (58.2%)
  - Industry: 1,104 (6.5%)
  - Public: 750 (4.5%)
  - Transport: 5,228 (30.8%)
    - Auto: 2,930 (55.7%)
    - Transit: 1,707 (32.5%)
    - Truck: 595 (11.7%)

### Air pollutions (2010)

- **Auto**: 198.3 g
  - 57.5% in Mobile Source
  - Bus: 57.3 g
  - Metro: 26.0 g
  - Taxi: 18.7 g
Status of EV deployment

- 776 EVs are under operation (353 passenger cars, 14 buses, 409 motorcycles)
**Status of EV deployment: public sector**

### EV distribution for public sector

<table>
<thead>
<tr>
<th>City Office 1 (Namsan)</th>
<th># of EVs (including NEVs)</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td>Including converted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evs</td>
</tr>
<tr>
<td>City Office 2 (Hangang)</td>
<td>12</td>
<td>Patrol</td>
</tr>
<tr>
<td>Seoul Forest Park</td>
<td>2</td>
<td>Patrol</td>
</tr>
<tr>
<td>Seoul Grand Park</td>
<td>1</td>
<td>Patrol</td>
</tr>
<tr>
<td>Worldcup Park</td>
<td>2</td>
<td>Patrol</td>
</tr>
<tr>
<td>Fire station</td>
<td>14</td>
<td>Patrol</td>
</tr>
</tbody>
</table>

*NEV*: Neighborhood Electric Vehicle (low-speed vehicle; max speed 60km/h)

- **< Converted EV>**
- **< Electric bus>**
- **< KIA Ray>**
- **< NEV for fire station >**
Status of EV chargers

- 483 EV chargers are under operation (54 rapid, 367 standard, 62 mini)
Charging stations: location and types

Types of charging post

[ Rapid ]
Capacity – 50kW
Voltage – DC 100~450V

[ Standard ]
Capacity – 3~8kW
Voltage – AC 220V

[ Mini]
Capacity – 2kW
Voltage – AC 220V
Namsan electric bus

- **EV Bus in Namsan**

<table>
<thead>
<tr>
<th>Type</th>
<th>Category</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle</td>
<td>Weight</td>
<td>10.7 ton</td>
</tr>
<tr>
<td></td>
<td>Size</td>
<td>11m(Length) × 2.49m(Width) × 3.5m(Height)</td>
</tr>
<tr>
<td>Engine</td>
<td>Drive Motor</td>
<td>240kW (322hp)</td>
</tr>
<tr>
<td></td>
<td>Battery</td>
<td>Lithium-ion polymer(80kWh)</td>
</tr>
<tr>
<td>Performance</td>
<td>Top speed</td>
<td>100km/h</td>
</tr>
<tr>
<td></td>
<td>Gradability*</td>
<td>30%(17°)</td>
</tr>
<tr>
<td></td>
<td>Distance per Charging</td>
<td>110km (Driving at 60km/h)</td>
</tr>
<tr>
<td></td>
<td>Charging time</td>
<td>20mins(Rapid charging)</td>
</tr>
</tbody>
</table>

- **Namsan EV Bus Routes**

![Namsan EV Bus Routes Map](image)
Pilot EV taxis program for the disabled

- Fleet size: 10 taxis
- Operations
  - Five hours operation during day time
  - Ride by appointment via phone or internet
  - Same fare for the other disabled taxis
  - Target area: Northeastern area

- Process
  - EV operation
  - Monitoring / Evaluation
  - Decision for expansion
EV Car Sharing

- About 200 Evs
- Start from May 2013 till 2015

Subsidy for vehicle purchasing & charging infra
- Seoul Metropolitan Government
- Central Government

Purchase vehicles & Operation
- LG CNS
- KORAIL Networks
- Korea Carsharing
- KT Rental

EV car-sharing locations
Ⅱ. OLEV Bus System
OLEV (On-Line Electric Vehicle)

Wireless Charging Electric Vehicle via Road-Embedded Power Line

- Power Line: Low cost / Segmented
- Pick Up System: High Capacity / Efficiency
- Battery: Capacity Reduced to 1/5
OLEV (On-Line Electric Vehicle) is new concept eco-friendly electric vehicle with a high-efficiency pickup device attached in its bottom. The OLEV uses the pickup device to receive electric power by means of non-contact magnetic induction from power supply lines laid under the road, so its battery can be charged while in operation or at a stop.

- can be powered via the non-contact magnetic field while at a stop and even when running.
- is resolved the recharging issues of conventional battery-powered electric infrastructure.
- is economically feasible because of its low price and cost-effective infrastructure.
- 's eco-friendly and efficient driving system helps overcome the technological limitations of conventional electric cars.
- can greatly contribute the creation of new jobs and national economic growth by promoting the fusion of automobile, construction, and industries.
Principles of OLEV System

Power Inverter:
- Generates high frequency current
- Performs high efficiency resonance control

Road Embedded Power Line:
- Meets safety standards for EMF

Pick-up Module:
- Performs contactless induction

Regulator:
- Charges battery while stopping or driving
# OLEV Operation

<table>
<thead>
<tr>
<th>Project</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seoul Grand Park</td>
<td>2011. 07 – Present</td>
</tr>
<tr>
<td>Yeosu Expo 2012</td>
<td>2012. 05 – 2012. 08</td>
</tr>
<tr>
<td>KAIST Campus shuttle bus</td>
<td>2012. 10 – Present</td>
</tr>
<tr>
<td>Gumi City public transit</td>
<td>2013. 07 – 2013. 12</td>
</tr>
<tr>
<td>Gumi City public transit pilot operation</td>
<td>2014. 03 – Present</td>
</tr>
<tr>
<td>Gumi City Commercial operation</td>
<td>2014. 03 – Present</td>
</tr>
<tr>
<td>Sejong City Commercial operation</td>
<td>2015. 06 - Present</td>
</tr>
</tbody>
</table>
Case study – Gumi city

OLEV Bus Operation in Gumi City (2013. 7 ~)

- Two OLEV buses operation in public road for passenger service
- Route length: 24 km
- Power supply line: 500 m
- # of charging locations: 4 dynamic charging, 2 stationary charging
Comparison of Electric Bus Economics

- Compared with pure electric buses, OLEVs have remarkable economic efficiency and safety, and they can share power-supply lines with other buses. In case bus routes are increased, they need relatively smaller costs, so there is potential cost reduction effect.

<table>
<thead>
<tr>
<th>Item</th>
<th>Pure electric</th>
<th>OLEV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Battery</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight &amp; price</td>
<td>Heavy and expensive (100)</td>
<td>Reduced to about 20% of the pure electric bus</td>
</tr>
<tr>
<td>Safety</td>
<td>High possibility of explosion</td>
<td>Low possibility of explosion</td>
</tr>
<tr>
<td>Driving Distance</td>
<td>Limited, depending on battery capacity</td>
<td>No limitation in case Power-supply infrastructure is constructed</td>
</tr>
<tr>
<td><strong>Recharging</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety</td>
<td>Possible electric shock</td>
<td>Non-contact type, Safe</td>
</tr>
<tr>
<td>Recharging Center and facility</td>
<td>At least 5 times compared with the existing gas stations (expensive rechargers additionally required)</td>
<td>Unnecessary (Recharging on roads)</td>
</tr>
<tr>
<td>Required time for Recharging</td>
<td>Long</td>
<td>No extra time since recharging during driving</td>
</tr>
<tr>
<td><strong>Driving pattern</strong></td>
<td>Driving, waiting for recharging</td>
<td>Continuous driving is possible</td>
</tr>
<tr>
<td></td>
<td>And then driving</td>
<td></td>
</tr>
</tbody>
</table>
Ⅲ. Bus with Battery Swapping System
BSS (Battery Swapping System)

BSS station
Composed of two unmanned automatic robot system that swaps batteries

Swappable battery
Detachable batteries for Electric bus

Total Operation Center (TOC)
Integrated real-time monitoring and controlling of electric vehicles and charging infrastructure

Battery swappable electric bus
Able to operate continuously with two swappable batteries on roof of the bus
BSS Bus

- Drive Motor
- Auxiliary Motor
- Battery
- Inverter
- DICO
- EVCU
- Roof Door
- BTM
Management

- TOC
  - Battery Swapping & Charging Management
  - Resource Management for BEGINS E-Bus System
  - B2B CRM
  - Connection BIS (Bus Information System)

- MRO
  - State Inspection & Monitoring
  - Maintenance & Repair

- SAFETY
  - Safety Monitoring
  - Safety Management System
  - Emergency Management
# Pohang pilot project

## Operation site and route
- Pohang Welfare Hall for aged shuttle bus route

## Operated data
- **2014.03~2015.11**
  - (Operating on regular route after)

## Number of operation
- 4times a day (2 in morning, 2 in afternoon)

## Size of Pilot
- 2 BSS Station, 2E-bus, 6 Batteries, 1TOC

## Testbed Construction and Operation Know-how

22km roundtrip pilot project on Welfare Hall for the Aged- Terminal- Pohang Station route in center of Pohang City

Successful pilot project by replacing free shuttle bus on the route

Acquired competitive ness by electric bus testbed construction and operation
# Jeju operation project

- **Battery Lease Business in Jeju-island**

<table>
<thead>
<tr>
<th>Yearly Plan</th>
<th>BSS Stations</th>
<th>Batteries</th>
<th>Electric Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>First year</td>
<td>12</td>
<td>146</td>
<td>49</td>
</tr>
<tr>
<td>Second year</td>
<td>1</td>
<td>70</td>
<td>33</td>
</tr>
<tr>
<td>Third year</td>
<td>1</td>
<td>74</td>
<td>37</td>
</tr>
</tbody>
</table>

- 14 BSS Station, 209 batteries and 119 Electric bus, 1,000 Electric Vehicle will be supplied by year 2017.
BSS Station

Confirmed (on the drawing, constructing)
Scheduled

- Jeju university (2 place)
- DaeRyundong community Service Center (1 place)
- Mangjangpo entrance (1 place)

<table>
<thead>
<tr>
<th>Location</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeju downtown</td>
<td>2</td>
</tr>
<tr>
<td>Seogwipo downtown</td>
<td>1</td>
</tr>
<tr>
<td>Seogwipo downtown ~ Eastward t circuit</td>
<td>2</td>
</tr>
<tr>
<td>Eastward t circuit</td>
<td>3</td>
</tr>
<tr>
<td>Westward circuit</td>
<td>4</td>
</tr>
</tbody>
</table>
BSS Station design

Mangjangpo Entrance

DaeRyundong community Service Center

Jeju university multiple BSS station [bird's-eye view]

Jeju university multiple BSS station [elevation]
**Expected Results**

- Promote international standardization through development of core technologies.
- Increase royalty revenue by forming a patent pool for core technologies.
- Advance future convergence technologies by combining IT, automotive, and road technologies.

By developing and commercializing OLEV

- Contribute to accelerating the spread of electric vehicles by enhancing user convenience
- Realize an eco-friendly public transportation system
- Decrease the volume of imported oil

- Reduce the emissions of CO2 and air pollutants.
- Improve urban landscape by removing upper wiring for lighted rail
- Increase citizen's welfare by providing eco-friendly environment
## Comparison

<table>
<thead>
<tr>
<th></th>
<th>Plug-in</th>
<th>BSS Bus</th>
<th>OLEV Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Battery Capacity</strong></td>
<td>100kWh~163kWh</td>
<td>52kWh</td>
<td>100kWh</td>
</tr>
<tr>
<td><strong>Charge/Swapping Time</strong></td>
<td>1 hour</td>
<td>5 min</td>
<td>30 min (at garage)</td>
</tr>
<tr>
<td><strong>Charger Cost</strong></td>
<td>USD 80,000~90,000</td>
<td>USD 1,700,000 (incl. charge station, 9 battery)</td>
<td>USD 120,000</td>
</tr>
<tr>
<td><strong>Vehicle Cost</strong></td>
<td>USD 500,000~550,000</td>
<td>USD 480,000</td>
<td>USD 450,000</td>
</tr>
<tr>
<td><strong>Operating City</strong></td>
<td>Busan</td>
<td>Pohang, Jeju, Kimpo(scheduled)</td>
<td>Gumi, Sejong</td>
</tr>
</tbody>
</table>

(source: http://www.jejuilbo.net)
Issues

- Initial Cost
- Technology Selection
- Technological Support/Maintenance
- Sustainability (Financial/Technological)
- Business Model
- Pilot or Commercial?
Thank You.
(jypark@koti.re.kr)
BSS Bus Operation System

① B2B(Bus) / B2S(Station) / B2C (Center)  ② Station-Center Networking
③ Battery, Charging, Swapping & State Monitoring  ④ Battery Entry Guide & Location Detection
⑤ BSS (Battery Swapping System) Management & History Management