Innovation in Electric Vehicle Technology and Application for Public Transport

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Innovation in Electric Vehicle Technology and Application for Public Transport

1. Innovation in EV technology
   • Acceleration performance
   • Easy to drive
   • Quiet and comfortable drive

2. Development of Electric bus for public transport
   • Specifications
   • Low CO2 emission of Electric bus
   • People prefer Electric bus with comfortable ride

3. E-mobility for public transport
   • “Future City Initiative” in Japan
   • Electric bus
   • One-way ultra-compact EV
1. Innovation in EV technology

Mass-production EV, LEAF introduced to the market in 2010
80kW Motor, 30kWh Li-ion battery (2015 model)
280km driving range (JC08 driving mode)
Bestselling EV model: over 230,000 units (Sep. 2016)

• Excellent acceleration performance
• Easy to drive
• Quiet and comfortable drive
Acceleration performance

- Acceleration performance of an EV is much better than a gasoline vehicle.
- Response time of an EV is less than 0.1 sec. compared to 0.5 sec. of a base gasoline vehicle under various acceleration conditions.
- Reasons for the excellent acceleration are small inertia of motor rotor, large torque at low speed condition, no transmission, and advanced control strategy.

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Easy to drive: Handling performance

- Traction torque control with steering angle
- To increase the traction torque at the initial of the corner and to decrease the torque at the end of the steering
- It can be operated in line with the driver’s intention.

Source: Yuuki Shiozawa, “Drive torque control system to improve the handling performance,” JSAE Symposium, May 2011
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Quiet and comfortable driving

- Low noise and low vibration under the start up to high speed driving

[Driving condition]
Start up at the parking lot through acceleration at the residence area

- Ultimate quiet with motor drive
- Low noise and low vibration under the start up to high speed driving
- Quiet and comfortable driving

Electric vehicle

Gasoline vehicle 2.5L

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Advanced EVs will be introduced soon

- Technologies of Lithium-ion battery and electric power-train are improving very rapidly.
- Advanced EVs with longer driving range will be introduced to the market in the near future.

**BMW i3**, 300km, Oct. 2016

**GM BOLT**, 383km, End 2016

**Tesla Model-3**, 344km, 2017

**Nissan LEAF** Next generation?
2. Development of Electric buses

- E-bus development at Waseda University since 2002
- Concept: Short driving range and frequent charging
- Demonstration field tests with local government since 2005
- Nagano city field test with 2 E-buses (2011 - 2013)

- Capacity 25 persons, Vehicle weight 6,430 kg
- Motor PMSM 145 kW/400Nm, Battery Mn Li-ion 44kWh
CO2 emission of E-bus compared to Diesel bus

- CO2 emission (WTW*) of an E-bus is 40% lower than that of a diesel bus.

*CO2 emission coefficient - WTW (Well to Wheel)
Diesel fuel: 2.83 kg-CO2/L, Electricity: 0.473 kg-CO2/kWh (2010)
Customer Survey: Attractiveness

Good points of E-bus vis-à-vis diesel bus?

*727 persons answered
3 points for 1st, 2 points for 2nd, 1 point for 3rd ranking

1. Smooth driving & no shaking
2. Quietness
3. No exhaust gases
4. Low noise and vibration
5. No smell of fuel and others
6. Nothing special
7. Others

Merit of E-bus:
1. Safety with smooth and no shaking
2. Calm life on board with quietness
3. No smell of exhaust gases and diesel fuel
Customer Survey: Shift to E-bus from private cars

If the bus is changed to E-bus, will you try to use the E-bus instead of your private car?  
*701 persons answered

- No use: 11%
- Not much use: 12%
- Use E-bus a lot: 23%
- Use as much as possible: 54%

[Do not want to use E-bus]
1. Inconvenience compared to private car
2. Less frequent rides
3. High fare
4. Not arrive on time
5. Diesel bus enough

[Want to use E-bus]
1. Low CO2 emission
2. No exhaust gases
3. Low noise
4. Quiet, no shaking and comfortable ride

- 77% of people want to use an E-bus.
- A lot of people would like to stop use a private car, and use an E-bus.

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Customer Survey: Introduction of E-bus

Do you think E-bus should be introduced for public transport?

- 87% of people want E-bus to be introduced for public transport.
- Regarding costs of E-bus purchases and charging equipment,
  1. Government or municipality supports some of the cost.
  2. Bus fares will be raised.
  3. Commercial facilities support some or all of the cost.

*712 persons answered
3. E-mobility for public transport

“Future City Initiative”

2 issues that Japan will be the first to face,
- Declining and aging population
- Environmental and energy constraints

The 21st Century is the age of the city
By 2050, 70% of people will live in cities

Creating sustainable cities is an issue that all of mankind faces together

Issues that Japan will be the first to face
- **Declining and aging population**
  Declining population: 130 million people (2004) → 95 million people (2050)
  Percentage of elderly: 23% (2009) → 40% (2050)
- **Environmental and energy constraints**
  Severe energy supply constraints due to nuclear power plant accident
  Global warming measures

- Creation of new social and economic systems focused on cities
- Addressing challenges shared by the entire mankind before the rest of the world

Source: Japan government: Future City Initiative
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“Future City Initiative”

- Through the creation of environmental value, social value, and economic value, create universally appealing communities and universally vibrant communities
- Restore a sense of social connectedness and improve the quality of people’s lives
- Action on environment and super-aging is essential. Add other themes as appropriate given individual city’s and region’s circumstances
- Build a model for sustainable value creation that can be deployed autonomously

Source: Japan government: Future City Initiative
Toshio Hirota, Environmental Research Institute, Waseda University, Japan
“Future City Initiative”

Source: Japan government: Future City Initiative
Toshio Hirota, Environmental Research Institute, Waseda University, Japan
Shift from Private car to Public transport

Wide Variety of Mobility for City in the Future

- New Mobility
  - Community Bus
  - Car Sharing
  - Ultra-small Car Sharing
  - Ride Sharing

- Public Transport
  - City Bus
  - Car Rental
  - taxi
CO2 reduction by shift to public transport

- **CO2 emission (Japan, 2005)**
  - Private car: 173 g-CO2/person·km, City bus: 51 g-CO2/person·km
- **CO2 emission of Bus: 70% lower than private car**
- **Share of transport:**
  - Passenger car 60%, Bus 6.2%, Rail 28%, Air 5.9%
- **Share of public transport esp. local area has reduced: below 20%**

Source: MLIT Ministry of Land, Infrastructure, Transport and Tourism
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Nagano city started E-bus operation in 2014

- Start of E-bus operation at the central area in Nagano city
- Round trip from the station through Zenkoji, 7.5km 45 min.
- Since Oct. 2014 through Oct. 2016, 42,000 km, 3.8k round trips, and 67k passengers estimated
- Including demonstration service since 2011, WEB-4, Waseda Electric Bus-4: Over 81,000 km, 120k passengers
- E-Bus has been evaluated as a clean and comfortable transport.

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<th>Nagano E-bus “Gururin-go”</th>
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### Advantages of E-bus compared to Diesel bus

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<th>Diesel bus</th>
<th>E-bus</th>
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| **Safety**       | • Fear of falling accident  
• Vehicle shaking at start and stop conditions  
• Especially for elderly persons | • Feel safe even when standing  
• Smooth acceleration and no shock of gear change                                                 |
| **Comfort**      | • Noise and vibration  
• Hard to communicate  
• Smell of exhaust gas and fuel  
• Car sickness                                   | • Quiet and easy to talk  
• Easy to hear announcements  
• No smell of exhaust gas and fuel  
• No car sickness                                       |
| **Convenience**  | • Does not arrive on time  
• No information where bus is  
• Insufficient service number  
• No service in the early morning and late-night | • Introducing information and on-demand bus system with ICT  
• Good compatibility with E-bus and ICT technology                                          |
MLIT caution: Safety when riding on the bus
*MLIT: Ministry of Land, Infrastructure, Transport and Tourism

- Remain seated until bus stopped.
- When standing or walking toward exit for getting off the bus, grasp a handrail firmly.

- There are many falling accidents in the bus in Japan
- Elderly may break the bones and become bedridden.

E-bus: Passengers feel safe even if they are standing with smooth acceleration and no shock of gear change.
Passenger’s comments: Comfort

Mrs. K
When I ride a diesel bus, I sometimes get motion sickness.
I prefer to ride an electric bus because of no smell of exhaust gas and diesel fuel.

Mr. T
I am a fan of the electric bus. It is very comfortable with quietness and low vibration. When I came to Nagano, I usually decline to ride on the diesel bus and wait for the electric bus and ride it.
Movie: Diesel bus vs. E-bus in Nagano

- Noise and vibration
- Hard to communicate
- Smell of exhaust gas and fuel

- Quiet and less vibration
- Easy to hear announcements
- No smell of exhaust gas and fuel

https://www.youtube.com/watch?v=V53TqcDlPfM
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One-Way EV Car Sharing “Choi-Mobi Yokohama”

Demonstration field test of ultra-compact mobility vehicles, which are much smaller than regular vehicles and contribute to energy conservation and carbon emission reductions, to popularize them as a new mode of local transport

- 2 passenger ultra-compact lithium-ion battery EV
- Trial period: Oct 2013 – Sept 2015 (2 years)
- 70 vehicles, 110 parking spaces
- Operators: Nissan Motors, City of Yokohama

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**Spread of Car Sharing in Japan**

- Number of members is increasing in Japan.
- 800,000 members in 2016 (0.6% of the population)
- 20,000 vehicles (40 members per vehicle)

*Source:* Foundation for Promoting Personal Mobility and Ecological Transportation

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Autonomous Car

- Autonomous drive technology and information communication technology are key technologies for E-mobility.
- These technologies make E-mobility more convenient.
- Part of the technologies were already introduced to the market.

- Adaptive Cruise Control
- Lane Keep Assist
- Pre-Collision Braking
- Pre-Collision Throttle Management

Nissan “ProPILOT” 2016

Subaru “EyeSight ver.3” 2014
DoCoMo, DeNA developing Ultrahigh-speed 5G Communication Tech for self-driving car

- Japanese mobile phone service provider NTT DoCoMo and internet service company DeNA are developing high-speed communication system for autonomous car.

- In self-driving, even a small data transmission lag could lead to an accident. So the ultrahigh-speed 5G communication technology -- which is said to be 100 times faster than existing LTE technology -- is seen as essential.

http://techon.nikkeibp.co.jp/atcl/news/16/111004970/?rt=nocnt

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Summary

Create Sustainable Mobility

- E-mobility technology will be getting ready.
- How the tech. will be applied for community?
- Key: Communication with different fields

Nature Science
- Science
- Technology
  - Vehicle
  - Energy
  - Electronics

Social Science
- Academia
- Government
- Real World
  - Citizen
  - Community
  - Municipality

Different Languages

Communicate to create sustainable mobility

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Thank you for your attention