Mikio MATSUMOTO
Expert Leader, EV System Laboratory,
Research Center
Nissan Motor Co., Ltd.

e-Bio Fuel-Cell
Key issues facing the auto industry

Energy

Global warming

[Image: NASA earth observatory](http://www.nasa.gov/vision/earth/environment/arcticice_decline.html)

Congestion

Traffic accidents
Nissan's corporate goals

Zero Emissions

Zero Fatalities
Keys for breakthroughs

Electrification

Vehicle intelligence
Uses of EV components in multiple powertrains

- e-Power and e-Bio Fuel-Cell systems use BEV powertrain components
Diverse applications of EV technologies

- EV technologies are at the core of Intelligent Power
- They combine driving pleasure and sustainable mobility, and allow future energy diversity
Concept of e-Bio Fuel-Cell

- **High efficiency**
  - Running cost equivalent to EV
  - Long range

- **Easy to supply**
  - Short refueling time
  - Low infrastructure constraints
  - Safe fuel (ethanol-blended water)

- **Clean**
  - Exhaust as clean as atmosphere

**Carbon neutral cycle**

1. **Sugarcane**
2. **Bio-ethanol**
3. **100% ethanol**
4. **Ethanol-blended water**

5. **e-Bio Fuel-Cell**

(C) Copyright NISSAN MOTOR CO., LTD. 2017 All rights reserved.
Market value of e-Bio Fuel-Cell

- Ideal vehicle for environmentally-friendly delivery services
  - Can be operated 24/7; quiet drive and short refueling time
  - Versatile, with ample power supply (for refrigerated delivery services, etc.)
- Running costs equivalent to EVs by using ethanol-blended water as fuel

Comparison of running costs (for reference only)

Running cost
- e-Bio Fuel-Cell... Calculated with Nissan target performance, assumed vehicle conditions and estimated 45% ethanol price based on the ethanol price: ¥64/L (based on E100 price in Brazil)
- EV and Gasoline ICE... Calculated with equivalent condition with e-Bio Fuel-Cell case
How the e-Bio Fuel-Cell system works 1/2

- Fueled by liquid fuel: easy to handle, can use conventional fuel tank
- Hydrogen generated through reformation of 100% ethanol or ethanol-blended water
- Power generated by SOFC (solid oxide fuel cell) stack from reformate hydrogen and air
- Generated electricity charges battery and powers drive motor

SOFC : Solid Oxide Fuel Cell
How the e-Bio Fuel-Cell system works 2/2

- Produces hydrogen from ethanol-blended water through reformer
  \[ \text{C}_2\text{H}_5\text{OH} + 3\text{H}_2\text{O} \rightarrow 6\text{H}_2 + 2\text{CO}_2 \] [Main reaction]
- Generates electricity through reaction of hydrogen with oxygen from air
- Reuses exhausted heat for reformation (highly efficient system)

**SOFC System**

- **Electrode (Anode):** Reformer
  - Reaction: \[ \text{C}_2\text{H}_5\text{OH} + 3\text{H}_2\text{O} \rightarrow 6\text{H}_2 + 2\text{CO}_2 \] [Main reaction]
  - Produces hydrogen from ethanol-blended water

- **Electrode (Cathode):** SOFC Stack
  - Reactions: \[ \text{H}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{H}_2\text{O} \]
  - Generation of electricity

- **Reformer**
  - Uses heat from SOFC stack

- **SOFC Stack**
  - Generates heat

- **Exhaust Heat**
  - Used for reformation

**Fuel Tank**

- Stores 100% Ethanol or Ethanol-blended water

**SOFC System**

- Fuel tank
  - SOFC System
  - Reformer
  - SOFC stack
  - Motor
  - Battery

(C) Copyright NISSAN MOTOR CO., LTD. 2017 All rights reserved.
**e-Bio Fuel-Cell prototype vehicle**

- Carbon neutral; exhaust gas as clean as atmosphere
- Driving pleasure and low running cost equivalent to EV
- Range equivalent to gasoline engine vehicles
- No need to charge from grid

### Specifications of research prototype vehicle

<table>
<thead>
<tr>
<th>Features</th>
<th>Specs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base vehicle</td>
<td>e-NV200</td>
</tr>
<tr>
<td>Battery Capacity</td>
<td>24kWh</td>
</tr>
<tr>
<td>Powertrain</td>
<td>Electricity</td>
</tr>
<tr>
<td>Fuel tank capacity</td>
<td>30L</td>
</tr>
<tr>
<td>SOFC power</td>
<td>5kW</td>
</tr>
<tr>
<td>Driving range</td>
<td>Over 600km</td>
</tr>
</tbody>
</table>

Note: Specifications are for Nissan’s research prototype vehicle, and are subject to change.
Thank you for your attention