Technology development of Nissan's Electric Vehicle and future vision

2010.3.4
Nissan Motor Co., Ltd
Fellow Haruyoshi KUMURA
1. Background on the Electric Powertrain
2. Development of Nissan’s EV
3. Preparation for Widespread EV Adoption
4. Approach to Future Mobility
Century of Energy Transformation

- Oil production has reached its peak.
- A hundred years have passed since the Ford Model T was first produced. Now is an era of new energy for automobiles.

*Calculated based on BP figures, WBCSD SMP reports, IEA WEO, and JPDA sources*
Oil: Changes in oil prices

- Price hike in fossil fuel
- No major changes in the price of electricity

*EIA: Petroleum “International Data” & IEO2009*
Nissan’s scenario for CO2 reduction

- Need 90% reduction by 2050 to remain at 450ppm (from the 2000 level)

New car’s Well To Wheel CO2 emissions (%)

450ppm

90% Reduction

2000 2010 2020 2030 2040 2050

ICE HEV EV FCV

Well to Wheel CO2 Emission Reduction by Future Powertrain (%)

Zero emission vehicle
Energy : Electricity for powertrains

- Dependence on fossil fuel to energy diversification.
- A major part of energy is used as electricity.
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2-1. LEAF, newly Developed EV

2-2. Core Technologies for Competitive EV

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LEAF unveiled in August 2009

- Launch JPN, US, EUR in FY10
- Expand globally in 2012
LEAF overview

- Seating capacity: 4-5 adults
- Cruising range: over 160km (US LA4)
- Motor: 80kW, 280Nm
- Battery: 24kWh Li-ion (produced by AESC)
LEAF overview

- EV dedicated IT support system
**Change Attraction of Vehicles**

- **EV** creates new driving pleasure.

- **Zero-emission**
  - Charged at home
  - Filled-up every morning

- **High Energy Efficiency**
  - Inexpensive Fuel Price

- **Quietness w/o engine noise**

- **Exhilarating Acceleration**
  - Feel Smooth Start

- **Torque vs. Motor Rotation (rpm)**
  - 90%
  - 95%
Quick acceleration with equal performance to 3L gasoline vehicle

LEAF acceleration

LEAF

3L gasoline vehicle

Hypermini

LEAF

FUGA

0m 10m 20m 30m

Time [sec]
Cruising range sufficient for daily use

- Cruising range for a fully charged Nissan EV is over 160km (US LA4)
- Covers daily commute for most major cities in urban areas
24 hours IT EV charging support

- IT supports charging for both on-board and off-board

Off-board support

On-board support

Off-board support

Before driving

Driving

After driving

Fully charged notice

Driving range

Trip review

Pre-cooling system

Nearby charging stations

Charging timer
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Change Structure of Vehicles

- Electronic components are main constituent, and highly possible to reduce cost.
- Modularization will make progress.

![Diagram showing changes in vehicle structure with increased electronics and reduced others in electric vehicles compared to gasoline vehicles.](image-url)
Battery evolution

In this 15 years, performance of automotive battery significantly improved, enabling EV introduction to the market.
Performance of laminated Li-ion battery

- Nissan is the first to believe in the potential of Li-ion batteries for automotive applications and has begun development since 1992.
- Nissan has developed a commercially viable automotive battery with high performance and reliability.

### Twice the power

- Cylindrical (2000) vs. Laminated
  - Output: > 2.5kW/kg*
- *after durability test

### Twice the energy

- Cylindrical (2000) vs. Laminated
  - Energy: 140Wh/kg*
- *after durability test

### Halved size and flexible packaging

- Cylindrical vs. Laminated
- ½ the Size

### High reliability

- Charge vs. Discharge

### Stable crystal structure material

- Higher cooling efficiency by laminated structure
Evolution of vehicle

- Advanced battery installed under vehicle floor, which results in improved cabin space

<table>
<thead>
<tr>
<th>Year 2000</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead-acid battery</td>
<td>Li-ion battery</td>
</tr>
<tr>
<td>Mounting image</td>
<td></td>
</tr>
<tr>
<td>Motor</td>
<td>Inverter Battery</td>
</tr>
<tr>
<td>eg) Capacity for storing 20kwh of energy</td>
<td></td>
</tr>
</tbody>
</table>
Electric parts on EV

- All major components of EV are electric, including powertrain, power steering and air-conditioner

- Charger
- Inverter
- Motor
- LED headlights
- Battery packs
- Electric air-conditioner
- Electric power steering
- Regeneration braking
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**EV Market: Potential demand of 100M units in urban areas**

- **Initial customers are users in urban areas, with a daily commutes within the charging station network**
- **Approximately 100 million units or 15% of the global automobile market is in urban areas**

*Number of automobiles counts only the city holds over 1 million units of passenger vehicle (CY2006)*
# Basic concept of charging infrastructure

## Charging network

<table>
<thead>
<tr>
<th>EV uses</th>
<th>Home charge</th>
<th>Charging network</th>
<th>Charge at destination</th>
<th>Charge on the road</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short distance</td>
<td>Ordinary charge</td>
<td>Choose ordinary or quick charge depending on how long stay</td>
<td>Quick charging</td>
</tr>
</tbody>
</table>

## Charging type

<table>
<thead>
<tr>
<th>Type</th>
<th>Power source</th>
<th>Charging time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary charge</td>
<td>Single-phase 100V</td>
<td>~15A</td>
</tr>
<tr>
<td>Quick charging</td>
<td>Single-phase 200V</td>
<td>~20A</td>
</tr>
<tr>
<td></td>
<td>Three-phase 200V</td>
<td></td>
</tr>
</tbody>
</table>
Nissan is developing a network of charging points with multiple partners.

As of March 2009

Number of public charging facilities in Kanagawa pref.

<table>
<thead>
<tr>
<th></th>
<th>Today</th>
<th>2010 Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quick charger</td>
<td>23 (current)</td>
<td>100</td>
</tr>
<tr>
<td>Ordinary charger</td>
<td>160 (planned)</td>
<td>1000 (~2014)</td>
</tr>
</tbody>
</table>
Houses with 200V power panelboards are now common due to the increase in electronics, IH heater and air conditioner. Once increased capacity is completed, supplying power to the EV for these homes will be easy.

Over 80% of detached homes are equipped with outside wall plugs.
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Change Surrounding Industries

- EV creates new business opportunities.

### Management of electricity
- Expansion of natural energy use
- "Smart House"
- Secondary use of battery

### Charging infrastructure
- Amplification of charging stations
- Synergy with service industry

### Business related to EV parts
- Expansion of power electronics components
- Equipment related to infrastructure

### New mobility business
- Car sharing
- Cooperation with public transportation facilities
Effective utilization of clean energy: Smart House

- Resulting in ultimate energy savings for the household, possible to deliver more clean energy through solar power and EV battery.
Introduction scenario for smart grid

- Evolution to smart house, smart community and smart grid

**smart house**
Increase facilities and houses with high energy self-sufficient rate

**smart community**
Power sharing among facilities and network

**smart grid**
Connection with clean power basement

- mega solar
- wind
Solar electric charging station demonstration (started 2009)

- Created battery storage facility through EV located on parking area
- Integrated solar electric generation for emergency power and quick charging station

Battery storage 168kWh
(EV on parking area)

Quick charge
DC/DC
50kW
For the most suitable mobility:

**YOKOHAMA mobility “Project ZERO”**

- Began examination that aims for a model low carbon city
- Divided areas in order to provide suitable mobility and reduce the city’s overall CO₂ levels
Global partnership for EV popularization

- Approximately 30 partnerships worldwide

*) As of the end of August, 2009