Innovation for Electric Vehicles in Japan

Utilizing Chances in Electric Vehicle Industry

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Introduction

Japan is the most successful country in the fields of Electric vehicles and HEVs

- Why Japan was successful?
- Which direction will be the future trend of Japanese EVs?
- What is the supporting innovation concept?

Opportunity of cooperation between European countries and Japan should be discussed

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 Shares of global production 2012

About 82 Mio Vehicles were produced in 2012

Shares of production by origin of technology/capital

- Japan 30%
- USA 16%
- Germany 16%
- China 13%
- Korea 9%
- Rest of Europe 12%
- Rest of World 2%

(Source: Marklines)

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~1.6 Mio. units HEVs and EVs sold in 2012 worldwide!

~1.4 Mio. units were Japanese brands!

~900 000 units sold in Japan!

(Source: Marklines)

Japan is the biggest producer and consumer market for EVs & HEVs

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Why Japan was successful in the field of EVs and HEVs?

Government, OEMs and Suppliers all played a vital role with their efforts in the early stage

- Japanese people have suffered from big air pollution in 1960’s and damaged economically by oil shock in 1973
- Fundamental research and development activities (science and industry) have been done continuously from 1970’s supported by the government
- Decision of car OEMs to go for EVs and HEVs

These early decisions and efforts led to today's Japanese advantage in EV & HEV technology
Brief history of Japanese EV development (pre-commercialization)

- **Japanese Government**
  - The Ministry of International Trade and Industry (MITI) aligned the approach combined all activities and spent
    - 40 mil. Euro for development of EVs in the 80’s
    - 70 mil. Euro for development of Li-ion battery in the 90’s

- **Developments 1980 – 1990**
  - Invention of Ne-Fe magnet (1982) and Li-ion battery (1986)
  - In 1990, IGBT was commercialized in Japan

- **California Mandate for ZEV at 1992**
  - Pushed Japanese car industries because the biggest share in California was Japanese automobiles

**Government, OEMs and Suppliers all played a vital role with their efforts in the early stage**
As Japan regarding E-mobility, the German government started in the end of the 1980’s to resolve and establish several laws and regulations to liberalize the energy sector.

Because of these early deregulations Germany became one of the leading countries in renewable energy.

Early decisions and initiatives by government and/or industry are essential for success.

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Brief history of Japanese EV development (after commercialization)

Decisions of executives in each company played a big role in commercializing EVs and HEVs

- Toyota Hybrid (1997)
- Mitsubishi i-Miev (2008)
- Nissan Leaf (2009)
Beside a battery, the electricity source can also be
- Fuel Cell
- ICE Generator (Range Extender)
The systematic is basically the same
Not necessarily the “best” technical solution survives!

Other Key Success Factors have to be met

- **Consumer orientated** - usability, service
- **Production orientated** - low production costs, easy to make
- **High efficiency** - running costs, energy consumption

Technologies succeeded as a combination of these factors:
- LCD display (against plasma), ICE & TGV against Linear Magnet

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### Evaluation of technology

<table>
<thead>
<tr>
<th>Feature</th>
<th>HEV</th>
<th>EV</th>
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<tbody>
<tr>
<td></td>
<td>Pure battery</td>
<td>Range Extender</td>
</tr>
<tr>
<td><strong>Usability</strong></td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td><strong>Simplicity</strong></td>
<td>++</td>
<td>+++</td>
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</tbody>
</table>
Comparison of Efficiency from several Energy Sources

Electric Power

- Electric Battery (plug-in): Efficiency 95%
- Hydrogen Production: Efficiency 50 - 60%
- Fuel Cell: Efficiency 70%

Overall Efficiency: 30%
Future trend of EVs and HEVs

- The evaluation of technology shows that currently EVs with range extender seems to be most promising. E.g. BMW i3 with range extender goes in a good direction.

- In-wheel motor has a 30% higher efficiency

- Only considering optimization of total drive system will create the best electric vehicle

Li-Ion Battery, Ne-Fe Magnet, IGBT invented and developed so far are enough to realize the high-performing EV
Structural Elements of Platform

- Frame with Built-in Battery
- Inverter (Speed Controller)
- Lithium-ion Battery
- In-wheel Motor
- Permanent-magnet Motor
- Internal Combustion Engine
- Vehicle Controller
- Fuel Tank
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Image of an EV with In-wheel motors and a range extender

- The focus is on using Japanese technology to generate profits.
- Efforts have been made to introduce the Solar Belt and SIM-Drive.
- What is currently needed is speed.

We wish to contribute to achieving our goals as quickly as possible.
Strategies of Japanese OEMs

- Toyota
  Development of all types of technology by themselves

- Honda
  HEV and fuel cell are main target

- Nissan
  Keep selling Leaf more and construct charging stations

- Mitsubishi
  Outlander with a new hybrid concept

**All OEMs have their own EV/HEV approach with different directions**
Also the Japanese automotive suppliers are leading in most of EV-related technologies and knowhow

546 Suppliers for EV components worldwide - 177 from Japan (32%)

The suppliers have the intention to grow and globalize their business:
- Tier 1 suppliers
- Major material and component suppliers (such as battery, Ne-Fe magnet and new electric devices)
- Raw material producers

Japanese suppliers want to expand their market shares in Europe
Status of power electronics devices

New Transistor devices will increase the performance of EVs from the view points of energy efficiency and the size of an inverter. SiC and GaN will be the best candidates.

- Japan steel have been developing the crystal of SiC.
- Rohm and Toyota is going to commercialize SiC device.
- Panasonic, Fujitsu and other venture companies have been developing GaN devices.

Collaboration to develop and commercialize new Transistor devices between European and Japanese companies will make a real opportunity.
Comparison European/Japanese Automobiles

<table>
<thead>
<tr>
<th></th>
<th>Europe</th>
<th>Japan</th>
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</thead>
<tbody>
<tr>
<td>Fun to Drive/Drivability</td>
<td>Best</td>
<td>Fast Follower</td>
</tr>
<tr>
<td>Mechanical Technology</td>
<td>Best</td>
<td>Fast Follower</td>
</tr>
<tr>
<td>Electronics and Material Tech.</td>
<td>Fast Follower</td>
<td>Best</td>
</tr>
<tr>
<td>Quality</td>
<td>High</td>
<td>Best</td>
</tr>
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</table>

Europe and Japan can complement each other
Glass-wall between European and Japanese Industry

- Currently only limited exchange of technology
- The mega-players in the (automotive) industry, suppliers and makers, have developed their own approach in Europe and Japan.
- There are glass walls between Europe and Japan in EV industry because many of the normal supply channels are not established yet
Benefits & Targets of European/ Japanese Cooperation

Customers Markets
• Combining the 2 leading markets to one potential
• Access to European or Japanese Makers in China, Asia and USA
• Achieving critical scale of business faster

Technology
• Easier to create global leading standards and norms
• Sharing R&D cost
• Utilizing technology leadership of other country

Society
• European and Japanese approach to environmental technologies is complementary = High commitment to Kyoto
• Common work on EV increases maturity of both countries
• Mentality is close and will even become closer

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How to participate in the Japanese Market

- M&A
- Classical Distribution
- Innovative Partnerships
- Grow Network out of Open Source Innovation

Success across Borders

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How to establish exchange between Europe and Japan?

To overcome the glass-wall and reach the targets, a common platform is necessary

Using different information channels and instruments (symposiums, workshops, newsletters, delegations) to align organizations and business between Europe and Japan
Next Steps

- Find a facilitator
- Create a collaboration scheme between Europe and Japan soon
- Implement the scheme
- Create benefits for all participants and with it substantial progress in E-mobility

It is essential that a certain number of participants will join

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Final Target

- Developing the next generation vehicle
  - High performing and environmental friendly
  - Capability have to enough to be accepted in the society
- Distribute the vehicle to all over the world
- People in the world should have comfortable mobility and sustainable environment

Collaboration between Europe and Japan are the key of developing mobility for the global future
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