Trends in the automotive industry around eco-friendly vehicles and business prospects in related industries

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[Abstract]

In December 2014, Toyota Motor released a fuel cell vehicle (hereinafter referred to as "FCV") called Mirai and the news spread not only in Japan but also worldwide. This means that all styles of vehicle electrification have appeared on the market: Hybrid vehicles (HEVs), plug-in hybrid vehicles (PHEVs), which can be charged at home, electric vehicles (EVs), and now FCVs. In this report, these are collectively called as "xEVs."

In the automotive industry in future, the acceleration of electrification is one of the factors that will change the industry's power map and will greatly influence other industries of related key components, including secondary batteries, motors and power semiconductors, as well as materials/parts, evaluation/analysis equipment, and contracted testing businesses.

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Technology Report

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Introduction

In December 2014, Toyota Motor released a fuel cell vehicle (hereinafter referred to as "FCV") called Mirai and the news spread not only in Japan but also worldwide. This means that all styles of vehicle electrification have appeared on the market: Hybrid vehicles (HEVs), plug-in hybrid vehicles (PHEVs), which can be charged at home, electric vehicles (EVs), and now FCVs. In this report, these are collectively called as "xEVs."

Honda Motor announced that they will begin commercial sales of FCV in FY2015. For the present situation and future of the surely upcoming so-called "war of eco-friendly cars", we can see various strategies and speculations of the companies struggling for survival in the automotive and battery industries.

The paradigm shift in the automotive industry will advance steadily in future. Twenty-five years have passed since the ZEV (zero emission vehicles) regulation took effect and HEVs have made a complete shift to a popularization phase. PHEVs, an extension of HEVs, have entered a commercialization phase.

In the automotive industry in future, the acceleration of electrification is one of the factors that will change the industry's power map and will greatly influence other industries of related key components, including secondary batteries, motors and power semiconductors, as well as materials/parts, evaluation/analysis equipment, and contracted testing businesses. Big waves have arrived to the business models of all industries related to the automotive industry and the future of related industries will be determined by whether they will be able to ride the wave successfully.

Argument still rages about which is the ultimate vehicle, FCVs or EVs. I would like to think about the intensifying trends regarding xEVs, the strategies of individual companies, and survival and competitiveness in the automotive industry.

1. Values and issues of HEVs

Table 1 shows the values and issues of respective xEVs. HEVs have completely reached a popularization phase and social recognition is extremely high. Because of their low fuel consumption, HEVs are products from which consumers can directly enjoy benefits. They have had a marked effect on Japanese road conditions and in markets where there is a high frequency of stop-and-go traffic in urban areas.

The Chinese government had first planned popularization by focusing on EVs and PHEVs. Last year, however, the government showed recognition of the values of HEVs and changed its policy to include HEVs in the targets for its subsidy system. The scenario of the popularization of EVs in China is based on the government subsidy system. Given the market conditions, it can be said that its policy was extremely
unreasonable and limited.

The current issue of HEVs is troubleshooting in the market. There are HEV-specific problems related to the program software that controls the engine and electric drive. Such problems were found in Toyota's Prius and Honda's Fit models. Since these companies are leaders in planning and implementing product strategies focusing on HEVs, it was natural that they experienced market problems ahead of others. When other companies follow the move with HEVs, they may experience similar problems.

The issue is that they cannot reproduce problems in advance from assumed conditions. On the other hand, the accumulation of development know-how will be tremendous in terms of the intellectual property gained. I hope such know-how will be inherited over time by developers.

### Table 1: Values and issues of xEVs

<table>
<thead>
<tr>
<th>Values</th>
<th>HEV</th>
<th>PHEV</th>
<th>EV</th>
<th>FCV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved fuel efficiency for saving fuel cost</td>
<td>Improved fuel efficiency for saving fuel cost</td>
<td>800 to 900 yen / 500 km</td>
<td>Leading edge technology</td>
<td></td>
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<tr>
<td>Variety of models</td>
<td>20 km or longer EV driving</td>
<td>Home chargeable and usable as external power supply in emergency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charging station unnecessary</td>
<td>Target of CA ZEV regulation from 2018</td>
<td>Quiet</td>
<td>Long enough cruising distance</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>External power supply providing home power for one week</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Target of CA ZEV regulation from 2018</td>
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<tr>
<td></td>
<td></td>
<td>Limited cruising distance</td>
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<tr>
<td></td>
<td></td>
<td>Long charging time</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Realization of innovative battery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Issues</td>
<td>Installation of a charging station at home</td>
<td>Installation of a charging station at home</td>
<td></td>
<td></td>
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<tr>
<td>Higher price level compared with gasoline vehicles</td>
<td></td>
<td>Charging infrastructure required</td>
<td></td>
<td></td>
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<tr>
<td>Recall caused by the HEV system control technology program</td>
<td></td>
<td>Vehicle (battery) price reduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toyota, Honda, Nissan</td>
<td></td>
<td>Increased CO2 emission from power generation system - China</td>
<td></td>
<td></td>
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<tr>
<td>Excluded from the target of CA ZEV regulation from 2018</td>
<td></td>
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</table>

2. Values and issues of PHEVs

Since home-chargeable PHEVs will be the target of ZEV regulation from 2018, they are indispensable for automobile manufacturers aiming for compliance. Because of the ability of EV driving, PHEVs are expected to rouse consumers' willingness to buy. On the other hand, the need to install a home charging station may impose certain costs on consumers.

There are responses in the market that demand in terms of fuel economy can be satisfied by HEVs and the PHEV market has not yet reached the expansion phase. Many major automobile manufacturers now offer PHEV models and ZEV regulation will be tightened in 2018. If the values of PHEVs permeate through consumers, there may be some hope for the PHEV market.
3. Values and issues of EVs

3.1 Flow and prospects of EV development

Now, let’s think about EVs. Electric power that corresponds to the cost of fuel is quite appealing. All problems such as the limited cruising distance and charging time depend on battery performance.

Commercialization of EVs began Mitsubishi Motors’ i-MiEV in 2009 and Nissan Motor’s LEAF in 2010. Some say the market is not expanding, while others see that these models are doing relatively well. It can be said that from their perspective both descriptions are true.

The cumulative sales of Nissan LEAF exceeded 150,000 cars to date. The company plans to launch the successor to the LEAF in 2016 as well as jointly develop an EV version of a miniature car with Mitsubishi Motors. Nissan said that the development objectives of the successor are to extend the cruising distance (228 km with the current LEAF) and reduce the price from the current price of 2.87 million yen. The price of the miniature car EV is said to be around 1.5 million yen.

BMW’s i3 and Tesla’s Model S entered the Japanese market in 2014; however, they are limited to a niche market even though they appeared as topics of conversation due to the i3’s superior design and brand power and the Model S’s novel sports car design and extended cruising distance which is achieved by equipping the vehicle with about 7,000 commercial batteries. Volkswagen will also introduce an EV model into the Japanese market in 2015.

As shown by the fact that the lithium ion batteries used in the i3 are manufactured by Samsung SOI, a concern of the Germans is the weak battery industry there. The same is true in the U.S. Batteries are the heart of eco-friendly cars and in order to offset such weakness attention is directed to the Japanese and Korean battery industries, resulting in a structure of increasingly fierce competition between Japan and Korea over in-vehicle batteries.

The reason why many Western companies are introducing EVs into the Japanese market is that Japan is a suitable market for EV driving, especially in urban areas, and consumers show a strong willingness to buy. The consumer culture in Japan is different from that in the U.S., where people want to buy larger cars as soon as the price of crude oil drops, lowering gasoline prices.

In Germany, where autobahn driving is the basic premise of the driving environment, it is difficult for both EVs and HEVs to be a suitable match. Since HEVs improve fuel economy with regenerative energy, you cannot expect improvement during autobahn driving, which has very little stop-and-go traffic. With EVs, it is also difficult to utilize regenerative energy and their short cruising distance is a great concern for autobahn driving.

The conditions above are the same as the case of freeways in the U.S. In some regions, however, EVs are receiving positive evaluations, such as in the state of Georgia, where electric power companies are committed to promoting EVs.

3.2 Basic researches of an innovative battery for promoting EV popularization

First of all, full-scale popularization of EVs requires the emergence of an innovative battery as, shown in Table 1 and Fig. 1. Until then, there is no way forward for EVs other than to remain within specific product ranges, such as ZEV regulation-compliant or in the niche city car market.

The evolution of EV is determined by evolution of in-vehicle secondary batteries. This spurs not only efforts to improving the current performance of lithium ion batteries, but also research an innovative, post-lithium ion batteries1).

Basic research among industry, academia and government to create an innovative battery which can lay claim to being a post-lithium ion battery are led and strongly backed by the government and have continued around various themes.
In May 2014, I was commissioned to do research on medium- to long-term strategies of the next-generation innovative batteries (controlled by the Ministry of Education, Culture, Sports, Science and Technology Japan) as a committee member, which involved participation by about 200 researchers and strategists. This shows great nationwide expectations for battery innovation.

Unfortunately, most basic research so far has not reached a practical level, providing no output of achievements to the industrial world. The biggest focus of this project is to further reinforce the competitiveness of the Japanese battery industry to build a nation based on battery technology with overwhelming strength. Basic research and derivative achievements for such an objective are two pillars of the project. To advance the project committed to that extent, I propose a basic research model and process, which are shown in Fig. 2.
To achieve results, it is necessary to remove many barriers and restrictions to allow flexible use of research budgets over several years, create a flexible system to allow changes in research methods and processes, and so on.

Moreover, we should consider structures and evaluation systems to drive the principle of competition, such as distributing research budgets based on the achievement creation level. National taxes spent on basic research will not be rewarded until resulting achievements are returned to society. Such an awareness must be remembered and shared among industry, academia and government.

Goals for 2030 are too late to accomplish innovative battery research achievements. By the time the ZEV regulation is tightened in 2025, the global power map of in-vehicle batteries may be almost completed. It is not an exaggeration to say that research and development during the ten years from now to 2025 is the key to the future of the battery industry in Japan.

4. Values and issues of FCVs

As Table 1 shows, the hydrogen used as driving energy is generated through cracking of natural gas or other material and this process causes emission of carbon dioxide. Consequently, FCV is not a perfect zero emission vehicle in terms of life cycle assessment. It will require a carbon dioxide-free process during oxygen generation in future. At the same time, if price reductions from using hydrogen fuel cannot be achieved, there will be no benefit to consumers.

It is true that Japanese companies are currently at the forefront. Back in the early 1990s, however, the leaders in this field were General Motors (GM) in the U.S. and Daimler in Germany, because of the ZEV regulation stipulated in California.

Japanese companies began development beginning in 1990, and they used polymer electrolyte
membrane fuel cells (PEMFCs) supplied from Ballard in Canada to develop in-vehicle batteries. Ballard imposed strong restrictions and the companies were prohibited not only from disassembling the fuel cell content but also could not even open the cell.

Under a technology license agreement that prevented direct analysis of the power generation ability and degradation level of the fuel cell stacks, the licensees could not expect to advance fuel cell technology development. In the end, Honda and other companies discontinued the license agreement and changed their approach to self-development.

Due to the excessively restrictive license, Ballard has since disappeared and we do not hear its name in the in-vehicle fuel cell field any more. On the contrary, for Japanese companies that had started research and development in a sort-of exercise style by using Ballard's fuel cell, the change to the self-development approach allowed them to accumulate techniques and promote differentiation. They could directly participate in technology development for performance generation and degradation control.

Furthermore, the development of platinum catalysts and polymer electrolyte membranes, which are crucial and important parts of fuel cells, continued in fierce competition among globally competitive Japanese material and chemical manufacturers, including Tanaka Kikinzoku, Asahi Kasei and JSR. By 2000, Japanese FCVs had advanced to the level of representing the forefront in the world. After that, FCVs evolved further through the achievement of a 700 atm hydrogen tank based on carbon fiber, which is a strong suit of Japan, resulting in achievement of extended cruising distance.

The price of FCVs at the time was 100 million yen per vehicle. Now the commercial price of Mirai is 7.236 million yen and it can be reduced to around 5.3 million yen when government subsidies are taken into account. This is a great evolution, including the price, but there is still a long way to go before popularization.

Commercialized FCVs appear frequently as topics of conversation in terms of novelty, rarity and eco-friendliness. Although pre-orders have far exceeded production capacity, it is hard to visualize a popularization scenario unless consumers can enjoy much greater benefits. Toyota will produce 700 FCVs by the end of 2015 and plans to sell 400 of them in Japan.

External factors to accelerate the popularization of FCVs include tightening of the ZEV and other environmental regulations, the participation of automobile companies aiming for conformance, rising gasoline prices, and a substantial subsidy system.

A true popularization scenario, however, cannot be achieved under conditions where a subsidy system is required. The spontaneous factors to accelerate popularization include further reduction of vehicle costs, infrastructure including hydrogen stations (the Japanese government aims to increase the number from the 20 locations currently in place to 100 in 2015), and user benefit from the reduced price of the hydrogen fuel used.

Considering both the external and spontaneous acceleration factors, the transition to the popularization phase is expected to be in 2030 at the earliest.

Japan overwhelms other nations in terms of sincere, patient, and long-term research and development efforts in the field of main components, such as motors, secondary batteries, and power semiconductor and control systems, as well as of materials and parts such as catalysts, polymer electrolyte membranes and separators. It is not hard to imagine that Japanese companies will also lead the world in future based on its superiority in these areas.

Western automobile manufacturers including GM, Ford, Daimler, BMW and Renault have been developing FCVs in cooperation with Japanese manufacturers; however, it is a relationship in which Japanese companies have the initiative and cooperation is limited to cultivation of markets. To symbolize this, in early January 2015 Toyota announced that it will make its patents of FCV technology available for royalty-free use until 2020. It can be seen to be an effort to building cooperative relationships, but also as a strategy for taking a strong initiative.
Hyundai Motor, which sells FCVs to local governments on a lease basis (for 15 million yen), could not hide its surprise at Toyota's commercial price. This clearly shows the superiority of Japanese manufacturers.

It should be noted that developing FCVs is not easy for mid-sized manufacturers other than the three major manufacturers in Japan. When the development cost and period are considered, it may make sense to select a practical scenario to obtain a license from a large manufacturer, or to not develop and manufacture FCVs but to focus on development and supply in the categories of HEV, PHEV and EV.

5. Role and business model of ESPEC

ESPEC has expanded its range of conventional environmental test chamber products and also built a business model to provide contract basis performance and safety evaluations of large batteries intended for use in automobiles. This was based on the judgment that it would be important to have a roadmap for the popularization of HEVs, PHEVs, EVs, and FCVs in the expanding automobile market now and in future as well as to prove the reliability of the secondary batteries mounted in these vehicles.

In November 2013, ESPEC opened the Energy Device Environmental Test Center in Utsunomiya City, which accepts all such reliability tests. Now one year and several months since it opened, the center has been attracting keen interest from the automotive and battery industries, and the contract business is making steady progress.

During the period, however, we have been hearing requests from automobile manufacturers for a business model providing not only contract business but also covering the processes until certification in the field of battery standards and safety evaluation. In response to these requests, we considered a business model to move up the layer stack.

As a result, ESPEC formed a partnership with TÜV SÜD, a major Germany certification company. More precisely, we established a foothold for the certification business with TÜV SÜD Japan and on November 4, 2014 released a press release about our business cooperation. ESPEC will invest in the certification business and will implement full-scale operation from FY2015.

In Japan, several organizations are providing large-scale evaluation tests of in-vehicle batteries on a contract basis, including such private companies as KOBELCO Research Institute and Japan Carlit, as well as the Japan Automobile Research Institute (JARI), which is owned by the Japan Automobile Manufacturers Association. Business cooperation is also proceeding in this field. KOBELCO Research Institute and JARI are steering toward business cooperation to generate synergy. Fierce competition can be expected among the competitors in the contract business field.

Comparing the competitiveness of these companies, ESPEC's strength is the ability to create a large and strong flow from upstream to downstream, from development to sales of evaluation equipment and contract business. Moreover, regarding evaluation equipment, we cover from development to sales of not only temperature controlled chambers but also the power supply units used for charging/discharging batteries. No other company can develop a series of battery evaluation equipment as a whole system, and this is also our great strength.

The new business to provide certification has raised the expectations of the automotive and battery industries for a new approach. The Ministry of Economy, Trade and Industry and other Japanese government authorities have also shown interest in our future evolvement.

Japanese government is pushing ahead to make Japan a nation based on battery technology in near future. I believe that progress can be accelerated further through contributing to the automotive industry from many related industries and individual companies, including contract and certification businesses.
References


2) Noboru Sato, Nikkei Business Online, Column on December 25, 2014