NRI Papers No. 80 September 1, 2004

Fuel Cells: Business Opportunities and Issues to Be Resolved

Tomohide KAZAMA

Nomura Research Institute

NRI Papers No. 80
September 1, 2004

Fuel Cells: Business Opportunities and Issues to Be Resolved

Tomohide KAZAMA

Many companies are in a rush toward the development of fuel cells. However, since they are being too hasty in commercializing fuel cell products, there are some areas in which technological progress cannot keep pace. While the market is nearing take-off, the pace of fuel cell penetration is not as fast as was anticipated, and the market size in 2010 is projected to be several hundred billion yen.

Japan has many companies (comprehensive manufacturers) whose business fields cover the production of not only fuel cells but also equipment that uses fuel cells. The requirements for these companies to achieve success include (i) quick commercialization of high-performance fuel cells and (ii) securing sales capabilities for equipment that use fuel cells. For portable-use fuel cell systems, an added factor is (iii) expanding business fields to include fuel sales.

In particular, requirement (ii) is important for home-use fuel cell comprehensive manufacturers. Now that joint development partners with gas companies have been determined, the keys to success consist of securing domestic sales channels, such as LPG (liquefied petroleum gas) and kerosene companies and housing manufacturers, and overseas business evolution. To achieve requirements (ii) and (iii), portable-use fuel cell comprehensive manufacturers should not only engage in the production of fuel cells to be mounted on existing equipment, but also in the creation of new equipment to make the best use of fuel cells.

I Fuel Cells Garner Increased Attention as the Next-Generation Power Source

1 Expectations toward Developing a Huge Market

Annual sales of fuel cells have so far been only several hundred units. However, a "research and development market" worth several hundred billion yen (including the costs of personnel) has been formed by the R&D budgetary allocations of governments and the R&D expenditures of mostly automobile manufacturers. Using these funds, many companies around the world have embarked on the R&D of fuel cells (Figure 1).

In Japan, automobile manufacturers, major electric home appliance manufacturers, heavy industry manufacturers, and environmental device manufacturers have been actively engaged in the development of fuel cells. In other countries, many venture firms are specializing in the development of fuel cells.

In a manner of supporting these activities, material manufacturers (carbon-based materials, chemical products, metal products, ceramics, etc.), fuel manufacturers (oil, gas, dimethyl ether, methanol, etc.) and system manufacturers (hot water supply systems, devices related to water treatment, the environment, etc.) have participated in the development of fuel cell technologies.

In addition, entities that use fuel cells such as utility companies (electric power, gas, communications) and housing manufacturers are conducting their own research and development activities concerning fuel cell operations.

The background behind the ongoing R&D activities related to fuel cell technologies by such a large number of companies includes expectations that fuel cells may develop into a huge market through their use in automobiles, housing and mobile equipment that already have gigantic markets.

For example, the annual sales volume of automobiles worldwide is more than 50 million units. If fuel cell systems are adopted in place of internal-combustion engines, the market size would be more than 17.5 trillion yen per year (calculation made on the assumption that the price of a fuel cell system is 5,000 yen/kW and 70 kW/unit is required). Similarly, as the worldwide sales volume of mobile phones is more than 400 million units, the estimated market size would be 200 billion yen per year.

2 What Are Fuel Cells?

Although they are called "cells," fuel cells, unlike batteries, do not generate electricity by themselves. Fuel cells are power generators somewhat similar to internal-combustion engines, and fuel must be supplied. The fuel used is hydrogen and oxygen, which is used to generate electricity, giving off water and heat by a chemical reaction. In short, a fuel cell is a device that uses the reverse reaction of the electrolysis of water (Figure 2).

Fuel cells have a core material called an electrolyte. Depending on the type of electrolyte, fuel cells can be divided into four groups:

- PEFC (polymer electrolyte fuel cells)
- SOFC (solid oxide fuel cells)
- PAFC (phosphoric acid fuel cells)
- MCFC (molten carbonate fuel cells)

Among these four groups, most of the attention is currently being given to PEFC (including DMFC, or direct methanol fuel cell) and SOFC (Figure 3). For PEFC, whose operating temperature is low and activation time is short, development is moving forward for their use as fuel cells in portable equipment, homes and automobiles. Ongoing development of SOFC is focused on stationary medium- and large-size fuel cells with a high level of power generation efficiency. This paper discusses the PEFC and SOFC types of fuel cells.

3 Why Fuel Cells?

As stated above, fuel cells are designed to be used as drive sources for automobiles, home- and business-use equipment and as sources of electric power for mobile equipment. At present, engines are used as drive sources for automobiles and home-use power sources, and batteries are used as sources of electric power for mobile equipment. Accordingly, the technologies competing with fuel cells are engines and batteries.

In comparison to internal-combustion engines, the advantages of fuel cells include a high degree of energy efficiency, a low potential for environmental pollution and silent operation. The advantages of fuel cells over secondary batteries are high energy density, quick recharging and environmental friendliness at the time of disposal. The following section introduces the specific methods of fuel cell use for each primary purpose.

The use of fuel cells as drives for automobiles will result in cars that are cost-effective, quiet and environmentally friendly. A hybrid car can meet this purpose as far as cost effectiveness is concerned, and an electric car can provide features that are both quiet and eco-friendly. However, a fuel cell car is new in that all of these features are accomplished simultaneously, giving it the reputation as an ideal car for the future.

While the fuel cell is essentially a power generator, it also gives off heat together with electricity. If this heat is used for home hot water heaters while at the same time providing electricity, households can enjoy the benefits of energy saving. (If a gas-fueled fuel cell

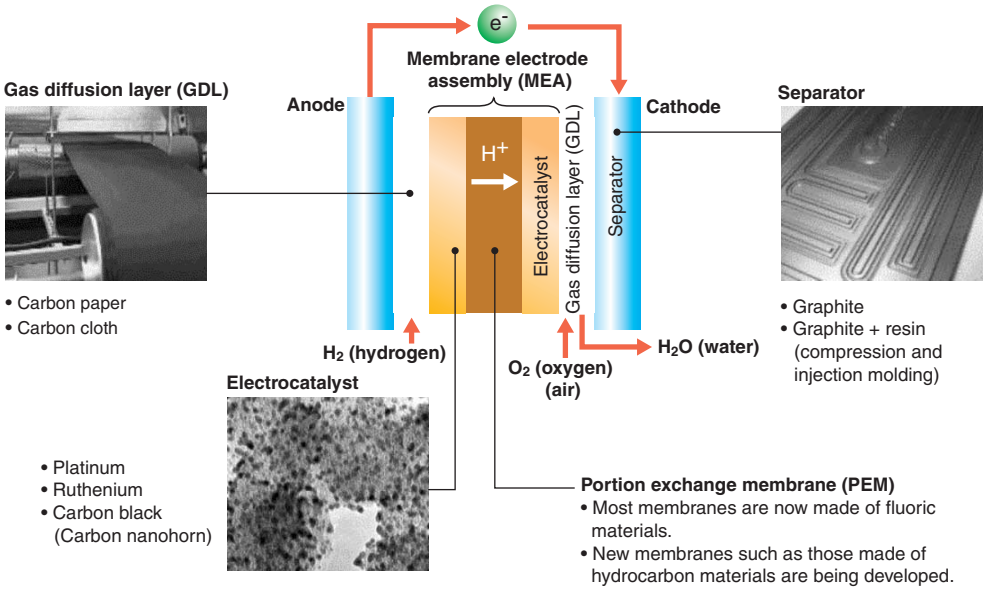
Figure 1. Domestic and Overseas Fuel Cell Companies and Organizations

Materials	
[Domestic]	**[Overseas]**
Fluoric membrane material manufacturers	
• Asahi Glass Co. • Asahi Kasei Corp.	• DuPont • W. L. Gore & Associates • 3M
New membrane material manufacturers	
• Hitachi Chemical Co. • Toray Industries • Toyobo Co.	• FuMA-Tech • PolyFuel • Celanese
Electrocatalyst manufacturers	
• Tanaka Kikinzoku Kogyo • N.E. Chemcat Corp. • NEC Corp. (carbon nanohorn)	• Johnson Matthey • Umicore • E-TEK • SGL Carbon • Cabot Corp.
Separator manufacturers	
• Nisshinbo Industries • Hitachi Chemical Co. • Toray Industries • Unitika • Sumitomo Metal Industries • Hitachi Metals	• SGL Carbon • GrafTech International
Gas diffusion layer manufacturers	
• Toray Industries • Mitsubishi Rayon Co.	• SGL Carbon • Other manufacturers

Fuel cells and fuel cell systems	
[Domestic]	**[Overseas]**
Fuel cell manufacturers	
[PEFC] • Toyota Motor Corp. • Honda Motor Co. • Sanyo Electric Co. • Matsushita Electric Industrial Co. • Toshiba International Fuel Cells Corp. • Fuji Electric Holdings • Hitachi • Ishikawajima-Shibaura Machinery Co. • Mitsubishi Heavy Industries • Mitsubishi Electric Corp. [DMFC] • Toshiba • NEC Corp. • Hitachi • Fujitsu • Yuasa MTI [SOFC] • Mitsubishi Heavy Industries • Mitsubishi Materials Corp. • Kyocera Corp. • NGK Insulators • TOTO • Sumitomo Precision Products Co. [MCFC] • Ishikawajima-Harima Heavy Industries Co.	[PEFC] • Ballard Power Systems • General Motors Corp. • UTC Fuel Cells • Plug Power • ReliOn • IdaTech • Hydrogenics Corp. • Nuvera Fuel Cells • Siemens [DMFC] • MTI MicroFuel Cells • Samsung Group • Giner • Smart Fuel Cell [SOFC] • Siemens Westinghouse Power Corp. • Acumentrics • General Electric Co. • Global Thermoelectric [MCFC] • FuelCell Energy
Reformer manufacturers	
• Tokyo Gas Co. • Osaka Gas Co. • Idemitsu Kosan Co. • Nippon Oil Corp. • Casio Computer Co.	• IdaTech
Heat discharge systems, fuel cell system assemblers	
• Rinnai Corp. • Ebara Ballard Corp. • JFE Holdings • Nippon Steel Corp.	• Fuel Cell Technologies • Alstom • Vaillant

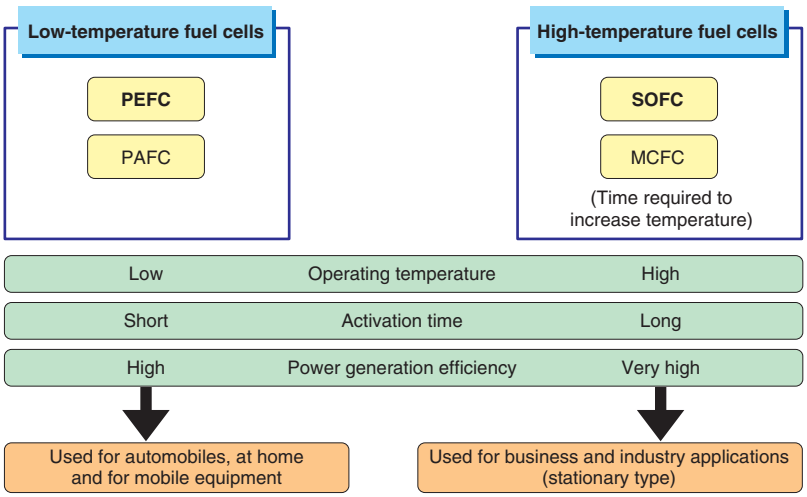
Sales and service	
[Domestic]	**[Overseas]**
Fuel cell system sales companies	
• Tokyo Gas Co. • Osaka Gas Co. • Toho Gas Co. • Nippon Oil Corp. • Mitsui & Co. • Sumitomo Corp. • Marubeni Corp. • JFE Holdings • Fuel cell manufacturers • Cogeneration system manufacturers • Housing manufacturers	• General Electric Co. • Fuel cell manufacturers
Fuel companies	
• Tokyo Gas Co. • Osaka Gas Co. • Toho Gas Co. • Nippon Oil Corp. • Idemitsu Kosan Co. • JFE Holdings • Iwatani International Corp. • Mitsubishi Gas Chemical Co. • Tokai Corp.	• Utility companies • Methanex Corp.
Service companies	
• Tokyo Gas Co. • Osaka Gas Co. • Toho Gas Co. • Nippon Oil Corp. • Idemitsu Kosan Co. • JFE Holdings • Iwatani International Corp. • Tokyo Electric Power Co. • Kansai Electric Power Co. • Chubu Electric Power Co. • Kyushu Electric Power Co. • NTT Corp.	• Long Island Power Authority • Energy Co-Opportunity • EWE • RWE • Other utility companies

Figure 2. Fuel Cell Mechanisms and Materials



Fuel cells convert hydrogen and oxygen into electricity and water.

Figure 3. Comparison of PEFC and SOFC Characteristics



cogeneration system is introduced, the total usage charges for electricity and gas become lower although the gas volume increases over that before the system was introduced.)

If engines are used as power generators for home use, more heat will be generated in comparison to the amount of electricity generated. However, because the fuel cell offers a higher level of power generation efficiency than that of engines, the balance between the amount of electricity generated and the amount of heat recovered matches the home energy demand. The same thing can be said for business use (office buildings, bathing amusement parks, etc.).

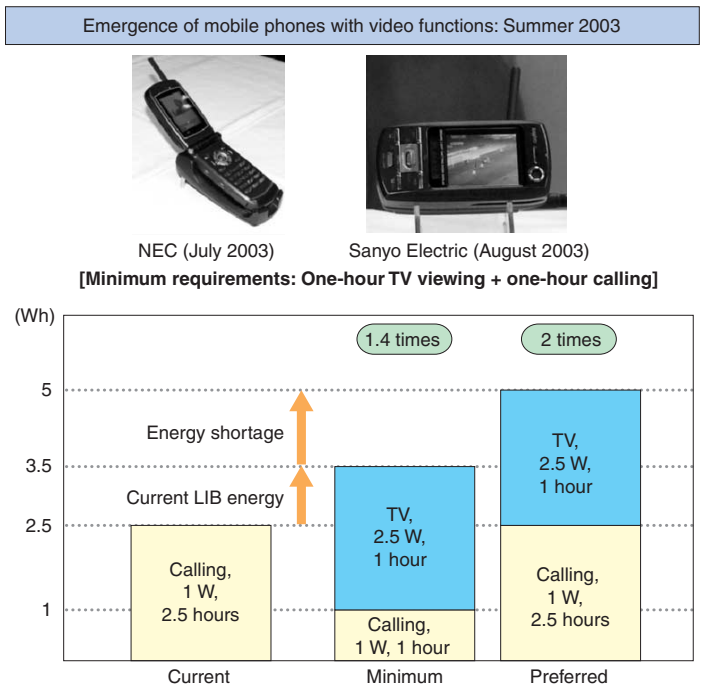
The demand for using mobile devices for a long time without the need to worry about the remaining capacity of a battery is still strong in notebook PCs, digital video cameras, etc. Furthermore, trends of functional additions and integration are seen for mobile devices, such as adding a TV function to mobile phones. Any attempt to meet these needs will increase power consumption requirements and expand usage hours, resulting in a shortage of the capacity of secondary batteries (Figure 4).

If fuel cells are used instead, these problems will be resolved because about three times the energy of the current lithium ion battery becomes available with the same cubic volume. In addition, because the cell can be refueled in a short time, mobile devices can be used for long time on a consecutive basis by repeated refueling.

Beside these advantages, solutions can also be provided for the issue of the disposal of spent batteries as seen in physical distribution and other industries. Such a problem can be resolved if the fuel cell cartridge is made to be harmless to the environment.

The fuel cell uses hydrogen. Hydrogen can be extracted from diversified fuels such as city gas, LPG and gasoline by means of improved technology. Accordingly,

Figure 4. Amount of Energy Required by Mobile Phones with Video Functions



fuel cells will demonstrate their strength when oil prices suddenly rise due to decreases in oil output, or if the government promotes the policy of reducing dependence on oil due to the issue of energy security.

II Fuel Cells Entering the Phase of a Burgeoning Market

1 Home-Use Fuel Cells at the Last Stage Immediately before Commercialization

Gas companies control the initiative in the development of home-use fuel cells. Tokyo Gas Co. has a plan to commercialize products by March 2005, and Osaka Gas Co. plans similar development by March 2006. These gas companies selected PEFC manufacturers as joint development partners in the spring of 2003. The selection was intended to promote development competition and to secure a certain scale of mass production.

As a result, the selected companies that include Ebara Ballard Corp., Sanyo Electric Co., Matsushita Electric Industrial Co. and Toshiba International Fuel Cells Corp. could jump a step ahead in Japan's residential fuel cell market.

2 Mobile-Use Fuel Cells Also to Be Commercialized in 2005

Fuel cell manufacturers have targeted commercialization in 2004 and 2005 (Figure 5).

In Japan, companies such as NEC Corp., Hitachi, Toshiba Corp. and Fujitsu are developing DMFC products for use in notebook PCs. At the same time, Casio Computer Co., which succeeded in the development of a microreformer, is developing PEFC systems. Casio announced that it would commercialize these products in 2007 by waiting for relaxation of regulations on airplane carry-on luggage.

In other countries, companies developing DMFC systems include the Samsung Group in South Korea, Smart Fuel Cell GmbH in Germany and MTI MicroFuel Cells and Motorola in the United States. Most mobile-use fuel cells that are being developed in other countries represent the cartridge type rather than the built-in type.

3 Fuels Cells for Automobiles Already Available on the Market

In the automobile industry, Toyota Motor Corp. and Honda Motor Co. took the lead worldwide by starting deliveries of cars powered by fuel cells in December 2002. Following these moves, competing companies such as Nissan Motor Co. also started deliveries of cars powered by fuel cells. Most of these cars have been delivered to government agencies and offices; some have been delivered to private-sector companies. Lease contracts have now been adopted as the standard delivery format.

Fuel cells currently available on the market are not limited to those for automobiles. Ballard Power Systems in Canada is marketing 1.2-kW "Nexa" fuel cells for portable use. These fuel cells are primarily intended for leisure purposes. In Japan, Ebara Ballard is selling fuel cells for portable use as well as fuel cell systems that include an auxiliary device necessary for generating electric power.

With respect to fuel cells designed for business use, fuel cells as sources of back-up power for communications base stations are primarily being sold in the United States. In 2002, Plug Power launched the sales of hydrogen-fueled GenCore systems in the 5-kW class. ReliOn (formerly Avista Labs) is also marketing fuel cell systems of several kilowatts. Hydrogenics Corp. in Canada is selling 10-kW fuel cells. However, in any of these companies, annual sales were limited to only several units or several tens of units.

No companies have yet established a structure for mass production, and the current status is similar to test sales. Nevertheless, the fuel cell market is starting to take off.

4 As Stationary Fuel Cells, SOFC Systems to Be Commercialized in 2005

With respect to business-use fuel cells from several kilowatts to 10 kW, not only PEFC manufacturers but also SOFC manufacturers have established plans to participate in the market (Figure 6).

In Japan, Kyocera Corp. and Mitsubishi Heavy Industries have aimed at 2005 for marketing their products.

In the overseas markets, Sulzer Hexis in Switzerland plans to market home-use fuel cells in 2004 or 2005. In the United States, Acumentrics plans to market 5-kW systems in 2005, and Siemens Westinghouse Power Corp. plans commercialization in 2006.

The market for SOFC systems is also getting ready to take off. These moves will stimulate technological competition among the different types of electrolyte fuel cells in the range of several kilowatts to several tens of kilowatts.

III Issues Facing the Commercialization of Fuel Cells

1 Catching Up with Existing Technologies

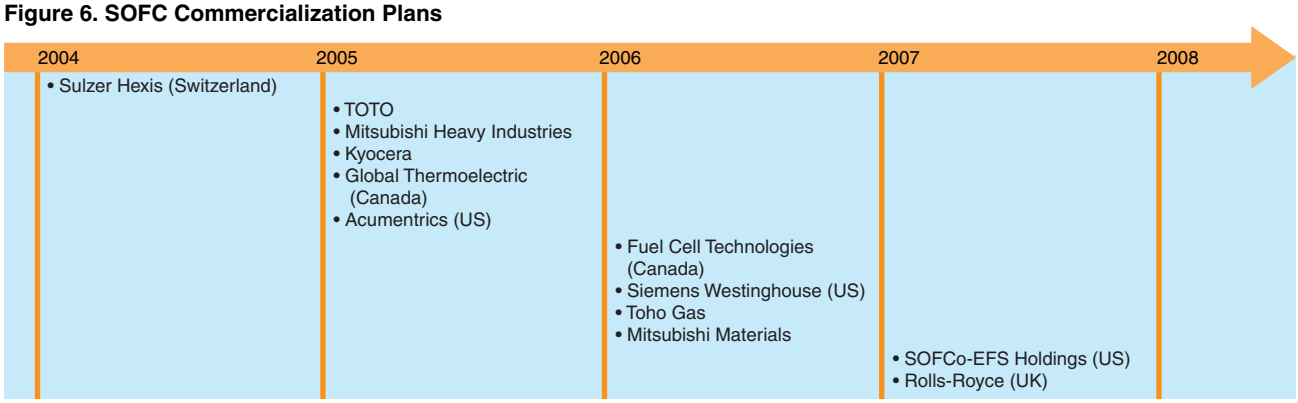
This paper has so far focused on the expectations placed on fuel cells and progress in their development. From my description thus far, the fuel cell market appears to present a rosy prospect. However, those who are engaged in the development of fuel cells do not share these rosy views. They know the difficulty of achieving predominance over the competing technologies that are explained in Chapter I in a short period, because they

Figure 5. Commercialization Plans for Mobile-Use Fuel Cells

		2002	2003	2004	2005	2006	2007	Substitute for secondary batteries	Cartridges, auxiliary power sources
Domestic	Toshiba			←	→			Notebook PCs	
					←	→		Mobile phones	
	Hitachi				↔			Notebook PCs	
	Casio Computer						→	Notebook PCs	
	NEC			←	→			Notebook PCs	
					←	→		Mobile phones	
Overseas	Smart Fuel Cell	←	→						Portable types, notebook PCs
	Medis Technologies		←	→					Cartridges
	MTI Micro-Fuel Cells			←	→			Business-use terminals	
	Samsung Group			←	→			2 to 40 W	
	Neah Power Systems			←	→				0.5 to 40 W
	Motorola			←	→				Mobile phones
	PolyFuel				←	→			Mobile phones

Note: The applications are prototypes and might be changed when the fuel cells are marketed.

Figure 6. SOFC Commercialization Plans



are well aware of the progress actually being made on-site in fuel cell development. They also know that many aspects of fuel cell technology must be overcome to catch up with existing technologies.

In the case of automobiles, one issue to be met relates to the reality that the energy efficiency of cars powered by fuel cells is not significantly different from that of hybrid cars. Other issues to overcome include: measures for cold regions (preventing water from freezing, etc.) are not yet comparable to gasoline-powered cars; and the cruising range is short (300 km for current fuel cell cars vs. 500 km for gasoline-powered cars).

In the case of home-use fuel cells, some have questioned whether users will actually benefit from the anticipated economic advantages. These views seem predicated on concerns about the ability to deal with various differences by a single mass-produced model. Such differences include the different weather conditions in different regions and different electricity/heat usage levels in each household. Other concerns are related to a single model meeting all the differences in fuel constituents depending on the region.

With respect to fuel cells for business use, since there are many cases in which fuel cells are used in boilers, etc., a high discharge heat temperature is necessary in order to use the heat effectively. Accordingly, points are frequently raised that question the feasibility of commercialization based on PEFC systems whose operating temperature is low.

A reality in the case of mobile equipment is that the power density and energy density are lower than are those of batteries. At the present stage, if fuel cells were mounted in the space taken by batteries, the equipment would not operate because the output is too low. For this reason, hybrid power sources involving batteries, capacitors, etc. are being considered. Moreover, at the time of commercialization in 2005, the operating hours of equipment powered by fuel cells are expected to be at the same level as that of batteries. Accordingly, the advantages of fuel cells must be found in the ability to extend operating hours by recharging.

In addition, some mobile equipment powered by fuel cells may be used in cold regions. Mobile phones may be used in snow-covered mountains. The considerable decrease in output that occurs in such cases as well as the issue of water freezing has yet to be resolved.

2 Three Topics to Be Dealt with in Preparation for Commercialization

Although the issues to be overcome in terms of performance were discussed above, there are also three issues to be dealt with that concern preparation for commercialization. They are "costs," "fuel and refueling infrastructure," and "regulations." With respect to costs, not only the costs of the fuel cell system itself but also its practical lifetime need to be considered.

The first issue relates to "costs (and lifetime)." This problem is encountered in any consideration of use.

In the case of automobiles, while the lease price of a fuel cell car manufactured by Toyota is 36 million yen for 30 months, the price of the base vehicle (gasoline car) is several million yen. At the very least, a reduction in cost to 1/10th of the current price is necessary. While the lifetime is now being assessed, a fuel cell car must achieve a practical lifetime of 100,000 km or more in mileage (which is the current average lifetime of automobiles) on a stable basis.

As for home-use fuel cell systems, it is said that a fuel cell price (the portion the user must pay) of 500,000 yen and a lifetime of at least ten years must be realized in order to provide adequate economic incentives to users. However, the current situation involves a price of 5 million yen for only the fuel cell system and a lifetime of several years rather than ten or more.

In mobile-use fuel cells, the hurdle that must be overcome in terms of costs and lifetime is not as great as that for fuel cells used for automobiles and at home. This is because mobile equipment is generally replaced at a faster pace within an average interval of two to three years, and the price per output (kilowatt) of batteries used in such mobile equipment is considerably higher than that of engines. Although the hurdle is lower, the costs of fuel cells still exceed those of secondary batteries, and the lifetime of fuel cells is now under evaluation.

The second issue of "fuel and refueling infrastructure" can be divided into fuels and the fuel infrastructure.

Regarding the matter of fuels, one question is whether fuel cells can appropriately deal with a variety of fuel properties. Fuel properties naturally differ from country to country; a variety of fuel properties exists within the same country depending on the area. Because methanol that is used as fuel is a harmful substance, the issue of safety is also important with regard to mobile-use fuel cells. Furthermore, if fuel is supplied as cartridges, measures to eliminate non-genuine fuel cartridges will be required to prevent uneven fuel properties. It is projected that using inappropriate fuel properties might result in harmful effects, such as fuel cells that are not only unable to function correctly, but also have a shorter lifetime.

The matter of fuel infrastructure is liable to run into the problem of the so-called "chicken-or-egg" question, i.e., which comes first, the penetration of fuel cells into the market or the development of a fuel infrastructure. In the case of automobiles, this question involves the spread of fuel cell cars vs. the development of a hydrogen refueling infrastructure. For mobile equipment, this question corresponds to the spread of fuel-cell-mounted equipment vs. the establishment of fuel sales channels. For home-use fuel cells, the hurdle of this issue is lower because the existing city gas supply infrastructure and the LPG/kerosene delivery network can be used as is.

Regarding the third issue of "regulations," the obstacles are high with respect to mobile-use fuel cells. Since methanol, which is used as fuel, is inflammable, bringing mobile equipment powered by such cells into airplane cabins is banned. Deregulation of this prohibition is expected at the beginning of 2007 at the earliest. Accordingly, these regulations may hamper the commercialization of fuel cells for notebook PCs, etc.

With respect to fuel cells used in automobiles and at home, studies are now underway towards deregulation in Japan. Fuel cells used in automobiles manufactured for sale in the global market will be affected by the progress of deregulation in each relevant country.

3 Fuel Prices Hindering the Prospect of Business Feasibility

As pointed out previously, cost is a major problem in the marketing of fuel cells. In making a decision on whether to use fuel cells, users will consider the total cost including not only the price and lifetime of a fuel cell system, but also the price of fuel to operate such a system. Accordingly, fuel price is an important factor for users. At the same time, the matter of fuel prices is vitally important for fuel cell manufacturers as this will affect the degree of penetration of fuel cells. However, because the right to determine fuel prices rests with fuel companies such as gas companies, especially with respect to home-use fuel cells, fuel prices constitute an almost uncontrollable risk factor for fuel cell manufacturers.

The initial investment required for purchase of a home-use fuel cell system is high. One conceivable way to absorb such high prices is to set up special discount programs on the price of fuel. In the case of gas, for example, the gas companies will have incentives in setting up a special price menu because the expansion of city gas sales can be expected if fuel cells are disseminated.

The noticeable point here is the price menu of electric power companies. If electric power charges decrease, the economic advantages of fuel cells will shrink, hindering the spread of fuel cells. If such a situation occurs, success or failure may depend on the strength in withstanding a price war between electric power companies and gas companies. Since it seems that electric power companies still have the ability to reduce charges, it is difficult for fuel cell manufacturers to have a clear-cut business outlook. This uncertain business prospect has also affected the material manufacturers.

While home-use fuel cells are discussed here, the fact that the future of business, good or bad, is influenced by the level at which fuel prices are set also applies to other usage purposes.

Figure 7 outlines the benefits of fuel cells as well as the issues to be overcome.

IV Size of Fuel Cell Market

While the potential market for fuel cells certainly appears to be big, a number of issues must be overcome before fuel cells can create value as products. The commercialization of home-use and mobile-use fuel cells is scheduled for around 2005. However, initial products appear to be unable to fully demonstrate the potential of

Figure 7. Benefits Provided by Fuel Cells and Issues to Overcome for Each Application

	Automobile use	Home use	Mobile use
Benefits (anticipated)	• Providing fuel-cost-effective, quiet and eco-friendly cars	• Reducing energy costs at home (suitable for the ratio of electricity/heat demand in households)	• Long operating time (improving energy density, refueling) • Resolving the matter of disposing of spent batteries
Issues to overcome in terms of performance	• Energy efficiency is the same as that of hybrid cars • Measures for cold regions (e.g., preventing water freezing) are not yet available • Cruising range is short (300 km at present vs. 500 km for existing cars)	• Discharge heat temperature from fuel cells (PEFC) is too low • A single system cannot cover all possible electricity/heat usage patterns and demand curves required in each household • A single system cannot cover all the differences in fuel constituents based on region	• Output density and energy density are lower than that of batteries • Measures for cold regions (e.g., taking proper measures against output decline, preventing water freezing) are not yet available
Issues to overcome toward commercialization	• Reducing costs (prices) • Securing reliability • Developing hydrogen refueling infrastructure (ending the chicken-or-egg discussion)	• Reducing costs (prices) • Extending life (goal of ten years, only several years at present) • Addressing varied fuel properties	• Reducing costs (prices) • Securing safety of fuel (methanol) • Measures to eliminate off-brand fuel cartridges • Deregulation (carrying fuel into airplane cabins)
	• Risk hedge against changes in fuel prices		

fuel cells. Consequently, it is projected that a full-scale startup of the market will occur around 2007.

With these delays in mind, if the market size of fuel cells in 2010 (the total market for fuel cells used in automobiles, at home and in mobile equipment) is calculated, the scale is not as large as first anticipated. The results of the calculation were 224 billion yen per annum (Figure 8), and are made up as follows: home-use fuel cells account for the largest portion at 140 billion yen, followed by fuel cells for mobile equipment at 60 billion yen and fuel cells for automobiles at 24 billion yen.

1 Fuel Cell Cars Replacing Electric Cars

In the automobile industry, the existing types of gasoline and diesel cars will continue to constitute the mainstream in 2010. For fuel cell cars, the replacement market for the immediate future will be that of electric cars.

At present, the annual market size of electric cars is several thousand. Projections for 2010 indicate annual sales of 10,000 cars at most. On the assumption that the prices of fuel cell cars will become lower than those of electric cars, the annual sales of fuel cell cars will be about 8,000. The reason why not all electric cars will be replaced is that some electric car users are electric power companies, and they have no incentives to use fuel cell cars.

Toyota's electric car RAV4 EV is marketed at a price of about 5 million yen; the body price is about 2 million yen. Based on this breakdown, the price of the fuel cell system to be mounted on the car is assumed to be 3 million yen. If this unit price is multiplied by the estimated number of cars sold, the market size of fuel cell systems for automobiles will be 24 billion yen in 2010.

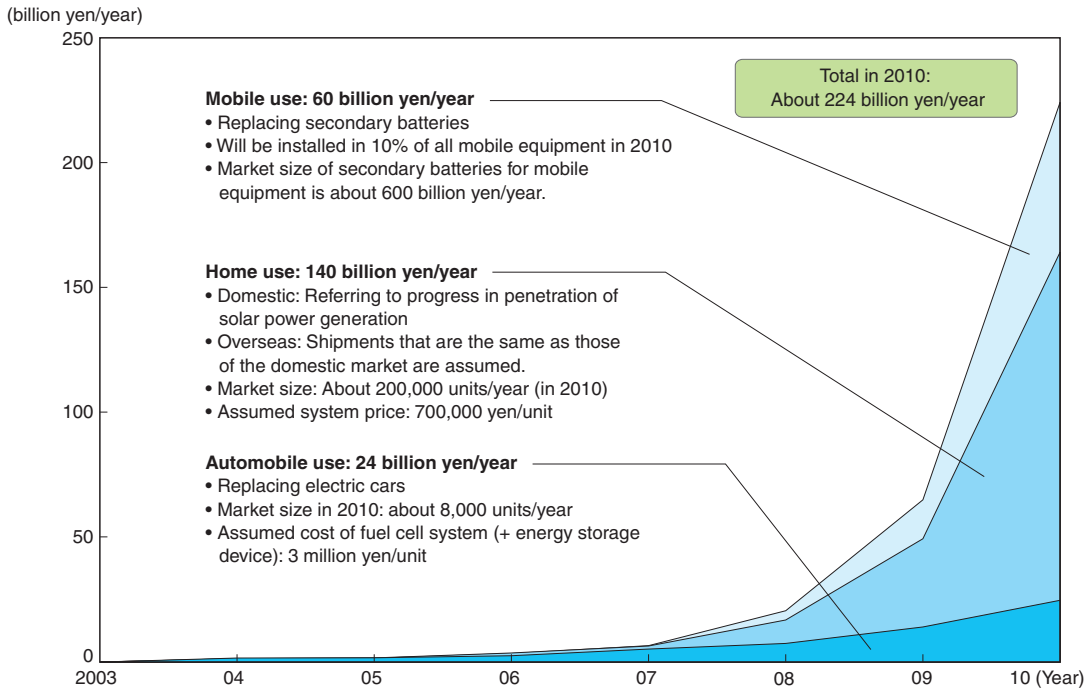
2 Japanese Market Is Most Promising for Home-Use Fuel Cells

Many persons view the Japanese market as the most promising in the world with respect to home-use fuel cells. These opinions are derived from more than adequate incentives provided by the government for the purchase of fuel cells and the fact that overall energy charges are relatively high in Japan. Neither of these factors is applicable in the United States and Europe. In order for ordinary households in these countries to benefit economically by introducing fuel cell systems, substantial cost reductions are required. Accordingly, the evolution of home-use fuel cell systems in the United States and Europe will be confined to niche markets such as single houses located in rural areas where an electric power network is not yet developed.

In estimating the size of the Japanese market, the progress in the market of home-use solar power generation systems was used as a reference case. As the prices of home-use fuel cell systems are high, purchase incentives are necessary for the market penetration of fuel cells. Because home-use solar power generation systems have been disseminated with the support of purchase incentives, these systems can serve as an example to forecast the future of the fuel cell market.

According to the calculation based on these conditions, the annual home-use fuel cell market in 2010 will number about 100,000 units. If the same number of

Figure 8. Estimated Size of Fuel Cell Market



Notes: (1) These projection estimates are based on best-case scenarios; (2) Markets of business-use, portable and bus-use fuel cells are not included; (3) The R&D markets that material manufacturers should consider are not included. Fuel cells for automobiles have the largest R&D market.

shipments to overseas markets is included, the estimated annual market size is about 200,000 units. The price of a fuel cell system was assumed to be 700,000 yen per unit. If this unit price is multiplied by the estimated number of units, the size of the home-use fuel cell market is projected to be 140 billion yen in 2010.

3 Mobile-Use Fuel Cells Target High-Grade Business-Use Models

Because technological development is still ongoing for fuel cells for mobile equipment, it is difficult to estimate the market size of these fuel cells. It appears, however, that the demand for business-use mobile equipment is higher than that for private-use mobile equipment.

For example, notebook PCs are frequently used as a substitute for desktop machines in private use, and they are used as mobile information equipment in many cases in business use. The latter usage group will have a higher need for fuel cells.

In the case of video cameras, professional photographers consider having their batteries run down a serious problem, and often carry several spare batteries with them. Since spare batteries for professional equipment are very expensive, initially targeting such equipment (professional models) is a logical conclusion in terms of cost as well.

Such professional equipment accounts for about 10 percent of the market. If it is assumed that fuel cell systems will replace 10 percent of 600 billion yen, which is the current size of the secondary battery market for mobile equipment, the market for these fuel cells is estimated to be about 60 billion yen.

Even if the markets for business-use, portable and other fuel cells that were not included in the calculation are included, the total market of fuel cell systems for all purposes including automobiles, home and mobile is estimated to be up to several hundred billion yen per year in 2010.

V Success Factors for Fuel Cell Manufacturers

The current status and future outlook of the fuel cell market were discussed in the previous chapters. While the pace of the market startup may be gradual, competition among fuel cell manufacturers has already begun.

Fuel cell manufacturers can be divided into two types: exclusive manufacturers that produce only fuel cells and comprehensive manufacturers that produce fuel cells and equipment that utilizes fuel cells. Because many Japanese manufacturers fall under the latter category, this section examines the keys to success for comprehensive manufacturers. Since it is apparent that "quick commercialization of high-performance fuel cells" is important and detailed explanations have been provided in the previous sections, this matter will not be restated in this section.

1 Securing Sales Capabilities for Equipment That Uses Fuel Cells

In the past, the formation of a "technological consortium" constituted an important factor in efforts towards establishing the de facto standards of technologies during the phase of market emergence. The formation of a technological consortium helps attain high technological capabilities and speeds up development activities.

In the future, however, "measures to secure sales channels" will become important with the aim of securing a larger market share during the phase of market growth. In such a case, competition will focus on the extent to which positive relationships can be established with companies that have high sales capabilities for equipment that uses fuel cells.

For example, the lineup of comprehensive manufacturers of home-use fuel cells includes many manufacturers in the fields of electric home appliances as well as heavy industry. These companies manufacture their own complete products on which fuel cells are mounted. However, as home-use fuel cell systems are not outright sales products, it is difficult to use existing sales channels such as sales agencies and volume sales outlets.

In actuality, sales of the equipment are dependent upon gas companies, etc. As stated in Chapter II, the background behind the competition among comprehensive manufacturers in establishing partnerships for joint development with gas companies represents their efforts to secure equipment sales capabilities. This suggests that the key to success for comprehensive manufacturers is to build good relationships with LPG and kerosene companies and housing manufacturers.

Another possibility for added success is to expand production output by developing sales activities in other countries. The important factors in overseas development include the establishment of sales partnerships with leading local companies and joint development to customize fuel cell systems in local areas. For example, Nuvera Fuel Cells (United States, Italy) has established a sales partnership with Mitsui & Co. to start selling their fuel cell systems in Japan. Acumentrics, an SOFC system manufacturer, has entered into a sales affiliation with Sumitomo Corp. Siemens Westinghouse has established a sales partnership with JFE Holdings.

Mobile-use comprehensive manufacturers primarily consist of mobile equipment manufacturers such as Toshiba, Hitachi, NEC, Fujitsu and Casio Computer. In applying mobile-use fuel cells to equipment, there is a great significance in that the equipment manufacturers themselves develop fuel cells. This is because differences in shape from existing secondary batteries, differences in restrictive factors in terms of design and differences in output control are all involved.

What is surprising here is that no equipment manufactured by Japanese companies has a high share of the world market, other than the high market share held by Toshiba's notebook PCs. In order to acquire the benefits of the mass production of fuel cells, it becomes inevitably important that companies in Japan establish relationships with overseas manufacturers that have a high market share. Actually, it appears that some companies are preparing to establish joint development arrangements, although such plans have not yet been publicly announced.

I would like to add that the development of new equipment that can make the best use of fuel cells would also serve as a success factor for comprehensive manufacturers. Because secondary batteries are multipurpose products, business opportunities for fuel cells will not expand simply by aiming at being their substitute equipment. It is likely that mobile-use fuel cells will enter the stage of full-scale penetration only after killer applications of fuel cells emerge.

Similarly, with respect to fuel cells for automobiles, it will basically become necessary to increase cost competitiveness by supplying fuel cell systems not only for their own products but also to other companies after the occurrence of technological competition during the period from market infancy to market growth.

2 Expanding Business Fields to Include Fuel Sales

Comprehensive manufacturers can, of course, generate profits by manufacturing fuel cells. However, it would be ideal if business fields could be expanded to include fuel sales (with no need to manufacture fuel). In other words, if a business model could be established in which profits are also generated from the sales of fuel that is consumed by the equipment that uses the fuel cells, a higher profit ratio would be realized. While the opportunities of building such a business scheme cannot be expected with respect to automobile-use and home-use comprehensive manufacturers, it is possible to expect such opportunities for the manufacturers of mobile-use fuel cells.

Studies are currently underway for the use of a methanol-fueled fuel cartridge as one fueling system for equipment that uses fuel cells. In such case, a conceivable business format for comprehensive manufacturers is to consign the production of fuel cartridges to a third-party manufacturer, and sell the cartridges under the manufacturer's own brand name. While methanol fuel is now being sold at about 40 yen per liter, this volume corresponds to that of several dozen cartridges. Depending on the prices set for cartridges, it would be possible to aim at building a highly profitable business. Furthermore, the fact that cartridge demand increases in proportion to the total sales of equipment that uses fuel cells over several years, rather than annual sales, should not be overlooked.

A similar business model can be seen in the printer business. In addition to earning profits by selling printers, printer manufacturers generate profits by selling ink cartridges under their own brand, which are made by third-party ink suppliers. Printer manufacturers have established a structure in which the type of ink cartridge is different for each printer model to make it difficult to use inks produced by other makers or third parties, thus ensuring steady sales of their own brand of ink cartridges.

If a comprehensive manufacturer expands its business fields to include fuel sales, one requirement to achieve success is to sell equipment that uses fuel cells in large quantities under its own brand name. "Under its own brand name" is added because the expansion of business fields to include fuel sales is not possible if fuel cells are supplied to other companies and the other companies sell equipment that uses these fuel cells. Naturally, the other companies will sell the fuel under their own brand name. In this sense as well, it is vital for comprehensive manufacturers to create new equipment that uses their own fuel cells.

In order to meet the requirements for success that have been described so far, each manufacturer is actively pursuing technological tie-ups and sales partnerships. These moves are expected to further accelerate as commercialization nears.

This paper focused on the current status and future outlook of the fuel cell market primarily with respect to fuel cell manufacturers. While space does not allow me to include a description of fuel cell materials, only looking at fuel cell manufacturers is not sufficient to fully understand the fuel cell industry. The movements of material manufacturers that play an important role in developing fuel cell systems—especially the trends in their R&D activities—also need to be analyzed. While I am also carefully watching the trends in fuel cell materials, I would like to use another opportunity to discuss this issue.

Tomohide KAZAMA is a chief consultant at the Manufacturing Industry Consulting Department of NRI. His specialties include business strategies in the secondary battery and fuel cell industries, and new business strategies.

As a leading think tank and system integrator in Japan, Nomura Research Institute is opening new perspectives for the social paradigm by creating intellectual property for the benefit of all industries. NRI's services cover both public and private sectors around the world through knowledge creation and integration in the three creative spheres: "Research and Consulting," "Knowledge Solutions" and "Systems Solutions."

The world economy is facing thorough structural changes led by the dramatic growth of IT industries and the rapid expansion of worldwide Internet usage—the challenges of which require new concepts and improvement of current systems. NRI devotes all its efforts to equipping its clients with business strategies for success by providing the best in knowledge resources and solutions.

NRI Papers present selected works of NRI's 3,000 professionals through its worldwide research network. The mission of ***NRI Papers*** is to contribute new ideas and insights into business management and future policy planning, which are indispensable for overcoming obstacles to the structural changes in our society.

Inquiries to: Corporate Communications Department
Nomura Research Institute, Ltd.
E-mail: nri-papers@nri.co.jp
FAX: +81-3-5255-9312