Roads Open for Electric Vehicles

The first electric vehicle was built in Great Britain in 1886, five years before the first gasoline powered automobile appeared. However, it was gasoline engines that entered widespread use, since electric vehicles had battery problems and a shorter range with poor dynamic performance. About a century later, a new era of electric vehicles dawned when the United States planned to introduce severe emission controls in 1990. Keio University Professor **Hisashi Ishitani** analyzes the today and tomorrow of electric vehicles.

When the electric vehicle came into being at the end of the nineteenth century, gasoline powered vehicles also appeared and a hybrid propulsion automobile was created. However, electric vehicles had problems associated with driving range and batteries. Quicker in technical advancement, gasoline vehicles came into more widespread use. Later, the two oil crises of the 1970s, together with growing emission issues during the age of motorization triggered research into electric vehicles and a development project at the initiative of the Ministry of International Trade and Industry. However, the development of electric vehicles remained modest in scale. The performance of lead-acid batteries failed to improve and the oil crises ended.

The full-scale research and development of electricity powered automobiles kicked off with California's Zero-Emission Vehicle Regulations in 1990. This U.S. state introduced a regulation that obliged any automobile manufacturer with a high sales volume to ensure that zero-emission vehicles account for at least two percent of its production in 1998–2000, five percent in 2001 and 2002 and 10% from 2003 onwards. To meet this requirement, car manufacturers began to seriously work on electric vehicle development. The problem with batteries remained unsolved, as the final challenge. It was difficult to find a solution in terms of recharging time, durability and price. As a result, the regulation was relaxed and enforcement was postponed.

Full-scale Development of Electric Vehicles

However, the initiatives of those days eventually helped bring about a massive improvement in the performance of electric vehicles. This led to Toyota's introduction of hybrid electric vehicles, which have no range limitations or infrastructure issues. Some Western car manufacturers abandoned their bid to develop electric vehicles and focused on R&D of fuel cells, establishing a trend towards fuel cell vehicles since 2002. After the shift of the Japanese government towards fuel cells, fuel cell powered vehicles look likely to be commercialized quickly. However, fuel cells had their own difficulties with cost, hydrogen storage and refueling infrastructure. Before the necessary technical advancements could be made, lithium-ion batteries made their own progress to draw attention for potential applications with electric vehicles. Another factor that accelerated the progress of electric vehicles was the orientation towards a departure from a dependency on oil as an energy security issue. This trend was sparked by carbon dioxide emissions control and by the 9/11 terrorist attacks in the United States.

With these factors in the background, hybrid vehicles have been diffused worldwide, mainly in urban areas in Japan and the United States. Moreover, a U.S. business venture modifies hybrid vehicles on the market to be plug-in hybrid electric vehicles with the use of an additional on-board battery. The plug-in model has an all-electric range of 40 to 50 kilometers per charge, which is sufficient for daily driving. Plug-in hybrid technology is therefore attracting growing interest, offering as it does electric driving without concerns about range limitation.

We now have three major options when it comes to reducing oil consumption and CO_2 emissions in the field of road transport: (battery) electric vehicles, plug-in hybrids, and fuel cell vehicles, their effectiveness being dictated by use pattern or city structure. For shorter distance driving in congested areas, such as in the city, electric vehicles work well, but for bigger and heavier vehicles and longer distance or higher speed driving, fuel cell vehicles may be more appropriate. Plug-in hybrids work well for most

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occasions, although their environmental effects may be limited.

Take Germany for example. The average driving distance per vehicle is 16,000 kilometers per year in that country. Located on a continent, many Germans use the autobahn to travel long distances. Therefore, it does not have very high demand for electric vehicles. On the other hand, Japan's average driving distance is 10,000 kilometers per year. Japan has a comparatively small area and its population is concentrated in urban areas. These conditions are suited to the proliferation of electric vehicles. Despite regional differences, it is the awareness of the CO_2 reduction challenge that underlies the development of electricity-driven vehicles, including the above three options.


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Obstacles to Wider Use of Electric Vehicles

Battery issues have been a lingering challenge since the advent of electric vehicles. Specifically, they are problems with energy density, cost and durability. Among other things, cost cutting is essential to the widespread use of electric vehicles. Without cost cuts, electric vehicles cannot compete. However, after the cost is lowered, there are still constraints on battery performance. Because of this constraint, applications for electric vehicles are limited to some degree.

One major inconsistency is that mass production is essential to reduce prices, while widespread demand is essential to mass production. To resolve that conundrum, it is important to carry out something like a community-wide demonstrative trial of electric vehicles as a community development initiative. These activities must then evolve into a movement towards energy independence with the objective of attaining significant CO_2 reduction in the future.

Many countries are focusing on technical research and development. In an effort to boost hybrid vehicles, electric vehicles, fuel cell vehicles and other types of new-generation automobiles, Japan is pursuing research and development involving innovative secondary batteries aimed at reducing cost and improving performance, energy and power densities. This is part of the initiatives to create a low carbon society by means of resource and environmental innovations. The Ministry of Economy, Trade and Industry and the New Energy and Industrial Technology Development Organization (NEDO) aim to achieve an electric vehicle range of approximately 500 kilometers and to reduce the price of traction batteries to nearly one fortieth of the current level by 2030, by inventing a revolutionary secondary battery characterized by high performance and low cost. The governmental Council for Science and Technology Policy evaluates the priority of science and technology policies. For fiscal 2009, it gave the top priority rating solely to basic research on innovative power-storing batteries to provide future support for this research.

At the moment, lithium-ion batteries, which account for 60% of the worldwide production, still have some problems, but they will be sufficient for application to electric vehicles and plug-in hybrid vehicles mainly used in urban areas if they become cheaper. In other words, the day is coming when electric vehicles will be widely accessible. In fact, electric vehicle technology is now attracting great attention as it has advanced to the level of widespread application. This means that the experiments and innovative technologies described above are of great importance.

The adoption of environmentally friendly cars will be quicker than expected if electric, hybrid, plug-in hybrid and other kinds of vehicles are cleverly introduced for appropriate purposes, such as delivery businesses and private use within urban areas. It is urgent given that volume production is after all a major key to battery price reduction.

—Keio University Professor Hisashi Ishitani

Advantage of Electric Vehicles

Basically, electric vehicles are environmentally friendly as they emit no exhaust gases on the road and generate no noise. Electric motors also offer superior acceleration performance. In addition, they have two other significant advantages that warrant emphasis.

One is the use of electric power

generated at night. In general, electric vehicles will be recharged at night and nighttime electric power generated from nuclear energy can be used. The daily average travel distance is estimated as some 40 kilometers, by dividing the aforementioned driving distance of 10,000 kilometers by 250 days. On the assumption that electric vehicles can travel about 10 kilometers per kilowatt-hour, this suggests that an electric vehicle consumes an average of only four kilowatt-hours a day. Recharging with this amount of electric power overnight from 11 p.m. to 5 a.m. requires approximately 800 watts. Simply put, electric power of one kilowatt is sufficient to recharge a single electric vehicle. If two million gasoline-powered vehicles are replaced with electric vehicles, the power consumption for recharging is merely two million kilowatts.

This allows electric power suppliers to benefit from surplus power without the need to construct any special infrastructure. It marks a major difference from hydrogen refueling stations and adds a major advantage to electric vehicles. Seeing a great opportunity, electric power companies are working hard on this.

Another advantage lies in the active use of natural energy. Increasingly popular as they are, wind power generation and photovoltaic power generation are both susceptible to weather conditions and they lack stability as sources of power. However, stability is secured if power generated from these sources of energy can be stored and supplied to electric vehicles. If this becomes a reality, we will take a major step forward in solving the problems with exhaust gas, carbon dioxide and the energy shift from oil. A key to realization is the battery price. There will be no breakthrough without a considerable price decline.

If it is assumed that gasoline powered vehicles and electric vehicles are produced using the same system and in the same volume, there is little difference in cost between the two types of cars, except in the battery cost. Even so, electric vehicles do not incur heavy electric power costs, as discussed above. Replacement of a gasoline vehicle with an electric one will result in fuel cost savings ranging from 500,000 yen (5,200 dollars) to 600,000 yen for a lifetime, ten years. If the battery cost is equivalent to this cost savings, electric vehicles will be able to rival gasoline-powered automobiles. Naturally, existing batteries cannot fully guarantee a driving range of 500 kilometers, but they can mostly cover driving for daily use.

Widespread Use a Solution to Every Problem

Battery charge exhaustion while driving is the greatest risk associated with electric vehicles. But even were electric vehicles to dominate the roads, there would be little need for special electric infrastructure facilities. It is always possible to use a power source somewhere in the event of a flat battery. There are various recharging options in the case of battery depletion. One is a quick charging station at the roadside. For example, it takes 15 minutes to recharge the battery of Mitsubishi Motor's compact electric vehicle to 60% of its capacity.

It is not necessary to recharge it to 60%, provided that the destination is not remote and that it is sufficient to merely store the necessary amount of electricity. Setting battery exhaustion aside, it is possible that branch offices and other recharging points may be systematically put in place. Even long-distance travel may be possible with frequent recharging every 200 km as necessary. In other words, the range of sustained driving will be extended by setting up infrastructural bases on an area-by-area basis.

With respect to plug-in hybrid vehicles, the pure electric mode, or electrically assisted blend mode, could meet demand for driving about 50 kilometers within an urban area. They can be used in normal hybrid drive mode for long-distance weekend trips. A person traveling a long distance can drive a hybrid vehicle while another person traveling a short distance can use an electric vehicle. If this mode of use is taken into consideration, it can be said that electric vehicles are already practical, even in view of their battery performance.

On the other hand, fuel cell vehicles could be applied for heavy vehicles or bigger long distance drive passenger cars. Under the current circumstances, the adoption of environmentally friendly cars will be quicker than expected if electric, hybrid, plug-in hybrid and other kinds of vehicles are cleverly introduced for appropriate purposes, such as delivery service businesses and private use within urban areas. It is necessary to proactively find different applications for these vehicles where possible. It is urgent given that volume production is after all a major key to battery price reduction.

Tokyo Electric Power Company, Inc. procured ten electric vehicles for a demonstrative trial. At first they were rarely used, and everyone started to use them after quick charging stations were provided at several points. But in fact, quick charging stations were rarely used. This does not mean that they were not needed. Quick charging facilities are a solution to concerns about battery exhaustion and any distrust in the remaining range indication. Therein may lie a clue to achieving widespread adoption.

Prices don't fall without mass production. Market penetration won't happen without price declines. No mass production begins without a decisive factor or confirmation. On the basis of the demonstration test, conducted over nearly two years by the electric power company, safety has been verified from different perspectives in an effort to facilitate volume production. When mass production lowers electric vehicle prices, proliferation and expansion will accelerate. If there are one or more problems with the cars, ongoing technical development to produce more advanced technologies will respond. Yet electric vehicles could find themselves without a future should any serious technical problem arise after the vehicles are launched and while their cost remains high. In this respect, government policy must provide strong support, not only in terms of financial aid, but also for establishing safety or performance codes and standards. HJ

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