Science and Technology Foresight in Japan

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Abstract

In Japan, Science and Technology (S&T) Foresights have been conducted every 5 years since 1971, with the 9th survey report summarized in July 2010. This survey employed a combination of methods, including (1) a Delphi survey on topics extracted through interdisciplinary discussions targeting visions for the future society, (2) scenario writing through several methods on the potential paths toward the desired future, (3) regional discussions addressing the realization of sustainable regional societies, besides other comprehensive discussions.

In the Delphi survey, 2,900 Japanese experts from every field of study were inquired of their predictions pertaining to 832 S&T topics 30 years into the future. The major results of these surveys include a vision of a future society underpinned by the evolution of S&T, its areas of key importance for the resolution of global and national challenges, potential paths toward the realization of this future vision, and a summary of the opinions commonly expressed by the expert groups.

The results of the 9th S&T Foresight were used to create a draft of the government's 4th S&T Basic Plan, initiated in 2012. In addition, the technological and social realization times forecasted in this survey led to the setting of R&D targets in governmental and industrial research organizations and universities, which may include S&T education or skill-building programs for human resources.

Keywords

Science and technology foresight, Delphi survey, Green innovation

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1. The 9th Science and Technology (S&T) Foresight

Since 1995, Japan has implemented S&T Basic Plans, according to the S&T Basic Law. Each plan covers a five-year period, and the 4th Basic Plan began in August 2012. Historically, S&T forecast results have been mainly utilized to prioritize research areas in each plan. Under the 4th Basic Plan, Green Innovation and Lifestyle Innovation are expected to be strongly promoted, leading to the creation of new markets and jobs.

In Japan S&T Foresights have been conducted every 5 years since 1971, and the 9th survey report was summarized in July 2010. In this survey, 2,900 Japanese experts from every field of study gave their predictions pertaining to 832 S&T topics 30 years into the future.

The results of the survey were used to draft the 4th S&T basic plan, which was initiated in 2012.The 9th S&T Foresight focused on discussions conducive to solving global and national challenges, with a clear view toward the future. Considering current global trends and realities in Japan, the survey narrowed down a specific course of action for S&T into the following four challenges:

(1) To be a central player in the S&T arena
(2) Aim for sustainable growth through green innovation
(3) Develop a successful model for a healthy aging society
(4) Create a secure life for citizens

The survey employed a combination of methods such as a Delphi survey on topics extracted through interdisciplinary discussion targeting visions for future society, scenario writing through several methods on the potential paths toward the desired future, and discussions on possible approaches toward the realization of sustainable regional societies.

The major results of these surveys are as follows: (1) a vision of a future society underpinned by the evolution of S&T, (2) an outline of potential paths toward realization of the future vision, (3) future visions expressed by the local populace and the youth, (4) areas of key importance in S&T for the resolution of global and national challenges, and (5) a summary of the opinions commonly expressed by the experts groups, extracted from the Delphi survey results.

2. The Delphi Survey

We established 12 interdisciplinary technological subcommittees, which consist of 135 experts from universities, industries, and research institutes. In addition four broad groups were established for discussing security, safety, international cooperation, and international competition.

Within these four groups, interdisciplinary discussions involving members of the humanities and social sciences were held.

These subcommittees and groups set out 832 topics. Figure 1 shows the technological theme of each subcommittee.

Dephi Survey - Targets and Technological Themes

No	Technological theme
1	Fully utilize electronics, communications technology, and nanotechnology in a ubiquitous society
2	Expand the scope of discussions on information processing technology to the media and contents
3	Link biotechnology and nanotechnology, to contribute to human quality of life
4	Make full use of IT to realize people's lives more healthy, with highly advanced medical technology
5	Use science and technology to help people understand the dynamism of space and the earth and expand the human sphere of activities
6	Make diversified changes in energy technology
7	Handle all kinds of necessary resources, including water, food, and minerals
8	Develop technology to preserve the environment and build a sustainable recycling society
9	Develop fundamental technology concerning substances, materials, nanosystems, processing and measurement
10	Develop manufacturing technology to comprehensively support the development of industry, society, and science and technology in general
11	Place overall subject matters under stricter management, due to advancements in science and technology
12	Create infrastructural technologies to support infrastructural and industrial bases

Target
Safety
Security
(Int'l)Cooperation
(Int'l)Competition

Source: NISTEP 2010

Figure 1 Targets and Technological Themes in Delphi Survey

Respondents were classified according to age and occupation. 38% of respondents were in their 50s, 25% were in their 40s, and 24% in their 60s. University researchers accounted for 47% of the respondents, industry researchers for 29%, and researchers from public research institutes for 15%.

The main themes of the questions were the importance of R&D, the timing of the occurrence of technological and social realization in Japan, and S&T sectors that will enable the realization. In addition, five items addressed Japan's approach in solving global and national challenges, including items of key importance for the resolution of identified challenges, the R&D required, the international strategy to be implemented, priority items to be addressed by the government, and the R&D needed for sustainable development.

In the energy field, Delphi survey results from over 400 expert respondents identified a total of 72 R&D items. Figure 2 lists the 10 most important R&D items in the energy field, along with the projected time for each item's technological and social realization. The first item is decommissioning technology, and the second is the development of a solar battery with efficiency higher than 20%. Following them are the development of next-generation high-efficiency lighting, fast breeder fuel cycle technology, secondary automobile batteries, disposal of high level waste, heat pumps for houses, next-generation Light Water Reactors, new material for batteries, and combined cycle power generation.

Important R&D Items in Energy Field (Top 10)

R&D Item	%	Technological Realization	Social Realization
Safe and rational decommissioning technology of commercial LWRs	100	2020	2028
Wide-area thin solar battery with more than 20% efficiency	98.9	2019	2027
Next-generation high-efficiency lighting with more than 150lm/W (LED, organic EL, etc.)	98.6	2018	2023
Fast-breeder reactor cycle technology	97.7	2029	2038
Low-cost secondary battery for automobiles (>100 Wh/kg, >2,000 W/kg, <¥30,000/kwh,)	97.7	2019	2025
Land-disposal technology of high-level radioactive waste	96.9	2022	2034
Super-high-efficiency heat pump for houses (COP > 8 for AC, COP > 6 for boiler)	96.9	2017	2022
Next-generation light water reactor technology (more than 5% LEU fuel, plant life of 80 years)	96.8	2026	2034
New material technology with higher energy conversion efficiency than Si/Ga-As batteries	96.8	2021	2029
Large-scale combined-cycle power generation using high-efficiency gas turbine (>1,700℃)	96.6	2018	2025

Figure 2 Ten Most Important R&D items in the Energy Field

Figure 3 depicts a better quality of living around the year 2025, based on the 9th Delphi Survey results. High-energy electric vehicle battery technology will be realized around 2025. The spread of a residential energy system that integrates renewable energies such as solar cells and fuel cells is envisioned to realize around 2019.

Construction technology for energy-autonomous buildings that enable the use of natural energies, natural ventilation, natural lighting, rainwater, groundwater, and other natural resources is predicted to realize by 2020. Next-generation energy transmission and distribution network technology enabling a stable, low-cost, and low-carbon power supply is envisioned to realize by 2025, through the optimal management of the entire supply-and-demand balance of large power supplies by utilizing information and communications technology.

People will use a variety of energy resources, selected according to their own values and preferences; they will also participate in activities related to environmental protection and the prevention of global warming.

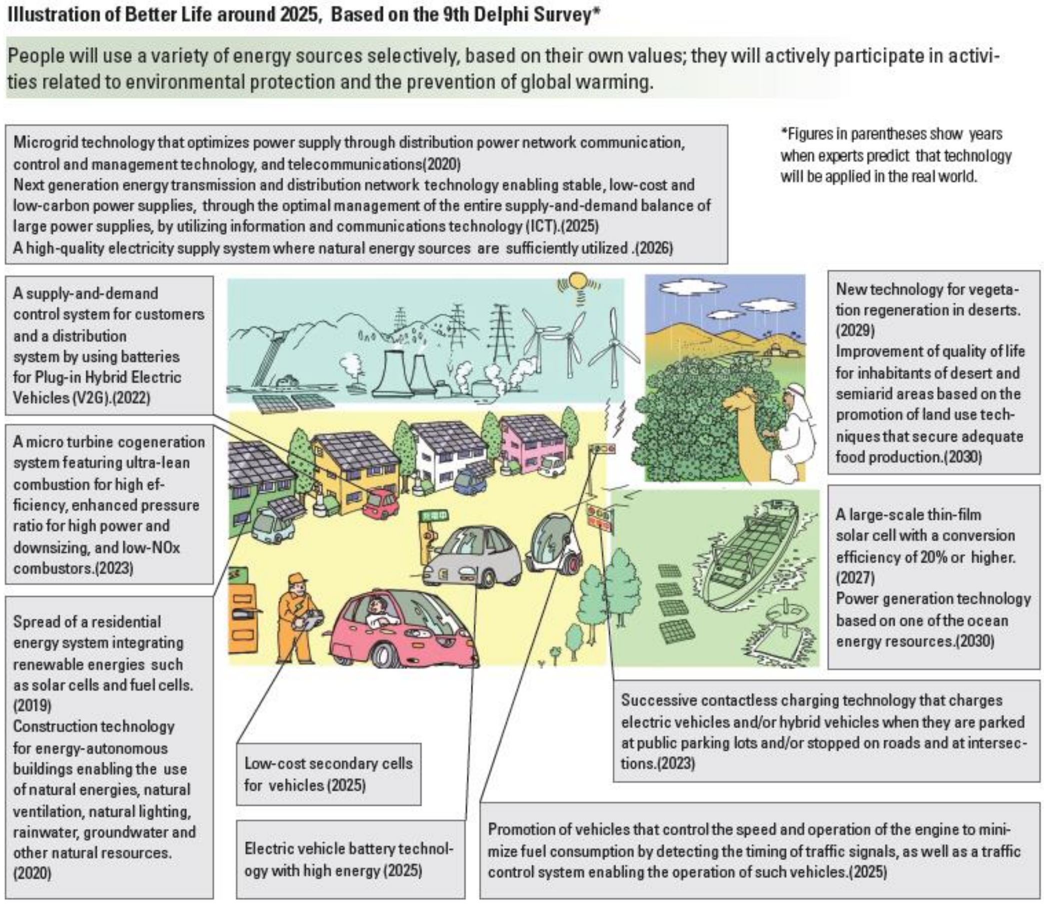

Figure 3　Depiction of a better life around 2025 based on the 9th Delphi Survey Results

3. Integration of three surveys

Three different approaches were followed for the scenario writing exercise, including scenario writing as a group (group scenario), envisioning a future scenario based on the results of the Delphi survey, and visions for a future society discussed by younger respondents.

Regional workshops were also held in eight locations in Japan, where participants proposed their visions of ideal life in their regions and their ideas about the kind of S&T required to realize that vision. Discussions emphasized green innovation and the creation of new industries and job opportunities through efforts to achieve a low-carbon society.

The integration process following completion of the three surveys involved three steps. The first step is to create a vision of the future society with an achievable goal, based on the Delphi Survey results and the forecasts made by S&T experts. The second step is to identify those S&T areas considered to have the potential to contribute significantly toward the realization of the future social vision. This process utilizes the results of the

Delphi Survey ("areas of key importance for the resolution of challenges") and the relation map that links the Delphi topics with the scenarios created by the expert groups. Based on results from the three studies, the third step is to attempt to extract and discuss the social requirements necessary for promoting these changes.

4. Future business in green innovation and life innovation

Through the promotion of green innovation and associated job opportunities, group scenarios predicted growth in industrial sectors that would construct this new infrastructure (i.e., electric vehicles and smart meters). These scenarios particularly emphasized global deployment of green businesses to secure Japan's market advantage, proposing out-of-the-box thinking to design the social infrastructure, along with the necessary underlying systems and industries. Many possibilities were suggested for the utilization of resources such as biomass (animal waste, forest), snow and cool energy, geo- and subsurface-thermal energy, and recyclable energy. Such possibilities leverage geographical conditions and regional industrial structures to contribute to a reduction in CO2 emissions by major local agricultural, forestry, and fisheries industries. Another suggestion pertained to the construction of environment-friendly and regionally compatible social infrastructure to bring about, for example, a compact city, a transportation system low in CO2 emissions, and an array of new services.

For life innovation, group scenarios envisioned the evolution of new businesses related to medical and nursing care that reduce healthcare costs through new, cost-effective techniques and accelerate the introduction of new medical techniques to eliminate drug/device lag and the vaccine gap. Items mentioned for health management and preventive medicine included the development of safe food products that would promote enhanced health and wellbeing, the construction of barrier-free households, and living environments equipped with a variety of sensors. A plan was also proposed whereby local regions would consider their natural environment as not only a tourism resource but also as a vital community resource enabling the local population to maintain healthy bodies and minds and to use this concept to create new industries and services.

Group scenarios emphasized the necessity of business deployment into Asian countries to develop colossal future markets. Specific proposals included the implementation of projects such as the analysis of gene polymorphism, a characteristic of the Asian population. The promotion of medical tourism is also included in this category.

5. Reliability of Delphi surveys

Reliability can be estimated by investigating the number of past Delphi survey topics identified that have subsequently been realized. The realization ratios (number of topics realized/total number of target topics) for surveys conducted from the 1970s to the early 1990s indicate that approximately 70% of the topics identified have been realized in some form, while full realization required a longer time. Approximately 30% of the topics are unlikely to be realized or are likely to evolve differently than initially conceptualized.

Fields relating directly to the daily life of citizens, e.g., medical care and environment have shown generally high ratios of realization, while fields relating to information and communications have shown reasonably high ratios of full realization, although the ratios of partial realization were not especially high.

In contrast, fields relating to social infrastructures, such as transportation and energy, have generally shown lower ratios of realization. As systematic planning is essential for successful realization of topics in these fields, the low realization ratios indicate that the larger the scale of the vision, more frequently should they be reviewed.

Topics in fields related to the life sciences, medicine, and healthcare tend to have longstanding and consistent objectives, which remain unchanged despite multiple rounds of surveys. Considering the ratios of earlier realizations, life sciences and medical care show the largest and second largest percentages of realization ratios, respectively. For example, 20 years ago, we could not have forecasted the creation of IPS cells and the realization of regenerative medicine.

In general, the Delphi survey is considered to be weak in predicting breakthrough achievements. Fields such as life sciences and medical care deserve continued attention. If the Delphi surveys are used, the tendencies shown here can serve as a useful guide for the future.

6. Delphi survey and future skill needs

Two reasons exist for the S&T Foresight survey not being directly used to guide future skill-building programs in Japan. First, S&T forecasts have historically attained only 70% accuracy. Second, especially in S&T, many innovations are continuously occur in each organization, and the skill-building requirements for each new technology must be continuously met. Therefore, it is not easy for the government to accurately predict and design the entire plan of skill-building programs necessary for Japanese workers.

In Japan, each organization devises its own R&D plan considering the results of the government's S&T forecast. Based on its R&D plan, each organization develops a future skill-building plan for its employees, including researchers and technical staff.

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