Nuclear Energy Strategy for Growth

(Tentative Translation)

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Japan Atomic Energy Commission

Introduction

The Japanese government announced a goal of reducing greenhouse gas emissions by 25 percent by 2020 from 1990 levels on the condition that a fair and effective international framework in which all major economies participate is established and that all other major countries set high targets. The government also issued the basic policy for a new growth strategy and is now discussing details. The policy includes key strategic issues, i.e., demonstration of the strengths of Japan through "Green Innovation" aiming to achieve the foregoing goal and "Life Innovation" aiming to become a country of good health, development of frontiers of growth, and improvement of the platforms that support growth.

Considering that the research, development, and utilization of nuclear energy can contribute to the solution of these strategic issues in various ways, the Japan Atomic Energy Commission (JAEC) has been steadily promoting research, development, and utilization of nuclear energy as per the Framework for Nuclear Energy Policy, and has decided to work on stipulating measures to be promoted with priority as the "Nuclear Energy Strategy for Growth" in order to contribute effectively to the above-mentioned goal of the government.

In starting this stipulation work, we solicited opinions from the public about matters considered important for the nuclear energy strategy for growth and measures to be promoted with priority to address such matters, and heard the opinions of 12 experts on these issues by holding an extraordinary meeting. Based on the opinions thus collected, we prepared and reviewed a "Draft of the Nuclear Energy Strategy for Growth" in reference to the opinions from 4 experts and the public, and finally completed the "Nuclear Energy Strategy for Growth" on this day.

As summarized in this Nuclear Energy Strategy for Growth, the research, development, and utilization of nuclear science and technology can play a significant role from the viewpoints of Green Innovation, Life Innovation, and Frontier Development, which are all provided in the basic policy for the new growth strategy, and are also expected to develop an "environment for encouraging challenges" and make a great contribution to the "formation of a platform for sustainable growth." However, it should be particularly noted that it is significant for each measure presented in this strategy to truly contribute to Japan's new growth to (i) "enhance the public confidence to nuclear energy" and (ii) "strengthen international competency in all aspects."

The JAEC expects that administrative organs, etc. concerned will plan and promote measures for the research, development, and utilization of nuclear energy with respect for the concepts presented here.

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Summary

1. **Nuclear power generation**: Increase the share of nuclear power in total power generation by realizing the world's highest capacity factor, promoting power up-rate, strengthening aging management, and promoting construction, expansion and replacement of nuclear power plants. To this end;
   1) Electric utilities should steadily promote the establishment of new maintenance programs, including the systematic promotion of aging management, and activities for construction and expansion of nuclear power plants;
   2) The central and local governments should steadily implement activities for ensuring the safety of nuclear power generation with clarification of their respective roles and responsibilities, and clearly explain the contents of such activities, as well as carefully explain the significance of nuclear power generation to the public, and;
   3) Activities for the nuclear fuel cycle including the interim storage of spent fuel, reprocessing, and disposal of radioactive waste should be promoted steadily.

2. **Utilization of radiation**: Promote the use of radiation in the medical field to realize a country of good health and in the agricultural, industrial, and academic fields so as to develop industries related to these fields into strategic industries. To this end;
   1) In order to expand the dissemination of advanced technologies for radiation use in the medical field, such as X-ray CT, PET, and cancer treatment with particle-beam radiation, development of supply systems for relevant radioactive pharmaceuticals, constant review of the content of related safety regulations so as to ensure application to new technologies, development of human resources necessary for the utilization of such technologies, and cost reduction of related facilities should be promoted;
   2) Improvement of the trial use system for promoting radiation use and development of mutual learning networks for users, improvement of the capability of existing radiation facilities, and research and development of innovative technologies should be promoted, and;
   3) Industries concerning technologies for radiation medicine and radiation use should be designated as strategic industries.

3. **Environment for encouraging challenges**: Develop an environment that encourages nuclear operators, company managers, local governments, and residents to have a spirit to challenge new projects that contribute to growth through the innovation of technologies, systems, and business. To this end;
   1) Literacy of the public with regard to nuclear power, energy, and science and technology should be improved;

2) A new system for data disclosure should be established so that data on policy formulation can be accessible to any person using the latest information technologies;
3) "Visualization" of the economic value of CO_2 should be promoted so that the public may further recognize the positive effect that nuclear power generation projects have on promoting global warming countermeasures, and participate in activities that contribute to such promotion;
4) The nuclear safety regulatory administration system that enables effective, practical, and timely regulatory activities with a focus on securing independence, openness, efficiency, rationality, and reliability from a public viewpoint so that the world-leading initiative in the research, development, and utilization of nuclear energy may be timely implemented with ensuring of required safety;
5) The subsidy system under the Three Laws on Power-source Siting, etc. should be constantly reviewed in view of changes in the social environment, and the central and local governments and electric utilities should promote activities of local residents at nuclear facility sites to take the initiative in increasing and upgrading employment with effective use of their own human resources, funds, and assets (industrial technologies, parts / service demand, culture, nature, etc.), as well as the activities of academic organizations, etc. located near their areas, and;
6) Government-Private sector networks in Asia should be strengthened in order to increase opportunities for starting new joint ventures in the nuclear field centering on Asia.

4. International development: Japan's nuclear industry should play a greater role in responding to the increasing demands for construction and expansion of nuclear power plants in the international community and for radiation use in developing countries including radiotherapy. To this end;

1) Networks with the IAEA and international community should be substantially strengthened in regards to nuclear safety, nuclear security, and nuclear non-proliferation in order to contribute to their development and maintenance at a high level in the international community;
2) Bilateral agreements that ensure the peaceful use of nuclear energy should be promptly and strategically concluded and executed with countries with a potential market for nuclear energy;
3) It is necessary to strengthen capacities for coordinating activities in Japan that identify and satisfy needs for systems in each country whose development is expected in accordance with the construction of nuclear power plants;
4) It is necessary to develop a system for active utilization of policy financing for nuclear investment projects, a scheme for evaluating the effect of such a system on global warming countermeasures, a system of liability and compensation for nuclear damage for reducing

investment risk, etc., and;

5) The dissemination of technologies of radiation medicine and radiation use technologies in the agricultural and industrial fields using ODA, etc. should be planned, and business development based on such plans should be proposed as part of infrastructure improvement activities incidental to the construction of a nuclear power plant.

5. Platform for sustainable growth: Continually supply effective nuclear science and technology for sustainable growth, as well as human resources who shoulder the research, development, and utilization of such science and technology. To this end,

1) The world's most advanced research and development of nuclear energy including fast breeder reactor cycle technology should be facilitated centering on nuclear research and development organizations, and the relevant infrastructure and international networking activities should be improved, and;

2) The nuclear education system should be internationalized to develop human resources who are capable of working on nuclear energy anywhere in the world.

Nuclear Energy Strategy for Growth

- "Enhancing public confidence to nuclear energy", *"Strengthen international competency in all aspects"* -

Green Innovation

Promote nuclear power generation.

- Realize the world's highest capacity factor and power up-rate, and promote construction, expansion and replacement.
- Improve and strengthen quality assurance activities for aging management and ensuring seismic safety.
- Clarify roles and responsibilities of the central and local governments.
- Steadily promote activities for nuclear fuel cycle including expansion of spent fuel storage capacity.

Life Innovation

Development of radiation medicine

- Develop human resources and reduce facility costs in ways that contribute to the dissemination of advanced radiation use technologies in the medical field.

International Development

International development of nuclear power generation

- *Ensure, maintain, and strengthen nuclear safety, security, and non-proliferation (3S) at a high level.*
- *Execute bilateral agreements that ensure peaceful uses of nuclear*
- *Coordinate exchange activities to identify various needs with order receipt based on needs.*
- *Utilize policy finance, develop a nuclear damage compensatory system. etc.*

Regional Vitalization

Revitalize agriculture, industry, etc. using radiation technologies.

- Develop a system for promoting use in agricultural, industrial, academic, and other fields by improving advanced radiation generators such as SPring-8 and J-PARC.
- Enhance the capability of existing facilities and R&D for innovative radiation sources.

- *Disseminate technologies of radiation medicine and radiation use in the agricultural and industrial fields using ODA, etc. and propose and promote the start-up of a package of businesses.*
- *Designate industries concerning technologies for radiation medicine and radiation use as strategic industries.*

Develop an environment for encouraging challenges

Improve the literacy of the public with regard to energy, science, and technology

Information disclosure innovation.

Develop a nuclear safety regulatory administration system from a public viewpoint.

Strengthen exchange networks between Asian governments and the private sector in the nuclear field.

Increase and upgrade employment

Support the activities of local residents in nuclear facility sites to increase and upgrade employment with effective use of their assets, and the activities of academic organizations, etc. near their areas.

"Visualize" the economic value of CO_2.

Platform for sustainable growth

Human resources

Develop international nuclear personnel through the internationalization of education systems.

Science / technology

The world's most advanced R&D of nuclear energy and international network activities

(Fast reactor cycle, high temperature gas-cooled reactor, nuclear fusion development, etc.)

1. Possible roles of the research, development, and utilization of nuclear science and technology

1.1 Roles for Green Innovation

(1) Stable energy supply as support for economic growth

Ensuring a stable supply of inexpensive energy is one of the significant issues to address in order to achieve economic growth.

Since uranium resources, fuel for nuclear power generation, are present in each continent, distribution is not uneven. And, because the energy density of uranium is very high, nuclear power stations can continue power generation for a long term once fuel has been loaded. In addition, although nuclear facilities hold a large amount of radioactive materials, they have ensured a high degree of safety by adopting safety design and safety management based on the concept of "defense in-depth". Meanwhile, the economic efficiency of nuclear power generation decreases when its financial costs are high since the percentage of capital cost to generating cost is high. However, in an environment where stable construction and operation are ensured, nuclear generation is one of the most cost-saving power sources, even when taking into account the disposal cost of radioactive waste generated from the decommissioning and operation of nuclear facilities. Also, the total generating cost is less affected by the violent fluctuation of uranium prices since the ratio of fuel cost to total generating cost is low. For these reasons, nuclear power generation is expected to be a leading means for ensuring an inexpensive stable supply of energy.

Furthermore, from a long-term perspective, nuclear energy is expected to serve as an energy source on which human beings, in the quest for sustainable development, can depend over a long period of time by pursuing innovation of the technologies and systems concerning nuclear energy and energy supply, such as the commercialization of the fast breeder reactor (FBR) cycle, etc., which can remarkably improve the utilization efficiency of nuclear fuel resources and reduce high-level radioactive waste that is geologically disposed of, and by searching for a future vision of the concept of international nuclear fuel cycle service, which is considered effective from a viewpoint of strengthening activities for nuclear non-proliferation.

(2) Reduction of greenhouse gas emissions

Targets for reducing greenhouse gas emissions can be achieved only by pursuing a combination of reduction means in the fields of energy supply and utilization. To determine such combination, it is important to evaluate marginal reduction cost, which is the cost for additionally reducing one unit of greenhouse gas emissions per means.

Compared with other means for reducing greenhouse gas emissions, this marginal reduction cost is smaller in the case of an improvement in capacity factor or construction or expansion of nuclear power generation facilities, whose CO_2 emissions are substantially less than those of thermal power

generation and whose commercial operation is already conducted on a large scale. In particular, little additional investment is required to improve capacity factor, so the relevant reduction cost is judged to be negative.

Japan is striving to improve the average capacity factor of 54 nuclear power plants in operation today, which has remained at a low 60% level in recent years, in view of the fact that power plants in the U.S., South Korea, Northern Europe, etc. have achieved 90% or more while keeping high safety indicators. If the capacity factor of nuclear power plants can be improved from 65% (actual result of fiscal 2009 was 65.7%) to 85%, CO_2 emissions will be reduced by about 50 million tons (4.0% of the 1990 year level) annually.

In addition, the construction of 9 new nuclear power plants is planned by 2020 in Japan. Operation of these 9 nuclear power plants is expected to reduce CO_2 emissions by about 60 million tons (4.6% of the 1990 year level) annually.

Accordingly, these initiatives together with the promotion of energy conservation and renewable energy use are expected to contribute greatly towards achieving Japan's goal of reducing greenhouse gas emissions by 25% by 2020 from 1990 levels, and play an important role in Green Innovation.

(3) Job security and improvement of the balance of international payments

The construction, operation, and decommissioning of nuclear power plants and related nuclear fuel cycle activities are expected to contribute to economic development and the creation of jobs, as well as improve the balance of international payments through reduced import of fossil fuels, since most of such activities are domestic plant-and-equipment investments and resources and equipment to be procured for such activities are all domestic products except for uranium, related enrichment services, etc.

1.2 Roles for Life Innovation

Radiation technology is now indispensable for diagnosis and treatment in the medical field. In the diagnosis field, for example, X-ray CT are used to diagnose about 2 million cases per month, and nuclear medicine diagnosis（PET, SPECT, etc.）is conducted in about 1.4 million cases per year. Moreover, since early diagnosis, early treatment, preventive care, and health examination are important for improving the nation's health and extending life spans, the advancement of diagnostic technologies in nuclear medicine is being promoted, such as visualization of functional information on the cellular and molecular levels using radiopharmaceuticals, i.e., imaging of human body functions at higher spatial resolution via molecular imaging technology. Such advancement is expected to promote the detection of cancer at a very early stage, advanced investigation of dysfunction in the human body, verification of the effect of new drug candidate compounds, etc.

In cancer therapy, surgery, treatment with anticancer agents, and radiation therapy have been established as the three major remedies. In particular, radiation therapy is fueling high expectations

worldwide as a remedy that does not lower quality of life (QOL) because of the recent progress in relevant equipment. Accordingly, the number of patients who choose radiotherapy for cancer treatment is increasing in the U.S. and Europe, amounting to about 60% of all cancer patients. In Japan, however, only 25% of all cancer patients receive radiotherapy.

Radiotherapy kills cancer cells by irradiating them with X rays, gamma rays, electron rays, etc. Moreover, therapies using proton and carbon nuclei have been recently established. Also, studies of methods using neutrons are underway. These "particle radiotherapies" are expected to present less adverse effects as radiotherapy, but are not necessarily prevalent mainly because relevant equipment and operating facilities are still costly.

Therefore, activities that promote the development and dissemination of such advanced technologies for radiation diagnosis and treatment are expected to make a significant contribution to Life Innovation in any country that aims to have good health.

1.3 Roles for frontier development

At present, construction of nuclear power plants is planned in many countries in order to secure energy sources for the near future and realize a low carbon society. According to the International Atomic Energy Agency (IAEA), plant expansion is planned in 24 countries out of the 30 countries that already have a nuclear power station, and more than 40 member countries are considering or planning the introduction of nuclear power generation, more than 20 of which are working on the formulation of a specific plan. Based on these facts, the IAEA forecasts that the total capacity of the world's nuclear power plants in 2030 will expand from the 372GWe at present to 748GWe due mainly to the construction and expansion of facilities in the countries that have already a nuclear power plant. Meanwhile, the Nuclear Energy Agency of the Organization for Economic Cooperation and Development (OECD/NEA) forecast that the total capacity of the world's nuclear power plants in 2050 will increase to 1,350GWe, of which the increase from 2030 to 2050 will occur substantially in newly developing countries.

Since it is essential for smooth progress in such construction and expansion to firmly ensure nuclear safety, nuclear security, and nuclear non-proliferation, advanced countries are cooperating with the IAEA in the development of infrastructure for nuclear generation in developing countries, including human resource development, so that the foregoing nuclear safety, etc. may be ensured and nuclear generation may grow steadily.

The nuclear power industry of Japan has consistently constructed domestic nuclear power plants and exported nuclear equipment. In recent years, activities that utilize policy financing to obtain orders for nuclear plants are prevalent in the U.S. With these activities, while advancing the knowledge and technologies to design, construct, and operate nuclear power plants, Japan's nuclear industry improves and maintains the production capacity of relevant equipment and develops and secures human resources who support such equipment, and their technical capabilities are highly

evaluated in the international arena.

With development of an appropriate business environment, Japan's nuclear industry will have the opportunity to increase orders for construction, operation, etc. of nuclear power plants in the market of developing countries, which is comparable to a "frontier" market, in addition to continuous expansion of orders in advanced countries, which is expected to make some contribution to Japan's economic growth.

Radiation is also used for diagnosis and treatment in the medical field, improvement of crop species and control of harmful insects in the agricultural field, and manufacturing of semiconductors, radial tires and various kinds of precision measurement and nondestructive testing in the industrial field. In food industries, radiation is also used in Japan for potato sprout inhibition, and used overseas as a sanitation management technology for many foods. The market size related to such radiation use amounts to as much as 4.1 trillion yen in Japan (FY2005 performance -- Source: Survey concerning Economic Magnitude of FY2007 Radiation Use [Cabinet Office]). Demand for such radiation-based technologies in the medical, agricultural, and industrial fields is expected to grow rapidly in developing countries in Asia and Africa as economies and per-capita GNP grow. For these reasons, activities to supply such technologies to these areas may constitute a strategic industry of Japan’s in the future.

Meanwhile, Japan needs to shift to a multi-axis structure that encompasses a range of independent areas in order to address various issues, including the decline in population, emergence of a knowledge-based society, expansion of economic and life zones, and diversification and escalation of resident needs. Accordingly, each area is developing activities to promote job creation based on the area, effectively using its own local knowledge, characteristics, and assets (including technologies of local industries, culture, nature, and service demand by local enterprises). As part of such activities, each area is pursuing the preservation and restoration of the natural environment, creation of new cultures and lifestyles, flat knowledge, human resources, formulation of mutual benefit networks, and establishment of international exchange functions, which are all appropriate for the global age.

Electric utilities continue to be a member of the community over a long period in the course of construction, operation, and decommissioning of a nuclear power plant, and the storage of spent fuel, and can, therefore, provide business opportunities that create stable employment in the site area through demand for various services and equipment and human and organizational networks. Moreover, local universities and nuclear R&D organizations can provide useful intellectual property for local people to initiate activities to produce such added-values.

Hence, in addition to the subsidies provided to equalize profits, promoting the siting of nuclear facilities will provide various business opportunities to people motivated to realize the area's vision, attract people and organizations with supporting capabilities, and contribute to the creation of active areas that support the future of the Japanese economy.

1.4 Roles in growth platform creation

Ongoing projects in the nuclear energy field include research and development concerning (i) the next-generation light water reactor aiming at further advancement of safe and efficient nuclear power generation technologies, (ii) the fourth generation reactor centering on fast breeder reactor and related innovative fuel cycle technologies, (iii) development of new nuclear markets, such as technologies for using non-carbon high temperature heat obtained from high temperature gas-cooled reactors, and small to mid-size reactors, and (iv) nuclear fusion expected to contribute to technologies for new energy supply in the future. These activities also aim at the commercialization of effective energy technologies for sustainable development of not only Japan but also mankind in general. And, these activities will, in line with efforts to solve development issues and spirals, require the development of knowledge frontiers involving many fields, including seismic technology, material engineering, computer control, human interface engineering, nuclear fuel cycle engineering, and risk management, which gives rise to opportunities for technical innovation related to various fields. Moreover, in recent years, modeling and computer simulation technologies have been widely used in these activities from a viewpoint of accelerating knowledge creation activities necessary for overcoming "death valley," which lies on the way to technical innovation. These technologies are also expected to contribute to the innovation of various fields.

Accordingly, these activities are expected not only to advance technologies for nuclear energy but also to function as an innovation platform for extensive related sciences and technologies.

Meanwhile, in the environment using quantum beams provided by large synchrotron radiation facilities (SPring-8), the Japan Proton Accelerator Research Complex (J-PARC) is also expected to lead to the creation of new industrial technologies. Quantum beams, including X-rays and neutrons, are useful means for R&D in various fields ranging from fundamental research in the material and life sciences to industrial applications. Particularly, in the development of environmental technologies for the reduction of carbon dioxide emissions, such as next generation solar photovoltaic systems, superconducting materials, and high performance batteries, it is essential to analyze atomic level structures, structural changes in substances in ultra-short time, etc. Also, quantum beam technology is expected to contribute greatly to these R&D activities. Since research into innovative quantum beam generators and miniaturization thereof may give rise to new sciences and technologies, innovation of technical business, and the deepening and expansion of markets for radiation use technologies, R&D into such quantum beam technology is also expected to function as a growth platform.

2. What should be done by 2020 to effectively and efficiently fulfill the roles in the research, development, and utilization of nuclear energy

As stated in Section 1, the research, development, and utilization of nuclear energy can play a great role for Japan to pursue sustainable growth up to 2020 by utilizing strengths in Green Innovation and Life Innovation, developing frontier markets, and strengthening platforms that support growth, therefore Japan should steadily promote activities for achieving the following four objectives.

<<Objective 1>>

Nuclear power generation: Increase the share of nuclear power in total power generation by realizing the world's highest capacity factor, promoting power up-rate, strengthening aging management, and promoting construction, expansion and replacement of nuclear power plants.

In order to achieve this objective, the following activities should be promoted.

○ Electric utilities should steadily promote the establishment of new maintenance programs, including the systematic promotion of aging management, and activities for construction and expansion of nuclear power plants.

Last year, the Japanese government approved a process whereby electric utilities prepare a new maintenance program for facilities and equipments at nuclear power plants, while maintaining risk at a sufficiently small level, through which they will manage priorities in disaster prevention, failure rate, and deterioration mode for each facility and equipment according to those relevant risks. This new method of maintenance will require the implementation of advanced knowledge management activities under certain quality assurance activities, including risk management, monitoring, and continual improvement activities over the life of the facilities including measures against aging. Accordingly, introduction of such a method will require a large amount of resources and increase management costs. However, it is known from experience in foreign countries where this new method has already been applied that this method can achieve a higher capacity factor through careful management of safety as compared with the maintenance method based on operating hours. Accordingly, electric utilities should be determined to achieve simultaneous improvement in safety and capacity factor, e.g., by implementing certain activities to share best practices, in order to establish this method.

In the "Basic Plan for Reviewing the Resources and Energy Policy (Draft)," which is under review in the Advisory Committee for Natural Resources and Energy, the target of "construction and expansion of 9 units by 2020 (about 85% capacity factor) and at least 14 units by 2030 (90%

capacity factor)" is planned in order to promote the future use of nuclear energy based on the supply plan. Central and local governments and electric utilities should cooperate with each other in making efforts to steadily achieve the objective by 2020. And, it is important to improve the environment so as to enable steady progress in construction and expansion after 2020, i.e., reduce lead time and control construction costs. It is also important to take into view wider-area operation beyond its regulated territory, as well as joint development, etc. in the examination of conditions to achieve such goals.

○ The central and local governments should steadily implement activities for ensuring the safety of nuclear power generation via a clarification of their respective roles and responsibilities, and clearly explain the contents of such activities as well as carefully explain the significance of nuclear power generation to the public.

The government should carefully explain to the public and residents near the sites of nuclear generation facilities that the construction and expansion of nuclear power plants, maximum utilization of existing reactors, etc. are important towards countering global warming and ensuring energy security, and are beneficial to the national economy.

Moreover, from a viewpoint of "disaster prevention" required by the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (Nuclear Reactor Regulation Act), the government requires electric utilities to deploy risk management activities based on the latest scientific findings and experiences so that essential facilities and equipment are reliable, in accordance with their importance, even in the face of natural phenomena such as earthquakes and typhoons, and aged deterioration. And, it should be confirmed through inspections, etc. whether such activities are appropriately conducted. However, as a precondition for promoting nuclear power generation, the public should understand that the government is implementing such activities appropriately. For this reason, the government should carefully explain the content of such activities to the public from their viewpoint.

What is important at this point are back-check activities of the seismic safety of existing nuclear facilities under the New Regulatory Guide for Seismic Design of Nuclear Power Plants based on the findings obtained from the Niigata Chuetsu-Oki Earthquake, and aging management for plants that have been in operation over 30 years. The government should require electric utilities to implement improvement measures promptly, including the aforementioned activities, which are the result of steadily promoting risk management activities, and carefully explain results of checking such implementation to the public.

On the other hand, local governments should request the central government to fulfill the duty of explaining if its explanation about such activities is considered insufficient. Furthermore, if a local government is suspect of a decision that an operator may continue plant operation, even when a defect was found, on the grounds that the operation is within the operation limit stipulated by the

security regulations, it should not require the operator to clear such suspicion but require the central government, which is responsible for safety regulations, to explain that its decision is appropriate from the viewpoint of keeping public risk at a reasonably low level.

○ Activities for nuclear fuel cycling, including the interim storage of spent fuel, reprocessing, and disposal of radioactive waste, should be steadily promoted.

In order to promote the construction and operation of nuclear power plants, it is important to steadily promote activities for relevant nuclear fuel cycling.

To be specific, it is important to steadily advance activities for plu-thermal (plutonium use in thermal reactor) power, which uses plutonium and uranium recovered by reprocessing in exisiting light water reactors. For what regards the Rokkasho Reprocessing Plant, which is behind schedule in establishing operating conditions for high-level waste vitrification in the final stage of active tests, the relevant institutions involved should comprehensively step up activities for nuclear fuel cycling by ensuring safety as a prerequisite and managing the reprocessing project with certainty under a basic policy of step-by-step progress in reference to the information obtained from actual operation of the facility.

Furthermore, in addition to the present principle that spent fuel will be reprocessed within the available reprocessing capacity for the time being and that the surplus volume exceeding the capacity will be intermediately stored, it is important to steadily develop on-site and off-site capability to store spent fuel until it is reprocessed, assuming the case where the reprocessing facility fails to operate smoothly as mentioned above. The government should consider development of the technical and social environment to that end.

Furthermore, it is important for the government to increase dialogue with the public concerning the safety and significance of activities for the disposal of low- and high-level radioactive waste generated from nuclear power generation and strive to ensure steady promotion of such activities.

<<Objective 2>>

Utilization of radiation: Promote the use of radiation in the medical field to realize a country of good health and in the agricultural, industrial, and academic fields so as to develop industries related to these fields into strategic industries.

In order to achieve this objective, the following activities should be promoted.

○ In order to expand the dissemination of advanced technologies for radiation use in the medical field, such as X-ray CT, PET, and cancer treatment with particle-beam radiation, development of supply systems for relevant radioactive pharmaceuticals, constant review of the content of related

safety regulations so as to ensure application to new technologies, development of human resources necessary for the utilization of such technologies, and cost reduction of related facilities should be promoted.

In order to promote the dissemination of radiation diagnosis and radiation therapy in the medical field, it is vital to ensure the development of human resources capable of using such technologies, development of supply systems for related radiation pharmaceuticals, maintenance of pertinent technical criteria, timely review of applicable safety regulations, etc. Then, concerned organizations including related academic societies should strengthen activities to this end. Also, for the dissemination of cancer treatment technologies using heavy-ion particle and neutron beams, equipment for such technologies needs to be easily available, so the government and research institutions should support the industry's effort to reduce prices by strengthening activities for relevant technical development and commercialization.

○ Improvement of the trial use system for promoting radiation use and development of mutual learning networks for users, improvement of the capability of existing radiation facilities, and research and development of innovative technologies should be promoted.

In order to further promote radiation use in the academic, agricultural, industrial, and other fields, the government and related organizations should make existing radiation facilities easier to use by not only the scientific world but also persons in agriculture and industry, and strengthen the user support system, such as by improving the trial use system and developing a network with the cooperation of concerned persons that enables improvement in mutual learning and knowledge management concerning radiation use.

Furthermore, in order to continually produce scientific findings that bring radiation-driven innovation to the industrial world, it is necessary to improve the capability of existing large radiation facilities and ensure the promotion of R&D into small radiation sources and innovative radiation sources.

○ Industries concerning technologies for radiation medicine and radiation use should be designated as strategic industries.

Since demand for advanced medical care and industrial application of radiation use technologies will increase rapidly in accordance with economic growth in developing countries, expansion is expected in markets of related equipment, chemicals, etc. In response, the government should support Japanese industries in their efforts to develop and strengthen their capability to supply such equipment, etc. in view of such future trend in the international market.

<< Objective 3 >>

Environment for encouraging challenges: Develop an environment that encourages nuclear operators, company managers, local governments, and residents to have a spirit to challenge new projects that contribute to growth through the innovation of technologies, systems, and business.

In order to achieve this objective, the following activities should be promoted in particular.

○ Literacy of the public with regard to nuclear power, energy, and science and technology should be improved;

In order for people to make a choice on programs utilizing nuclear science and technology, it is necessary for the public to understand the basics of activities concerning nuclear energy, science and technology and to be nuclear-literate, which is the competency to evaluate policy options concerning such activities from a public viewpoint. Accordingly, the government should ensure the provision of school education concerning nuclear energy and radiation use, and further improve and promote programs that provide the public with opportunities and space for learning about nuclear power and activities to develop persons engaged in activities for mutual understanding of nuclear power, in cooperation with the private sector.

○ A new system for data disclosure should be established so that data on policy formulation can be accessible to any person using the latest information technologies.

Data concerning policy decisions has been in principle opened to the public, but there is no system that allows for sharing such data so that anyone may use it at any time. Also, the government implements R&D activities focusing on the themes expected to produce knowledge and performances that cannot be exclusively owned by the private sector due to its long-term and generic characteristics. Accordingly, such activities should be provided with a scheme that allows for sharing the performance of such activities widely among the public. Meanwhile, for the themes for which redundant investment is expected in the private sector due to competition, the government should lead the private sector in performing efficient and effective knowledge creation activities in terms of national economy, e.g., by organizing research communities, etc.

Incidentally, in addition to enabling the aforementioned activities to be performed by the government, it is effective for the technical progress and innovation of systems and policies to promote cross-functional knowledge and interactions, and mutual learning among people using such knowledge. Moreover, it is important towards promoting policy decisions the public can trust that as much information as possible is utilized in the policy-making process and shared with the public.

If the government widely provides the public with inputs and results of technical evaluations made in relation to policy selection online, using the latest information technology, as well as data on research activities, the public will have more opportunities to participate in policy discussions by processing such data.

For these reasons, the government should, in order to take the initiative in pursuing technical progress and policy innovation in diversifying science and technology fields, launch a new initiative that may be called "data disclosure innovation," which discloses information generated by the government and inputs and results of social impact evaluations of various technologies (i.e. technology assessment) using the latest information technology and online systems as much as possible.

○ "Visualization" of the economic value of CO_2 should be promoted so that the public may further recognize the positive effect that nuclear power generation projects have on promoting global warming countermeasures, and participate in activities that contribute to such promotion.

"Carbon footprint" projects aiming at "visualization" of carbon-dioxide emissions over the life cycle of products and services, and projects attempting to apply economic principles directly to CO_2 reductions by adding economic value to CO_2 (e.g., carbon tax, emissions trading system [cap-and-trade system], etc.) are implemented on a trial basis in some countries. Introduction of these projects as an established system has already been done in Europe and is under examination in the U.S. In Japan, some local governments have decided to introduce these projects, and a project for urban areas to purchase electricity generated from renewable energy sources in remote areas has also been produced.

The Kyoto Protocol has adopted the International Emissions Trading, Clean Development Mechanism (CDM), and Joint Implementation (JI) as flexibility measures for achieving reduction targets of greenhouse gas emissions with international cooperation, but excluded nuclear power generation from the scope of CDM and JI. The government should, therefore, approach the international community on including CO_2 reductions from the construction and operation of nuclear power plants in such international credit systems or establishing a similar independent system for the framework in and after 2013, in cooperation with countries that agree to such ideas.

Thus, the government should provide local governments and the public with opportunities where they can recognize the effects from or directly participate in the promotion of global warming countermeasures using nuclear power generation by systematizing mechanisms and ideas that include nuclear power generation.

○ The nuclear safety regulatory administration system that enables effective, practical, and timely regulatory activities with focus on securing independence, openness, efficiency, rationality, and reliability from a public viewpoint so that the world-leading initiative in the research, development,

and utilization of nuclear energy may be timely implemented with ensuring of required safety.

In order for Japan to lead the world in nuclear research, development, and utilization, or undertake activities to propose global standards, it is necessary to be able to implement projects never before undertaken anywhere in the world. In the past, however, it often occurred that the implementing entity mainly had to explain that a new project in the nuclear field could be executed with sufficient safety assurances and that new proposals were deferred or implemented abroad since the safety regulatory administration authorities were too careful. In order to prevent recurrence of such a case, the relevant institutions concerned have to improve and correct their projects.

Moreover, from a viewpoint of utilizing regulatory administration resources effectively and efficiently and enhancing the ability to foresee regulatory decisions, nuclear developed countries around the world are making efforts to promote projects for the standardization and acceleration of permitting and licensing procedures such as a "design certification" system and efforts to reduce the inconsistencies amongst safety standards that differ according to country. One such project is the international safety assessment for new nuclear reactor design (MDEP: Multinational Design Evaluation Program). Japan tends to hesitate participating in such international joint projects, but it should constructively join projects concerning such international standards in view of public interest arising from the addition of reactor types produced by Japanese industry to international standards.

The objective of nuclear safety regulatory administration is to publicly and consistently pursue efficiency and minimize public risk sufficiently with the high awareness, morality and expertise of an administration that works and exists for the sake of the public. Hence, in order to achieve this objective, the safety regulatory administration should aim at making consistent, logical, and practical decisions using all scientific findings available at home and abroad. Furthermore, it is also important to listen carefully to the concerns of stakeholders, make timely decisions the public can trust with regard to achieving regulatory targets, and carefully convey such decisions to the public.

In reviewing the current way of safety regulatory administration undertaken by the government, attention should be paid to the above-mentioned issues, as well as these basic requirements of safety regulations. Furthermore, in order for the nuclear safety regulatory administration to assess whether the public risk caused by nuclear facilities can be maintained at a sufficiently low level and make timely decisions with scientific rationality, it should be sufficiently capable of understanding advanced technical content and explaining relevant results to the public. Accordingly, it should be kept in mind that it is also important to improve the education and training functions that nurture human resources capable of performing the aforementioned projects, develop a system to ensure competent personnel, reform the current status where organizations supporting nuclear safety regulatory activities in scientific and technical ways are not integrated, and then improve such organizations as scientific and technical information organizations via integration.

○ The subsidy system under the Three Laws on Power-source Siting, etc. should be constantly

reviewed in view of changes in the social environment, and the central and local governments and electric utilities should promote activities of local residents at nuclear facility sites to take the initiative in increasing and upgrading employment with effective use of their own human resources, funds, and assets (industrial technologies, parts / service demand, culture, nature, etc.), as well as the activities of academic organizations, etc. located near their areas.

For areas where nuclear power generation facilities that contribute to public interest are located, Japan has so far taken measures including the subsidy system under the Three Laws on Power-source Siting that aim to contribute to the construction of nuclear power generation facilities and the facilitation of operation using the electric power development promotion tax as a resource, from a viewpoint of ensuring an equal interest between electricity consumption and generation areas. The government should constantly review this subsidy system according to social changes in light of its purpose so that the system may become easier to use for sustainable growth of the relevant local communities.

In order for local communities to develop as an active society, it is desirable that motivated people actively engage in activities that create employment centered on their communities through the effective use of local knowledge, characteristics, and assets (including the technologies of local industries, culture, nature, and service demand by local enterprises). Then, the operators of nuclear facilities, universities, R&D organizations, etc. should provide support to such activities by the people around the site of nuclear facilities through the wide use of their facilities, business characteristics, and know-how. They are also expected to make an active contribution as a community member through the preservation and restoration of the local natural environment, creation of new cultures and lifestyles, formation of a flat network of knowledge, human resources, and mutual benefits suitable for the global age, creation of international exchange functions, joint planning and promotion of projects pursuing the synergetic effect of related facilities and local assets, etc. The central and local governments and electric utilities should promote such activities.

Note that many local governments are devising various ways of local development including funding for inducing businesses using a limited budget. In general, multiple local governments form one economic bloc, so it is difficult for a specific local government to achieve development independently. For this reason, in the aforementioned promotion activities, when considering how to use subsidies under the Three Laws on Power-source Siting or projects aiming at self-sustained development of areas where nuclear power generation facilities are located, the usefulness of pursuing wide-area development through cooperation with the people from the surrounding local governments should also be considered.

○ Government-Private sector networks in Asia should be strengthened in order to increase opportunities for starting new joint ventures in the nuclear field centering on Asia.

Radiation use in the medical care, agricultural, and industrial fields in Asia is very important since it is useful for social and economic development and welfare. The Forum for Nuclear Cooperation in Asia (FNCA) has made a great contribution to Asian countries over the past ten years in the fields of radiation use, etc. For the future, this activity should be improved so that individual countries can use results of R&D and cooperate in human resource development more effectively using Official Development Assistance (ODA) projects where equipment provision is possible. Moreover, since growth is expected in related industries of Japan as these activities spread, the government should contrive ways to promote the combination of such concerns between industries and each country, such as holding seminars or trade fairs periodically.

Meanwhile, it will be required in this area in the future to strengthen activities for multilateral cooperation in infrastructure development for nuclear power generation. It is desirable for the FNCA to promote activities in this area in active cooperation with the IAEA, which has been developing sufficient activities, with focus on mutually complementing each other. In addition, sharing various kinds of technical standards and codes of conduct will be significant in this area for such promotion. Future visions for cooperative activities with nuclear power industries in Asia should be considered with recognition of the necessity for joint operations in the industrial world.

<< Objective 4>>

International development: Japan's nuclear industry should play a greater role in responding to the increasing demands for construction and expansion of nuclear power plants in the international community and for radiation use in developing countries including radiotherapy.

In order to achieve this objective, the following activities should be promoted.

○ Networks with the IAEA and international community should be substantially strengthened concerning nuclear safety, nuclear security, and nuclear non-proliferation in order to contribute to their development and maintenance at a high level in the international community.

Ensuring nuclear safety, nuclear security and non-proliferation is indispensable for the utilization of nuclear technologies. Then, it is important for Japan to actively take part in the establishment of international standards for these, consistently play a leading role, reflect such efforts in domestic projects, and ensure that Japan's nuclear technologies and activities continue to be trusted as a good example. This is because these requirements that Japan places on nuclear power generation are evaluated to be international in terms of both soft and hard aspects.

At the same time, it is important towards maintaining public trust in nuclear technologies that nuclear safety, security, and nonproliferation are maintained at a high level in the international community. It is, therefore, important in this regard for the government to markedly strengthen

activities that plan and promote joint operations with the IAEA and the international community.

○ Bilateral agreements that ensure the peaceful use of nuclear energy should be promptly and strategically concluded and executed with countries with a potential market for nuclear energy.

From the viewpoint of advancing bilateral exchanges necessary for nuclear research in Japan, development, and utilization, Japan has conventionally been executed bilateral agreements concerning nuclear cooperation in accordance with predetermined priorities. However, in the world from today forward, countries that seek to promote nuclear cooperation with Japan are expected to increase. Furthermore, promotion of exchange and trade with such countries may lead to their development, as well as the interest of Japan. Accordingly, bilateral agreements concerning that ensure the peaceful use of nuclear energy should be promptly and strategically concluded and executed with such countries in the future.

○ It is necessary to strengthen capacities for coordinating activities in Japan that identify and satisfy needs for systems in each country whose development is expected in accordance with the construction of nuclear power plants.

Projects for construction and operation of nuclear power plants vary according to country. In resource development projects in Africa, developers are required to develop various kinds of infrastructure on the site. In Southeast Asian countries, it is pointed out that there are needs for measures, know-how, etc. for obtaining an understanding from residents of nominated areas. Since social infrastructure has already been developed to some extent in countries that plan to construct a nuclear power plant, infrastructure improvement will not be a key issue even if needs for infrastructure may arise. However, construction and operation of a nuclear power plant is a major project for the relevant country; various investments are likely to be made in connection with the relevant project. Therefore, the government should strive to deepen understanding from a long-term viewpoint about how to advance nuclear power generation projects with countries that may become a market in the future, including measures for coexistence with local communities in the relevant country, by developing student and professor exchange systems, dispatching experts in the private sector and research institutions to the nuclear field without limitation, and developing a multi-faceted human network.

Moreover, in reference to needs information obtained through such activities, the government should develop a framework with a coordination function that enables system proposals in response to such needs from the standpoint of the relevant country. Since such needs may include the development of social infrastructure or an education or culture environment other than nuclear energy, and it will require a highly sophisticated political decision whether a comprehensive proposal including such development should be given to the relevant country. The foregoing

framework should include a mechanism for seeking such decision, making proposals based on such decision, and implementing the proposals.

○ It is necessary to develop a system for active utilization of policy financing for nuclear investment projects, a scheme for evaluating the effect of such a system on global warming countermeasures, a system of liability and compensation for nuclear damage for reducing investment risks, etc.

In order to promote the participation of Japan's industries in the construction of nuclear power plants overseas, etc., it is essential to develop the environment in financial and institutional aspects. In particular, the government should, as urgent issues, reduce financial risks via the utilization of policy financing, which is effectively working in the U.S. towards receiving orders for nuclear plants, and participate in the international framework for nuclear damage compensation, etc. Moreover, since entry into overseas nuclear projects contributes to the development of global warming countermeasures, it should be pursued to develop a mechanism for sharing effects arising from such projects with the counterpart country.

○ The dissemination of technologies of radiation medicine and radiation use technologies in the agricultural and industrial fields using ODA should be planned, and business development based on such plans should be proposed as part of infrastructure improvement activities incidental to the construction of a nuclear power plant.

As examples in Japan, in the siting of a nuclear power plant, some electric utilities started up an aquiculture business using thermal discharge from the plant in order to promote the local industry, and others started a project for desalinating seawater for self-consumption of fresh water. In developing the nuclear power generation business in Asia, it is unknown what kind of incidental business can be started up or is necessary, but effective utilization of radiation and medical technologies may be proposed as regards how to achieve coexistence and co-prosperity with the site area, including the viewpoint of utilizing the characteristics of the relevant area. Then, a system that realizes such proposals should also be developed.

3. Promotion of measures for improving the platform for sustainable growth

Nuclear science and technology should not only support the policies to be implemented by 2020 as described in section 2, but also continue contributing to Japan's achievement of sustainable growth after 2020. Activities to enable these themes should be promoted from a long-term perspective since necessary and effective technologies and findings should be continually provided to enable such activities.

<< Objective 5 >>

Platform for sustainable growth: Continually supply effective nuclear science and technology for sustainable growth, as well as human resources who shoulder the research, development, and utilization of such science and technology.

In order to achieve this objective, the following activities should be steadily promoted.

○ The world's most advanced research and development of nuclear energy, including fast breeder reactor cycle technology, should be facilitated centering on nuclear research and development organizations, and relevant infrastructure and international networking activities should be improved.

In order for nuclear science and technology to contribute to ensuring energy security and promote global warming countermeasures after 2020, short-, medium- and long-term projects for nuclear research and development should be steadily promoted, including (i) the next generation light water reactor aiming at further advancement of safe and efficient nuclear power generation technologies for short- and medium-term activities, and (ii) the fourth generation reactor centering on the fast breeder reactor and related innovative fuel cycle technologies, (iii) development of new nuclear markets, such as technologies for using non-carbon high temperature heat obtained from high temperature gas-cooled reactors, and small to mid-size reactors, and (iv) nuclear fusion expected to contribute to technologies for new energy supply in the future for long-term projects. It is also necessary to consistently improve and upgrade quantum beam technology to new applications and high quality applications according to the scientific and technical development and technology and needs of the time.

Also, international needs for constructing nuclear power plants vary according to the conditions of countries / regions, e.g., some countries seek early introduction of a next generation light water reactor, while other countries need small to mid-size reactors. Accordingly, Japanese industries should maintain and improve the capability to develop technologies so as to respond accurately to such needs.

Since such R&D activities are comparable to a challenge for overcoming uncertainty, it may be

reasonable from the viewpoint of cost-effectiveness to advance them jointly with countries that have the same purpose. For these reasons, it is important in promoting such activities to improve international network activities concerning them, produce reasonable activities for mutual benefits through constant dialogue, and jointly promote such activities.

Note that a wide range of science and technology activities including the basic research that supports such activities requires large research facilities and equipment. Then, the government, while appropriately maintaining and upgrading such research facilities and equipment, has to improve support systems to enhance their availability for researchers, including improvement of convenience for users and development of an environment that facilitates ways for new use and application. Since such improvements to equipment take a long period, it is also important to ensure a budget while constantly renewing improvement plans and steadily putting them into practice.

○ The nuclear education system should be internationalized so as to develop human resources who are capable of working in nuclear energy anywhere around the world.

Global competition is intensifying in various fields, and international cooperation intended to address such intensifying competition is increasing. Business development or R&D aiming to maintain a closed society only in Japan is likely to obstruct the revitalization of industries and R&D in Japan in the long-run. For this reason, the nuclear power industry and R&D activities of Japan should pursue self-change so as to truly maintain competitiveness in the international community and keep originality and advanced status in a borderless environment.

At the same time, the government should improve social infrastructure that enables such self-change. As part of such infrastructure, the internationalization of education sites is also important. It is essential to internationalize Japan's nuclear education system based on the expectations placed in nuclear research, development, and utilization and their international environment. To this end, it is also important to build a system that facilitates active mutual acceptance of students, researchers, and teachers from overseas institutions, and promote innovation in Japan's educational organizations, enterprises, etc. so as to value internationalism in human resources and activities, including a review of the career system.