CURRENT STATUS AND FUTURE PROSPECTS OF NUCLEAR ENERGY UTILIZATION IN JAPAN

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1. Introduction

Nuclear power is recognized in Japan as a safe, reliable and competitive energy source as Japan's 55 nuclear power plants supply about a third of the country’s electricity and contribute to the rise in her degree of self-sufficiency in primary energy supply from 4% to 17%. It is also recognized as one of the most practical and effective means to observe the Kyoto Protocol to reduce carbon dioxide emissions into atmosphere. At the same time, it is recognized that the research and application of nuclear science and technology contributes to the advancement of science and technology in various fields and, through the application of radiation to medical diagnosis, cancer treatment, insect pest control, production of semi-conductors, radial tiers, etc., to the improvement of health and living standards of the people as well as to the prosperity of industry.

Based on these recognition, major goals of current nuclear energy policy in Japan are to reinforce the basic measures that compose the foundations for the utilization of nuclear energy technologies in civil society, to encourage and support industries and academia to grapple with the challenges to sustain the share of nuclear power in electricity generation after the year 2030 at the level equal to or greater than the current level of 30–40%, and to explore innovation in and expand the use of nuclear science and technology and radiation technologies, in particular.

The AEC emphasizes five common principles as important in the design and implementation of nuclear energy policy measures for pursuing these goals. These are;

1. Assure safety and security as a prerequisite for actions;
2. Pursue multilateral and comprehensive approaches in cooperation with relevant policy actors and actions in other fields;
3. Pursue a set of actions across several different time frames, e.g., short term, mid-term, and long-term, in parallel, to assure the contribution of nuclear science and technology to the welfare of the nation for a long term;
4. Pursue international partnership and cooperation as intensively as possible;
5. Execute policy reviews for improving the effectiveness and efficiency of policies and use the result to facilitate the public understanding of them.

In the following, summarized are major policy actions planned to pursue the goals of promoting; 1) safe and effective utilization of nuclear energy technology including radiation technologies; 2) effective and efficient research and development activities; and 3) bilateral and multilateral cooperative activities necessary and/or useful for facilitating these activities.

2. Reinforce the infrastructure for nuclear energy utilization

In order to achieve the goals for nuclear energy utilization, it is necessary to carefully plan action across three different time frames: short-term, mid-term and long-term. The action for the first of these time frames is to aim at maintaining and enriching the basis for effective and efficient utilization of existing nuclear facilities and necessarily demands toughness, determination and close attention to details. The objectives of such action are to;

1. Restore the public confidence in both the plant operators’ safety and security management and the effectiveness of regulators’ activities.
2. Maintain Japan’s nonproliferation credentials by faithfully executing the obligation of the IAEA
safeguards agreement and Additional Protocol, and by further improving the transparency of plutonium utilization activities.

3. Establish necessary arrangements for radioactive waste disposal and make steady progress toward the determination of the site for high-level waste disposal.

4. Secure necessary number and quality of talents in nuclear businesses by improving the attractiveness of nuclear businesses, supporting the nuclear science and engineering education in universities, and organizing training programs for technicians necessary for the maintenance of nuclear facilities.

5. Pursue the co-existence of nuclear activities with society by improving the transparency of activities, strengthening the activities for public hearing and public communication, and increasing the opportunity for public participation in policy making processes.

6. Improve both school educations and lifelong educations by increasing diverse opportunities for the public to learn about energy and nuclear science and engineering.

7. Improve the system for subsidizing the local governments that locate nuclear facilities so that they can utilize the subsidy in wider and more comprehensive development projects come up from the area, in cooperation with plant operators and neighboring universities as partners.

8. Improve communication between central government and local governments on the effectiveness of safety and security regulation and on the policy of promoting nuclear activities.

The reason why the first of them is to restore the public confidence in both plant operators and regulators is because the public confidence in them has deteriorated severely in Japan due to operators’ misconducts during the last few years, and the average availability factor of nuclear power plants has dropped to miserably low levels in recent years. Furthermore, several local governments have canceled their approval of MOX fuel loading to operating plants on that account and even the characteristic of nuclear energy as a secure power supply source has been questioned due to unavailability of not a few nuclear power plants for power supply in season.

The AEC therefore has requested the top management of nuclear facility operators to reconfirm safety-first principle, implement a mechanism to prevent misconducts, establish safety culture in their organization to deter them, and facilitate risk communication with local communities, placing priority on the understanding of what the people wants to know. At the same time, the AEC has expressed its expectation that nuclear safety regulators should restore their credibility to the public by improving and clarifying rules and regulation based on the most up-to-date available knowledge obtained from research and operational experiences in the world.

The AEC is asking every party involved to pay close attention to detail so as to make sure the maintenance of high transparency of activities related to nuclear research, development, and utilization. This is because the utilization of nuclear energy is strictly limited to the peaceful purpose in Japan and it is requested to promote the utilization of nuclear energy transparently in accordance with the principles of openness and democratic decision making. In addition, as a party to the Nuclear Nonproliferation Treaty, all of its nuclear activities are put under the IAEA safeguards. The AEC believes at the same time that increase in the transparency and accountability of nuclear activities also contributes to the strengthening of the public’s sense of controllability of nuclear energy technology, while increasing diverse opportunities for the public to learn energy and nuclear matters.

It is essential for the promotion of nuclear energy utilization to maintain the acceptance of the operation of nuclear research, development, and utilization facilities by the society where they are located. Therefore it is important for the government and operators to strive to establish close communication with local authorities. In particular, when the regulatory authority makes decision related with the safety of local people, the authority should explain the local authorities and the residents themselves beforehand what kind of technical information is considered, and which assumption and value system are premised in the making of the decision, as such communication would contribute to the prevention of the occurrence of rage among residents as the cause of the rage is often the lack of explanation in advance about the issues related directly to their safety. Keeping this fact in mind, the government and operators must proceed positively with diverse activities for mutual understanding with such stakeholders including public hearings.

The central requirement for the operators of nuclear facilities, however, is to soundly operate their facilities through excellent plant management, paying due attention to the aging of the facilities, among others. They
are also required to steadily promote new nuclear plant construction projects. As it is a basic policy of Japan to recover and recycle useful nuclides through reprocessing of spent fuel so as to improve the utilization of uranium resource, and reduce the size of disposal site necessary for the disposal of high-level radioactive waste generated in the course of power generation, it is also required to operate the Rokkasho reprocessing plant steadily, while promoting the use of plutonium in light water reactors as already put into practice in various countries in the world, and to push forward the activities related to determine the site for disposal of high-level radioactive waste so as to be able to start the disposition of the waste in 2030.

3. **Innovation to make the best use of nuclear energy for security and environment**

In order to improve energy security and reduce the emission of carbon dioxide into atmosphere, it is reasonable for Japan to pursue the increase in the utilization of both renewable energy and nuclear energy rather than either ones. As the final energy consumption is predicted to start decreasing soon due to the progress in energy conservation and gradual decrease in population and the electricity demand is predicted to stay at constant level all the time in this century after reaching the maximum in a few decades, the most practical way to attain the goal of maintaining the share of nuclear power in electricity generation after the year 2030 at 40% or greater is to make every efforts for improving the performance of existing plants and facilities and take every opportunity of the retirement of fossil fuel plants for the introduction of nuclear power plants in competition with renewable energy.

As for the improvement of the performance of the existing plants, the innovation in regulatory as well as administrative processes should be pursued so as to make it possible to improve plant availability and introduce power up-rating and life extension. A prerequisite to as well as a part of such innovation is to improve the visibility of the responsible regulatory activities to the local government and local people. The regulatory body should continue to intensify their efforts to organize and participate in the public meeting on the issues of safety regulation, including the safety of ageing plants, seismic safety evaluation, and safety of the utilization of the plutonium recovered from the spent fuel in light water reactors.

At the same time, it is required for the government to establish, based on comprehensive consideration of public interests, an environment for the private sector to be able to make long-term large scale investments such as that for the construction of nuclear power plants, as the deregulation of electricity market will make electric power companies careful to making investment for large scale facilities since it takes a long uncertain period of time to recover the investment. Measures under consideration at present are the visualization of the share of electricity generated without carbon-dioxide emission to the consumer and inducement of joint construction and operation of nuclear power plants by several electric power companies.

The nuclear power plant manufacturers are also required to innovate in the existing businesses to cope with the prediction that the domestic market will be a small size till the start of a large-scale replacement of the retiring plants in 2030 or so and the international market will continue to be severely competitive though gradually increase its size toward 2020. They are required to develop unique and innovative technologies and dramatically improve the efficiency of business execution by integrating the design and equipment manufacturing system and innovating new methods for construction. To facilitate such innovation, government should identify and characterize good elements of innovative technology effective for the realization of competitive plants and businesses, and fund for the development of such technologies.

4. **Innovation to facilitate the diffusion of radiation application**

Radiation technologies are used in the area of academic research, agriculture, industry, and medicine for measurement, processing and therapy, as a technology superior to other technologies or as a technology with indispensable characteristics. Today, the technologies significantly contribute not only to the advancement of science and technology in a variety of fields but also to the improvement of health and living standards of the people and industrial prosperity through radiation diagnostics, radiation treatment for cancer, insect pest control or sprout inhibition of potatoes using radiation, growing of disease resistant pears or low-protein rice by radiation breeding, and production of semi-conductors and radial tiers, etc.
It can be said that a new realm of technology called “Quantum Beam Technology,” is being established, which technology consists of, on the one hand, generating and controlling electromagnetic waves such as high-strength and high-quality photons and particle beams such as neutron beams, electron beams, and ion beams, etc. and utilizing them to perform high-precision processing or observation, etc. on the other. These technologies are expected to contribute to the progress in various areas of science and technology and industries such as life-sciences, nanotechnology, medicine, agriculture and manufacturing, among others.

In order to make sure the realization of such expectation, concerned parties are requested, as a prerequisite for such utilization, to be stringent in reviewing the safety measures taken in the utilization and make utmost efforts to ensure the utilization effective and efficient under the strict safety control system. At the same time, it is important to make efforts to close the information gap for potential users, regarding information of available technologies including their merit and safety for the enhancement of their utilization.

The Government should make continuous efforts to introduce state of the leading-edge quantum beam facilities and equipment, such as high-intensity proton accelerators like J-PARC as basic and common science and technology infrastructure in Japan. The Government should also create at these facilities an environment for industry, academia and local governments to cooperate to utilize them, by encouraging the local governments and neighboring universities to effectively utilize such radiation facilities by attaching facilities useful to the local industry and thereby creating opportunities for local industry to share the merit of having such national innovation infrastructure in their neighborhood.

It is important for the government to disseminate information on radiation therapy to the practitioner of medicine and medical education, so as to make radiation therapy more widely available. As for food irradiation, it is necessary to deepen mutual understanding, based on scientific grounds, between producers and consumers on the merit and risks of actual tasks and proposes concerned parties to assess the scientific rationality using scientific data and other materials and to take appropriate measures needed to the utilization in due course. It is also expected to continue efforts for 1) creating new breeds through radiation breeding in the area of agricultural biotechnology, 2) promoting technological development for pest control by sterile insect technique and others and projects for the eradication and prevention of pests based on the results, and 3) pursuing the advancement of radiation technologies for environmental protection.

5. Promotion of research and development

In order that nuclear energy technology will be able to compete with other innovative energy supply technologies in future market, it is essential to carry out various research and development activities for technology innovation, ranging from long-term exploratory research to short-term research and development for improvement and modification of current technologies. These activities can be categorized into five categories with different objectives: 1) those aiming at generating innovative concepts, methodologies and data; 2) those aiming at originating innovative technological systems based on innovative concepts; 3) those aiming at developing innovative technological systems to the point where they become a candidate for commercialization; 4) those aiming at putting the innovative technological system into practice; and 5) those aiming at improving competitiveness of technologies already in practice.

Those aiming at generating innovative concepts, methodologies and data are basic and fundamental research and development activities which support the utilization of nuclear energy in Japan in a cross-cutting manner by maintaining its high level of technological infrastructure and supplying new knowledge and technical concepts as seeds for innovation. They also contribute significantly to the development of researchers and engineers. Therefore, research and development of this category should be proactively promoted by the government through research and development institutions and universities, while making effective utilization of international cooperation. Major activities included are research and development of the base technologies of nuclear energy, such as nuclear science and engineering, material engineering, and simulation techniques, safeguards technologies, quantum beam technologies, fuel cycle technologies including advanced reprocessing technology and partitioning and transmutation technologies. As far as quantum beam technologies and radiation utilization research using radioisotopes and others are concerned, it is necessary to consistently promote research to seek innovative technologies, explore new usage and extend usage to areas other than nuclear energy.
As for the second category of R&D, the Government should appropriately evaluate new knowledge and technical concepts developed at this stage and determine whether to designate them as seeds for developing an innovative technological system. The Government should specify as a result of the activity in this stage the approach to pursue the feasibility of commercialization of such system, according to the degree of public interest expected to be generated by the commercialization in relation to the costs required for the process. Currently items for research and development in this category include technological systems for fusion energy production based on the Third Phase Basic Plan for Fusion Research and Development including the ITER (International Thermonuclear Experimental Reactor) project and technological systems for a high temperature gas reactor (HTGR) which can be a high temperature heat source for efficient power generation and hydrogen production. As far as quantum beam technologies are concerned, a technological system based on innovative technical concepts, such as small-size accelerators for cancer treatment, must be developed under the same principle.

Regarding research and development intended to upgrade the innovative technological system, which has good potential to bring about innovation in the utilization of nuclear energy as well as in various science and technology areas, the Government should take proactive initiatives of pointing out the path to realize the commercialization of such technology candidates through R&D activities, share a roadmap and other information with the industries and promote cooperation and collaboration with universities and industries for these activities. The major task at this stage is the research and development of fast breeder reactors and its fuel cycle technology. The milestone of this task in coming ten years is to explore and clarify their concepts which should be commercially available in the year 2050s with enhanced safety, reliability, and economic performance, sufficient security in terms of proliferation resistance and physical protection, and by which the nation can enjoy the benefits of high fuel utilization factor and the reduced requirement for area or number of disposal sites. The core organization to promote the research and development is the Japan Atomic Energy Agency. The JAEA is expected to fully apply lessons learned from past experiences, while resuming the operation of prototype fast breeder reactor “Monju” and related fuel cycle facilities as soon as possible. The JAEA and electric utilities are expected in 2015 or so to present an appropriate picture of commercialization of the fast breeder reactor and its fuel cycle system and the research and development plans leading up to the commercialization from 2050 onward to the government.

The research and development planned and implemented to select the technological system for commercialization among candidates is basically conducted by industries that will eventually conduct business with the selected system, using their own resources. Only when the commercialized technological system is important from the perspective of public interest, the Government should support the activities following an appropriate and suitable cost-benefit analysis. Major tasks at this stage include radioactive waste disposal technology, advanced LWR technology, full core MOX fuel loading technology etc.

Research and development activities necessary for improving and or modernizing technologies already in practice should be conducted by the operating entities using their own resources. However, in the case where the success of such research and development greatly contributes to public interest, it is reasonable for the Government to provide support and guidance by developing a framework of collaborative development projects, while appropriately and suitably assessing the details. Major activities in this category include advancement in existing LWR technology and centrifuge uranium enrichment technology, establishment of MOX fuel fabrication technology to be adopted at a Japan’s first private MOX fuel fabrication plant, and advancement of vitrification technology for the treatment of high-level radioactive liquid waste.

6. Promotion of international cooperation

The AEC believes it important to promote international cooperation, such as exchange of information and experiences and promotion of joint activities through bilateral and multilateral channels as well as through international organizations as far as such cooperation is effective and or efficient for using knowledge and achievements of nuclear science and technology in efforts to elevate people’s living standard and to combat global warming.

Japan has identified international organizations such as the International Atomic Energy Agency (IAEA) and
the Organization for Economic Cooperation and Development/Nuclear Energy Agency as common infrastructure for the peaceful use of nuclear energy in the international community and will continue proactive participation in their activities of providing needed services to the global communities. Japan is making efforts toward nuclear non-proliferation, such as the call on the international community to conclude Comprehensive Safeguards Treaty and its Additional Protocol with the IAEA. Japan also promotes the development of advanced measurement and accounting technology to detect diversion to military uses and proliferation resistant technology to prevent diversion to military uses. In addition, as an effort to prevent proliferation in cooperation with the international community, Japan will actively participate in discussions on new proposals for maintenance and strengthening of the nuclear non-proliferation regime, including Multilateral Nuclear Approaches (MNA) initiated by Dr. ElBaradei of the IAEA, as Japan can share with him the view that it is important to realize multilateral schemes to nuclear fuel cycle that can reduce unnecessary incentive for states to have national enrichment and reprocessing facilities. Japan should provide not only experiences and ideas in such discussion but also proliferation-resistant technologies and capabilities of the activities involved if fitted to the realization of the approaches, in order to devise and implement an equitable, adequate and achievable framework to assure the competitive supply of nuclear energy services to international community.

Japan would like to continue cooperation with developing countries and with Asian developing countries which have close geographical and economic ties to Japan, in particular, on the application of radiation in the areas of agriculture, industry and medicine, the development of human resources engaged in such activities of radiation application, and preparatory works for the introduction of nuclear power generation, so as to contribute to the establishment of intellectual infrastructure concerning the utilization of nuclear energy in the recipient countries, to the improvement of social and economic infrastructure, to the establishment and enhancement of the nuclear non-proliferation regime, and to the building of safety nets; among others.

Japan continues actively cooperating, with a view to the fulfillment of the common responsibility of a developed nation to contribute to the welfare of all mankind and better utilization of resources for and reduction of project risks associated with research and development activities, as in the case of The ITER and the Generation IV International Forum. Since energy technologies generally change only slowly and at considerable cost and the social rate of return of the investment into nuclear energy R&D to the world as a whole is higher than to the individual countries, the AEC believes that co-ordination of research activities beyond national prestige to reduce the duplication of effort at the world level must be an absolute priority in world nuclear community and global community should pursue international coordination of efforts in research and development needed to realize the required technological innovations in a timely manner for many countries.

7. Conclusion

Energy is indispensable for the human being to strive for improvement of welfare. As the nuclear technology has characteristics that allow its wide scale utilization for energy production as well as advancement of science and technology, the AEC believes it an obligation to make utmost efforts so that more countries will enjoy the benefit of this technology in the near future. It is essential for us to disseminate the relevant knowledge in the society, to foster human resources, to carry out adequate operation of nuclear facility, and to pursue steadily construction program of nuclear facilities, while ensuring safety, nuclear nonproliferation and adequate system and technology for radioactive wastes disposal. In addition, it is essential to pursue innovation in processes and products for nuclear energy utilization and promote the innovation of nuclear science and technology through R&D activities. For these activities countries sharing the same vision should cooperate mutually to reach the goal. Our final goal will be to see that the value that put weight on the sustainable development of the human society will be cultivated through these activities and collaboration among individuals, regions, countries, and in the international society.