Research and Development on Nuclear Power in the Future Should Be (Statement)

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Japan Atomic Energy Commission

In September, 2012, the Government made an announcement concerning future energy and environment policy, based on the “Innovative Strategy for Energy and the Environment” (decided by the Energy and Environment Council on September 14, 2012), striving to secure a stable energy supply as well as realize a green energy revolution and favoring the use of nuclear power plants provided safety is guaranteed as a key power source. Targeting a society not dependent on nuclear power in earliest possible future, they would engage in responsible discussions with related local governments and members of the international community, and while attaining the understanding of the people of Japan, they would execute policy, ceaselessly striving to flexibly implement verification and revisions.

In setting out actions to achieve a society not dependent on nuclear power, the Strategy for Energy and the Environment stipulates the following, while highlighting maintaining and strengthening of human resources and the technical basis: 1) Ensuring nuclear safety is the top priority, supported by human resources with advanced techniques and high safety awareness: 2) promoting technology R＆D and cultivation of human resources for decontamination, etc. is important to facilitate efforts to expedite the homecoming of Fukushima residents who were forced to evacuate due to the Fukushima nuclear accident: 3) enhancing reactor decommissioning and spent nuclear fuel processing technology is a key challenge to realize a society not dependent on nuclear power: 4) developing human resources and technology is essential for the peaceful use of nuclear power, experimental demonstrations of the impact of radiation, technical support etc. in developing countries to safely manage nuclear power plant operation and reactor decommissioning: and 5) Japan is responsible for helping improve nuclear safety worldwide by sharing experiences and lessons gained from the nuclear disaster last year.

In addition, in the nuclear fuel cycle area, for now, Japan should 1) commence research on the direct disposal of spent nuclear fuel, 2) as for “Prototype FBR Monju,” summarize the achievements of fast breeder reactor (FBR) development under international cooperation, and engage in research targeting waste volume reduction and mitigation of hazards, etc., develop and implement a research plan for a certain period for the same, confirm achievements, and end the research, 3) work to promote R&D on spent nuclear fuel processing technology and burner reactors, etc.; targeting reduced radioactive waste and hazard, etc. in advance.

Previously, the Japan Atomic Energy Commission (JAEC) considered the target of nuclear R&D, pursuant to the Atomic Energy Basic Act, to be: “securing energy resources in future, to achieve progress in science and technology and promoting industries by fostering research, development and utilization of atomic energy; thus boosting the welfare of mankind and elevating national living standards." JAEC saught research development institutions, universities, private operators, etc. to work on the challenges in the various R&D projects concerning the usage of reactors and radiation that ranges from basic research to sophistication of practical technology, according to their own missions in their assigned roles in the projects.

The accident affecting the Fukushima Dai-ichi Nuclear Power Plant of the Tokyo Electric Power Company (TEPCO), however, released a significant amount of radioactive materials from the facilities, greatly damaged society, and forced people to leave their homes, many of whom remain unable to return. JAEC seriously took this to heart. While highlighting the importance of ensuring safety to the related parties and feeling deep remorse at the lack of insistence in pushing them to achieve the world's highest level of nuclear power safety, JAEC is aware that decontamination of the environment contaminated by released radioactive materials, alongside community requests and demands, is the top priority so that refugees can go home as soon as possible. Accordingly, it has requested the Government, R&D institutions, universities and private operators, etc. to work on and contribute to this on the basis of their characteristics and responsibilities. In the R&D area, based on its own mission, each entity should continue to puts strongest emphasis on this in future.

Given the Strategy for Energy and the Environment with the above contents, the JAEC released a draft statement, stating that it is important for the government, research development institutions, universities and private operators, etc. to conduct a full-scale review of R&D projects set new priorities based on this concept, revealing the challenges, and to effectively elicit international cooperation more than before. JAEC sought public comments on it and now the statement was completed with reference to comments to those invited. JAEC expects the parties concerned to note the following points and steadily push forward with the required actions.

1. Enhancement of R&D to ensure Nuclear Safety

The Strategy for Energy and the Environment states that nuclear power plants, the safety of which is ensured by the Nuclear Regulation Authority (NRA), should operate and function as a key power source in the process, targeting a society not dependent on nuclear power at the earliest possible occasion. Therefore, ensuring nuclear safety at this time is a key challenge.

Even if not highlighting the Fundamental Safety Principles by the International Nuclear Safety Advisory Group (INSAG) of the International Atomic Energy Agency (IAEA), we know commitment to nuclear power safety starts from establishing a safety level, e.g. the extent to which how far the occurrence of severe accident (the release of massive radioactive materials) can be limited. Moreover, to guarantee the targeted level of safety can be achieved, with possibility of human error and the potential for malfunction in mind, we should reduce the probability of "reactor core damage" sufficiently, even if beyond design basis events should happen. Still, we need to assume that core damage accident could occur, and we should upgrade the containment in order to ensure it remains functionally intact even under that case in accordance with the requirement of defense-in-depth.

Although nuclear power plant owners should be primarily responsible for ensuring safety, the national government is also responsible for developing governmental agencies working on safety regulations, which objectively reveal conditions under which safety is ensured, allowing only those deemed competent to engage in such actions to own/operate nuclear power plants, confirming that the permission is correct and the work at the site is compliance with conditions as required, and explaining details to the public.

A safety culture is required for organizations taking actions involved in ensuring safety. This is an organizational climate whereby all involved, from the leader to the workers on a work site, should prioritize safety over other values in their operations and all facility activities, from design/construction to operation and maintenance/repair, and raise questions on all concerns, confirm the extent of any impact on safety, and pay attention accordingly.

The wide-ranging R&D required to plan and drive such actions has been promoted. Based on indications in the final report by the Investigative Committee on the Accident at the Fukushima Nuclear Power Stations of TEPCO, key above all is R&D which helps reduce the potential for a severe accident to occur, leading to serious ground pollution. To devise countermeasures, knowledge on natural hazards such as earthquakes and tsunami, etc. necessary for planning and promotion, technologies to ensure the prevention of accidents caused by such hazards, and technology to mitigate any impact of a disaster, assuming the ineffectiveness of preventive measures accompanied by probabilistic risk assessment technology, etc. are required to assess the safety standard achieved as a result of such actions.

To deepen understanding of severe accidents supporting these technologies, the continued need is acknowledged for the promoting experimental works, evaluating the acquisition of basic and fundamental data and uncertainty thereof, and upgrading computer simulation technology. In fact, prominent research organizations in Europe promote joint research into severe accidents. Japan must strongly propel R&D activities in this area, including participations in such activities. In addition, evaluating the safety level allows us to determine the current state of safety culture in organizations and reflect it in the risk assessment. We should promote the study of psychology, organizational theory, business administration and sociology, etc. as areas enabling such work.

In addition, to determine whether technology to evaluate aged reactors is compatible with the latest safety standards, the change in on-site conditions, progressive deterioration and effects of equipment replacement should be correctly assessed, as well as how they impact the likelihood of occurrence of a severe accident. Japan, which targets the world's highest level of safety realization, should strive its utmost to foster high ability to reflect the influence of ageing in risk assessments.

While R&D achievements made in response to this challenge benefit not only Japan but also many other nations worldwide, we should also prioritize exchanges with researchers in various countries since these R&D activities are being promoted globally. In addition, lessons and information from analyzing the cause of and evaluating the accident at Fukushima can be a key contribution to such R&D work. Japan must not forget to promote actions to ensure they are communicated globally, including joint analysis and evaluation with other countries.

2. Developing Technologies concerning Decommissioning, etc.

We do not mention mid- and long-term on-site R&D/developing technologies for decommissioning, etc. by the Fukushima Dai-ichi Nuclear Power Plant of TEPCO because JAEC showed its view titled “Mid-and-long-Term Roadmap towards the Decommissioning of Fukushima Dai-ichi Nuclear Power Station Units 1-4, TEPCO (Statement)” on November 27, 2012.

As for the decommissioning of nuclear power plants after their operational period, technologies have been developed both inside and outside Japan. Based on them, actual decommissioning has been implemented, the required costs of which are then calculated, and in readiness for future initiatives, fund has been established by charging consumers through additional electricity rate. However, in Japan it is a time to renew social infrastructures, and thus abundant innovative technologies are being developed and introduce on site for that purpose. In addition, introduction of revolutionary technologies for cleaning reactors slated for decommissioning due to the accident are expected for decontamination, radioactive waste volume reduction and management, etc. Consequently, we should consider adopting such technologies to upgrade the decommissioning of ordinary light-water reactors. Such actions are also important for decommissioning nuclear fuel cycle facilities.

3. R&D into the Nuclear Fuel Cycle (NFC)

3-1. Final Disposal and the Storage of Spent Nuclear Fuels and High-Level Radioactive Waste

Spent nuclear fuel generated during nuclear power generation is subject to forced cooling in a nuclear power plant storage pool while its heating value is high. Subsequently, after a specified cooling period has elapsed, the fuel can be stored both on and off site, including dry storage, such as to avoid the dependence on the power source for cooling as much as possible.

Historically, if increased storage capacity for used nuclear fuel is required, storage pools with large management capacity were established. In future, options for mid- and long-term storage other than simply transferring to reprocessing plants are more likely to be required. R&D to ensure the safety of mid- and long-term storage of used nuclear fuel is important. While previously such actions depended on verification tests, the longer the storage period, the more important it is to effectively use the knowledge and technology to forecast long-term behavior of facilities/equipment. Therefore, operators should promote, long-term storage in mind, new R&D of innovative measuring techniques enabling “in situ observation”, advanced state prediction techniques, coping techniques, and so on in partnership with R&D institutions.

As for the geological disposal of high-level radioactive waste, we should promote R&D to establish fully safe disposal technology, after continuously and conservatively predicting the geological conditions of areas around disposal facilities for vitrified high-level waste. In concrete terms, it is important to continuously engage in deep underground scientific study that is the basis of ensuring absolute long-term safety of geological disposal and R&D into more reliable disposal technology, better methods to evaluate safety, desirable nature of reasonable security for retrievability, etc., and reflect the latest knowledge thus obtained upon the evaluation of actions, and implement revisions as required.

In addition, considering measures for used nuclear fuel generated by research reactors and those by the Fukushima Dai-ichi Nuclear Power Plant, it is obviously necessary to enable not only the disposal of vitrified waste but also direct disposal of used nuclear fuel. Hence operators and R&D institutions should highlight any shortcomings in technology used to dispose vitrified waste, establish R&D projects, and steadily promote actions to promote them, fully taking into consideration of trends of direct disposal technology for which a safety review will soon commence overseas, with a view to implementing it in Japan.

In addition, regardless of whether the disposed materials are vitrified waste or used nuclear fuel, they will be stored for about half a century until disposal gets underway. In addition, even after the disposal, retrievability must be ensured until the disposal site is sealed. Therefore we should conduct these R&D actions with full consideration of the above.

3-2. Fast Reactor Cycle and Advanced Waste Treatment Technology

As for R&D into Japanese fast breeder reactors (FBR), JAEC cited actions targeting the Generation IV reactor when it is practically implemented. More specifically, it believes we should act to make the reactor safer and more environmentally friendly than Generation III light-water and fast reactors, establish stringent standards and check and review actions while targeting the same, and consistently strive to refine our approach. We should consider the Strategy for Energy and the Environment, which states that research targeting reduced waste volume and mitigation of hazards, etc. should be conducted in this field, with calls to once again regroup and take concerted action, in response to public opinion regarding nuclear power generation.

Consequently, as for the Prototype FBR Monju, with responsibility to international society to ensure nonproliferation and the peaceful use of atomic power, R&D institutions should clarify how the "Prototype FBR Monju" can boost R&D into reactors to ensure they can be safely harnessed by future generations under international cooperation and help upgrade radioactive waste management, establish actions for the same, develop and implement research plans for a certain period, confirm achievements, and complete research.

In addition, to reduce waste and mitigate hazards, etc., advanced fuel processing technology is also required. As the technology is on the verge of feasibility on an engineering scale, R&D institutions must engage in R&D, evaluating the system-wide targeted result with a fast reactor, repeated basic and fundamental searches as required; targeting efforts to establish technology by proof.

The Strategy for Energy and the Environment says, "Even if the road to a society not dependent on nuclear power is realized, to ensure it takes hold, the Government, should always verify the strategy, disclosing related information, and ceaselessly striving to implement revisions, considering the state of the expansion of green energy, influence on the lives of Japanese citizens/economic activities, international energy situations, public level of confidence in nuclear power and nuclear administration, local governments' understanding and cooperation on disposal of spent nuclear fuel, relations with international society, etc.." Based on this, in setting and fulfilling these targets and challenges and deciding on the way forward, it is crucial to win public support for R&D investment. R&D institutions should always check what society hopes for, not only in terms of the characteristics of "Prototype FBR Monju" but also when setting R&D goals, leveraging the latest scientific knowledge and using the same as the basis to form a roadmap. Also reviewing how R&D develops using fast reactor technology, including "Prototype FBR Monju," and steadily working on such actions. Needless to say, on this occasion, we should strive to ensure existing R&D facilities, simulation technology and international cooperation, etc. are all used effectively.

4. Basic and Fundamental R&D that Support Human Resources and Technologies for Utilization of Nuclear Power

4-1. Steady Basic and Fundamental Research Implementation

The fundamental R&D cornerstones for reactors and radiation are: nuclear physics, radiation incidence and control, radiation biology, reactor physics, heat transfer and fluid flow, fuel/material, technique for computer simulation of reactor behaviour, measurement/control technique, accident risk assessment, etc., while other R&D benchmarks concerning nuclear fuel cycle are physics/chemistry of radioisotope elements, geological/geological feature data, underground transport simulation, accident risk assessment, knowledge management, isotope separation and transmutation, etc.

These scientific/technological pillars and fundamental R&D regarding nuclear energy and radiation spawn new knowledge and technical concepts to maintain the technical basis allowing globally unrivalled nuclear R&D and human resources to be developed.

In particular, the promotion of basic research is an important action to promote/regulate sound uses of nuclear power in the private sector and maintain the ability of national government to engage in R&D of prototype technology in an age where market liberalization prevails. To date therefore, it has been recognized as important for ensuring efficient progress of it to allocate public research funds to universities, etc. with expertise in technologies and develop effective research infrastructure in a concentrated manner.

In future, however, we should fully examine what level of activities should be maintained and how such fundamental generic R&Ds should be continued for the medium- to long term, based on a policy of reduced nuclear dependency and in consideration of what the nuclear industry should be in future, strategy for promotion of academic research and future innovation strategy.

On this occasion, we should consider the following: given the increasing percentage of actions for reactor decommissioning and waste treatment, it is indicated crucial to secure the R&D programs for those purposes in the future and to develop a basic and fundamental academic system for such R&D. Moreover, given increasing demands on human resources development in nuclear power, effort must be made to ensure these intellectual infrastructures flourish in Asia and elsewhere. In terms of actions, meanwhile, it is effective for the parties concerned to use their characteristic networks, the implementation of which is reflected in trends.

In addition, the science of radioisotope has been facilitating the progress of various existing technologies and spawning new technologies by revealing materials through monitoring technology and is recognized as a commonly desired academic infrastructure. In actions after this accident, understanding the behavior of radioactive materials by applying such learning is the basis for insight into effective and efficient decontamination of equipment and revealment of the dynamic state of radioactive materials in environmental terms, both of which are effective measures to explore the desirable form of decontamination and monitoring. Therefore, based on the increasing importance of such needs, there is a need to review what research system and education should be.

In addition, the recent accident raised awareness that in the field of medicine in particular, basic education on radiation is lacking, and immediate measures are now being taken in Fukushima prefecture. The way to ensure radiation safety is to inculcate scientific knowledge on radiation risk, hence R&D institutions and universities should ensure proper study of radiation physics/chemicals/biology, medicine, and health physics, etc. on this basis and foster high-quality experts in the process.

Basic research must contribute to maintaining and improving the technical basis, and should be conducted in all organizations, including R&D institutions and public sectors. In universities in particular, it is desirable not only to develop human resources who forge the future but also to promote research based on new free ideas. In addition, recognized is the importance of research in an area transcending conventional nuclear power research, such as a multidisciplinary understanding of the need for safety is recognized, and elucidation of a "peace of mind" mechanism that is confirmed as being attributable to emotions of trust/mistrust in human beings and organizations. It is also important to support actions in basic research from a fresh dimension based on a free idea unconstrained by convention.

4-2. Development of R&D Infrastructures for Basic and Fundamental Research

R&D facilities for the nuclear basic research program are widely used as basic scientific and technical infrastructure supporting R&D activities, not only in the field of nuclear energy but also many others. Due to deterioration, etc., however, the use of some facilities is no longer possible without any revision or installation plan. The national government should avoid functional overlapping at facilities which must be maintained based on functional requirements and usability, and implements improvements such as renewal and replacement, etc.; planning based on domestic and overseas needs. On this occasion, the fact that decommissioning requires proportionate funds should be noted and a plan made accordingly. In addition, achievements in these R&D facilities should be widely returned to the public. It is important to work/cooperate with local governments where facilities are upgraded, exercise ingenuity to improve user-friendliness, and use them in actions for the industry creations.

5. Radiation Use

The market size of radiation use is equal to that of energy use by nuclear energy in Japan. Radiation is used as technology supporting cutting-edge R&D, promoting the advancement of academic research and public lives and elevating various facets of health, industrial development, and others in various fields such as physics, engineering, medical care, agriculture, etc. As applications of radiation and radioactive materials evolve, it is important to try and actively transmit information on radiation use such as its effect and safety and promote public understanding of the same. To this end, networks, etc. should be developed so that operators, the public, and researchers can exchange information among each another.

Radioisotopes and radiation generators can be used to upgrade medical care through diagnostic techniques such as X-rays, CT scans and PET scans, etc. Such advanced technologies using radiation are representative of present-day medical care, used to maintain public health and reduce patients' burdens. It is important to continuously promote R&D in these areas. In addition, as the overall radiation source for this medical care depends on overseas imports, academic, business, and Government bodies should cooperate and advance efforts for developing domestic production capability. The use of radiation generators and sterilization of medical apparatus with radiation generators is becoming widespread and is often used to sterilize foods in many countries. Food irradiation, which is regarded as an effective means of quarantine, is limited to potato retard sprouting in Japan. In future, many countries are expected to proceed to evaluate the safety of proven foods based on scientific data, etc., foster mutual understanding with consumers based on the same and include food irradiation technology in options in many actions.

Meanwhile, the Fukushima Dai-ichi Nuclear Power Plant disaster has exacerbated social anxiety over the impact of radiation on health, meaning efforts to ensure safety should be focused on relevant use of radiation, and carefully designed safety management systems should be installed. Related administrative bodies and R&D institutions, etc. recognizing the importance of risk communications related to the impact of radiation on health, should develop locations and contact places, preparing basic data. At the same time, they should cooperate with parties in healthcare and education, etc. and develop experts who can establish user-friendly explanations of the impact of radiation on health based on scientific knowledge.

6. R&D into Nuclear Fusion, Particle Beam Technology

R&D into particle beam technology and nuclear fusion is promoted in cooperation with R&D in various other areas of industry, the achievements of which are expected to be applied to a wide range of science and contribute to re-energize academia and industries other than nuclear power. The Science Council of Japan (SCJ) points out some of them in a large facility plan for academia and the Japanese Master Plan for Large Research Projects 2011, etc. as proof.

R&D related to particle beam technology is expected to achieve a technical breakthrough via continuous implementation rather than short-term achievements, for example, the creation of high-function materials for fuel cell and/or hydrogen storage, astonishing improvements in solar battery performance, etc. Therefore, it is desirable for R&D institutions to continuously strive in this area in the medium- to long term in conducting fundamental research to promote our growth strategy beyond the scope of nuclear energy and develop related facilities according to the plan. In addition, the national government should continues to support actions facilitating the use of particle beam technology in industry and tries to activate R&D in various industries.

The final target of R&D into nuclear fusion is energy use. At present, however, nuclear fusion equipment developed according to the ITER plan, etc. is for experiments to elucidate phenomena/control concerning plasma physics of the occurrence of nuclear fusion reactions triggered by high-temperature plasma and strong magnetic fields. In addition, R&D into inertial confinement fusion generated by high-performance laser equipment and energy technology facilitates the application of high-energy density physics. These years, by deploying achievements in the field of equipment development and test achievements like those in wide-ranging science and technology such as Green/Life Innovation, etc. they are applied and spread in various industries. Therefore, for the moment, it is appropriate to steadily proceed with work to elucidate phenomena/control, and high-tech materials developed alongside via basic and fundamental R&D to evolve into wide-ranging science and technology to strengthen industrial competitiveness.

7. Special Remarks on Working on Nuclear R&D Items

(1) Ensuring Safety/Security during R&D Activities

Also in nuclear R&D actions, we must establish a safety culture putting safety first and continuously review risks without fail from the perspective of ensuring safety. With this in mind, naturally, we must show information concerning the safety of nuclear R&D actions to the public as well as ask domestically and overseas established organizations and experts to assess how the situation can be improved.

At the same time, as for security in place to ensure key social functions, which is a national challenge, we are proceeding with studies and actions on how to protect such functions and handle any crisis. In particular, implementing measures to combat any threat to information and telecommunications and terrorism is the urgent issue, and the need to strengthen security measures on nuclear power facilities from such perspectives is increasing. Consequently, we must note access restrictions on relevant information as well as conventional physical protection, and meet the requirement to confirm reliability of those workers handling nuclear materials, etc. In addition, it is important to fulfill R&D that can make it possible to implement effective and efficient actions.

(2) What Nuclear Safety Research Should Be

In nuclear safety regulations, as part of efforts to judge the validity of licensees' actions, regulators have to judge on its own using their own computer program for the assessment of earthquake responses, calculating criticality, numerical simulations of dynamic reactor characteristics etc. Specialized skills required for such work are cultivated through R&D

activities, including works to create and use such programs. Therefore, nuclear power plants regulators and organizations supporting regulations must engage in technological R&D activities on their own, and/or must develop human resources through those activities. It is one of the core activities of nuclear power R&D institutions, however to promote making, using, and improving such computer programs, develop such tools and measure characteristics of relevant materials and perform demonstration experiments for tool verification. Therefore, the national government must study whether to develop a system to let safety regulation organizations take such actions by themselves or share the opportunity with other organizations and consolidate the system.

Standard concepts of international society applicable to the same are as follows. First, it is impractical for safety regulation organizations to conduct R&D into such tools on its own. However, R&D is required to make such tools available in safety regulation services, and safety regulation organizations should do so. Second, as the workforce behind such development in safety regulation organizations should participate in such activities to foster their expert ability, a system should be devised for this purpose. Third, if the use of various analysis tools developed at R&D institutions can be made efficiently and effectively pursuant to safety regulations, safety regulation organizations should determine a protocol for the use of such tools independent from the promotion perspective. In addition, as such tools are the source of international competitive power like the technical standard, major countries advance the development of national projects, with the participation of industry and other parties. Provided the potential to use such tools in safety regulations in future remains, it is worthwhile for experts in safety regulation organizations to advise on development. We allow them to do so while also considering intellectual property protection (IPP).

(3) R&D into Prototype Technology to Reflect Social Needs and Secure Diversification

There is a stage of R&D of nuclear energy technologies when actions are taken to integrate generic technologies, in the form of actions involving basic and fundamental research into nuclear power, leading to good functions, which can be realized via a system. It is called "prototype technology" stage. At that stage, many technology system concepts exist in so-called "the Darwin Sea" (many technical options are created from basic and fundamental research, but they are only selected at this stage, and only a limited number go into actual use.) as candidates for eventual commercial development.

Among them, the national government evaluates the potential of units such as small reactors that innovatively enhance safety, innovative hydrogen production technologies using high-temperature gas-cooled reactors, the use of thorium, high-energy laser-applied technology, uranium recovery from seawater, etc. comprehensively, and promotes developing technologies as actions to determine commercial viability, fully or to a limited, but significant, extent. R&D institutions, etc. should widely seek opportunities to develop them into commercial technologies domestically and overseas to avoid missing any opportunity, and continue acting in the medium and long-term to develop prototype technology that repeats creative deconstruction based on new ideas. These actions are implemented as core actions to maintain human resources and levels of technology that shoulder intellectual creation activities, and gain/create new knowledge and technical concepts.

We should advance R&D projects targeting the commercial application of specific prototype technology under strong leadership, eliminate constraints and create ideas for an integrative system capable of achieving performance targets and devise new methods of eliminating intervention by several performance requirements. In shifting to the stage of commercial application, even a new technological system based on new principles cannot be realized without supporting technology (material or component manufacturing technology, system control technology, etc.). To “widely distribute a technology in society” the following is necessary: not only must the technological system be feasible in technical terms, it must also meet conditions imposed by society (in terms of safety, reliability, economical efficiency, etc.). Robustness is required for the integration system, whereby the system feasibility and performance should be subject to minimal impact from any uncertainty on those conditions. Consequently, in R&D activities, while knowledge gained can be swiftly fed back, it is important to secure diversity for R&D projects in hand and provide many options at optimization. From this perspective, we should make strict reviews as appropriate and give suggestions on what actions should be to enhance the probability of success.

In addition, based on the significant changing performance target of nuclear technology in future and the urgent need to be ready for future uncertainty, we should exploit information technology, modeling and simulation techniques, all of which have progressed considerably in recent years and examine the feasibility of a system capable of achieving performance targets in all processes of design, manufacturing/construction, operation, and disposal and fulfillment of R&D activities by adopting front loading to study R&D multilaterally and thoroughly from an early stage. By taking these actions with the private sector and end-users involved, those in charge of R&D are expected to achieve progress in R&D activities by further adopting cost-awareness and technology transfer from an early stage.

(4) Maintenance of Nuclear Technical Basis and Contribution to Developing Human Resources

In all R&D activities, from fundamental research to R&D targeting advancement of the commercialized technology, the actions to maintain technical basis involves understanding scientific principles and accumulating knowledge and experience for engineering safety in tangible archives or as intangible knowhow are essential. Without such acts, even human resources with advanced technology and high safety awareness will struggle to secure nuclear safety, the top priority, and support nuclear security. In addition, the parties concerned should also always remember that R&D activities not only involve developing science and technology but also see growth in those who develop and/or are engaged in technology, accumulating knowledge and experience through such activities. Recognizing this aspect, we should not forget to cultivate this function. Also from this recognition, progress in developing technologies through cooperation with universities, research organizations, and industries is anticipated with a view to developing human resources. Moreover, aggressive activities to transfer R&D achievements should be pursued, being aware that they will enhance not only the potential to realize a transfer but also the subsequent feedback that will encourage people to create new evolutions.

(5) R&D Activities Based on Recognition of Contributions to and Coordination with the International Society

Japan ratified the Treaty on the Nonproliferation of Nuclear Weapons and has pursued peaceful applications of nuclear energy under a system of strict safeguards. In addition, to date, Japanese nuclear R&D has been conducted in close cooperation with foreign countries. We believe it important to continue to do so in future. It is thus crucial to closely consult with international organizations and foreign countries and determine the feasibility of establishing effective cooperative agreements, including joint research/developments in planning and promoting R&D actions.

In addition, Japan is also responsible for helping improve global nuclear safety by sharing experiences and lessons from the Fukushima Dai-ichi Nuclear Power Plant accident. We must remember and promote this action incessantly in advancing R&D while targeting safety improvements, nonproliferation, and mitigating nuclear security risks,

(6) Support for Research Promotion in the Art and Science Field concerning Nuclear Energy

Needless to say, in proceeding with nuclear R&D and its use, obtaining the public’s full understanding and judgment is crucial. Following the Fukushima Dai-ichi Nuclear Power Plant accident, the public is more aware of the fact that nuclear R&D and its use are associated with society and their individual lives and beliefs than ever before. Under these circumstances, there is an increasing need for knowledge from a scope going beyond nuclear engineering and engineering in general so that the public can evaluate nuclear power. Consequently, to ensure the public are fully aware of such knowledge, research from the perspective of art and science should be reinforced; for example, to determine how best the use of nuclear power in Japan and worldwide should evolve and the social influence of nuclear power etc., based on analyses from perspectives of law, political science, economics, philosophy, ethics, psychology, and sociology. The national government should develop an environment where research into nuclear power from the perspectives of diverse sciences is actively conducted.

(7) Comprehensive Evaluations

For R&D activities, high cost-effectiveness is expected by multi-valued evaluations of potential achievements in a certain commercialization period assuming certain environmental conditions. In addition, if it is introduced into society, the potential for unexpected social influence (safety, environmental impact (EI), and ethical issues, etc.) must be assessed in advance. In conducting R&D, the parties concerned should conduct an integrated evaluation of the planning, implementation, achievements as well as ensuring the safety of facilities/equipment from multiple perspectives and at regular intervals. In addition, as the plan is promoted further, the amount of resources required is generally predicted to increase. Based on the “selection and concentration” concept, numerous R&D actions should be evaluated by crosscutting analysis, and R&D resources should be effectively and efficiently allocated.

In this case, large-scale R&D facilities, etc., are often effective methods of studying other areas of science and technology also, providing seeds for various technical innovations in these fields as a knock-on effect. Consequently, it is important in such a comprehensive evaluation to gain independent opinions; not only from wide areas of physics and engineering but also from the social science academic community and civic groups, constituting an autonomous comprehensive assessment organization from a wide perspective of ELSI ‘ethical, legal, and social issues) and remit works.

(8) About the Japan Atomic Energy Agency

The Japan Atomic Energy Agency (JAEA), as the only core R&D institution stipulated in the Atomic Energy Basic Act, conducts many Japanese nuclear R&D activities. After the Fukushima Dai-ichi Nuclear Power Plant accident, JAEA is promoting various R&Ds related to energy policy, and basic and fundamental research, prioritizing R&D into decontamination, decommissioning, decommissioning/radioactive waste measures, and those ensuring nuclear safety.

While future uses of nuclear power will vary, JAEA should play a major role in maintaining safety, security, and technical bases and solving important and common issues; e.g. by contributing and cooperating to develop human resources and international society. Consequently, JAEA should strive to maintain/strengthen the technical basis and its ability to solve problems, and develop a system to offer adequate support to society. At the same time, it should conduct self-evaluation and improve and remedy schemes to promote business and management so that targeted achievements are met steadily in solving such important challenges.

In addition, nuclear technology is widely used, not only to generate power but also in many other areas: including R&D, medical care, and industries with low-level radioactive waste generated in various sites. JAEA collectively disposes of its own waste and that from others who commission it with disposal work. As a rule, radioactive waste should be processed/disposed of safely and reasonably and JAEA should steadily and reliably develop this business for both existing and future waste.

The national government should implement appropriate measures to foster J JAEA into an organization that can fully carry them out.

End