Japan's Nuclear Energy Research, Development and Utilization Policy[1]

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Thank you Mr. Chairman, for your kind introduction.
Good morning ladies and gentlemen.

It is a great pleasure to be asked to address this Joint International Conference of the 7th Supercomputing in Nuclear Application and the 3rd Monte Carlo or MC2010. Today, I will be providing you an overview of how the AEC promoting research, development and utilization of nuclear energy, as an organization responsible to plan, deliberate and decide the framework of nuclear energy policy in Japan.

Before I begin, I must say that I made an opening address at the first SNA conference in Mito in 1990 as an organizer. Looking back on my note at that time, I feel ashamed, thinking how tedious it was for the audience, the experts in modeling and simulation. to listen to my reasoning of the importance of simulation. Nevertheless I will address the importance of modeling and simulation again this morning as a policy planner. One big difference this time, though, is I have the nerve to ask you a favor of being relaxed at this moment.

The Atomic Energy Basic Act provides that the basic goal for Japan's nuclear energy policy is to promote safe, secure, safeguarded and sustainable utilization of nuclear energy for the promotion of science & industry and the improvement of a living standard of the people in Japan, and contribute to the shaping of international environment for safe, secure, safeguarded and sustainable utilization of nuclear energy in any part of the world.

Pursuing this goal, the AEC has been asking the Government and industries to attain six strategic objectives: they are;

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i. To maintain infrastructure for assuring safety, security and nonproliferation and the public trust in the infrastructure.
ii. To make the share of nuclear power in electricity generation after the year 2030 greater than 40 %.
iii. To store and reprocess used fuel from LWRs and utilize fissile material recovered by the reprocessing in LWRs.
iv. To develop and operate waste disposal facilities, including a geologic repository for disposing vitrified high-level radioactive waste from the reprocessing.
v. To expand the opportunity of utilizing radiation and radioactive materials and maintain a level-playing field for radiation application activities in science, medicine, agriculture, industry, etc.
vi. To promote carefully planned but aggressive basic research activities and near-term, mid-term and long-term R&D activities in parallel.

As a result, in the area of nuclear power generation, 10 electric power companies (EPCs) are currently operating 54 LWRs, 30 BWRs and 24 PWRs, that supply about 30% of electricity in Japan. 2 units start beyond-40 years-operation this year and several NPPs are loaded with U-Pu Mixed Oxide fuel.

Currently 2 units are under construction and 12 units are in preparation for construction, on the one hand and 3 units are in the decommissioning stage.

These BWRs and PWRs have been supplied by three nuclear power plant vendors, Toshiba, Hitachi, and Mitsubishi Heavy Industries, on time and within budget in most cases.

It should be noted that and one large scale low-level waste disposal facility has been in operation for more than 10 years.

As for radiation utilization, more than 5,000 firms, including industries, hospitals and research organizations, are currently registered as the user of radiation and radioactive materials and are promoting research, development and utilization of radiation technology for various purposes. The Government has supported the construction of large scale radiation sources such as RIBF, SPring-8, J-PARC, HIMAC, which are currently open to various users in the world.

As for research and development, the AEC has specified that four categories of R&D activities should be promoted by the Government and industries in parallel. These are

i. Base technology research that aims at expanding knowledge basis for nuclear energy, including nuclear physics, mechanics, materials, chemistry, digital simulation, etc. and maintaining test facilities for R&D such as test reactors, hot laboratories, etc.
ii. Near-term R&D that aims at creating knowledge for utilizing existing assets effectively, including those for trouble shooting and management of plant ageing, power up-rating, safe geological disposal of HLW, etc.
iii. Mid-term R&D that aims at developing new products and processes to replace those currently in use; a major activity is the R&D of next generation LWRs.
iv. Long-term R&D that aims at developing innovative products and processes that open sustainable nuclear energy use such as fast reactor and its fuel cycle technology, fusion energy technology, etc.

The basic research and long-term R&D are promoted by the Government in most cases and in the case of mid-term R&D activities, the Government and industries are jointly sponsoring the activities, though the government support should be limited to generic technologies R&D part, in principle.

The next generation LWR R&D project is sponsored by both the Government and electric utilities and aiming at preparing high performance LWRs that can meet the domestic demand for replacing existing plants that will start to appear in the 2030's and global demand for nuclear power in many part of the world.

The project team recently decided the major characteristics of the plants to be developed and the innovative technologies to be incorporated in the designs, including the plant electrical output of 1800 MWe and 900MWe, and use of innovative materials and components for better performance, and adoption of seismic isolation for building foundation aiming at pursuing standardization over a wider area of design and construction.

The objective of a fast reactor and its fuel cycle technology R&D project is to commercialize it in the energy supply market of the latter half of this century, satisfying

the requirement of enhanced safety, economy, fuel utilization and proliferation resistance, low heat generation rate of radioactive waste to be disposed of, etc. Currently the project is at the stage of developing system concept, narrowing candidate for coolant to sodium and that for fuel to mixed oxide fuel with uniform or partial loading of minor actinides.

They are struggling with various issues to satisfy the requirement. One of major issues is the necessary degree of MA recycling that should be realized from the viewpoints of endowing intrinsic proliferation resistance and reducing heat generation rate of high-level waste. As minor actinide-bearing fuels feature a considerable increase in gamma and neutron doses and of the decay-heat, which would require specific protection and cooling means for every stages of fuel cycle including fuel transportation, they are required to find an innovative way of coping with the need for these means without bringing about excessive economic penalty to the system.

The project team is soon to present their interim report on the selection of innovative technologies and rough idea of the reactor and fuel cycle system to be realized to the Government. If the result is judged to be promising by the Government, then the team will be asked to present a conceptual design of demonstration reactor and its fuel cycle system in 2015.

As for fusion energy R&D, major efforts are currently devoted to the ITER project and broader approach activities accompanied, which aim at demonstrating engineering feasibility of fusion energy utilization based on Tokamak plasma confinement scheme in 10 years or so. Research and development of helical confinement scheme and inertial confinement scheme are also being pursued to explore their potential for science and engineering application including fusion energy production.

Reviewing the current status of these R&D activities as a part of Commissions policy review activities, the AEC has made recommendation to the research organization last year. These are

a. Leaders of R&D project should be capable of leading to invest, innovate and create values where none existed before, having determination to excel and timely decide what he should decide:
b. Leaders should attach importance to science to the maximum:

c. Leaders should strengthen front-loading and spiral development that facilitate interaction with stakeholders effectively, recognizing that devils lie in details: and
d. Leaders should encourage development and utilization of high-fidelity science-based modeling and simulation tools.

The reason we recommended to strengthen front-loading activities is because although it should have been well known that the most cost-effective activities for product growth can be done in the early phase of the project, we have often encountered or are encountering even today with the situation that was caused by the deficiency in the operational as well as scientific reviews of the design on the drawing board.

Our claim of the importance of spiral development has its roots in our recognition of the importance of feedback and iteration across the phases of the R&D life cycle. In the pursuit of a robust as well as safe, secure, safeguarded and sustainable nuclear energy system, which should be necessarily an integrated socio-technical system, it seems essential to promote the evaluation of risk of successful completion of the project through iterative feedback from engineers and end-users at each specific time of their research, development and utilization.

Needless to say, successful modeling and simulation is applicable to solving important problems in engineering, science and society. It would provide new intuition and insights making a qualitative contribution to human knowledge.

Modeling and simulation effort is indispensable to the promotion of front-loading activity in nuclear energy R&D projects as they can reduce the number of prototypes and large-scale experiment needed before demonstration, quantifying uncertainties and design and operational parameters.

One big issue in the promotion of wider use of modeling and application in R&D project is how to change the prevailing culture of considering the importance of demonstration by prototype in diverse technology development teams. Based on this recognition, we have recommended leaders of R&D organizations to pursue communications between R&D project teams and basic research teams, which are responsible to develop basics of various simulation tools, on the need for and possibility of modeling and simulation to promote the project as effectively and efficiently as possible.

Then I would like to talk about some of the difficulties we are faced with at present. One of them is the fact that the average capacity factor of operating plants is currently miserably low in Japan, though it is required to improve it to 85% by 2020 and 90% by 2030 so as to make the share of nuclear in power generation 49% in 2030 as a part of actions for combating global warming in the basic energy plan decided by the Cabinet this June.

The second is that the reports of delay in the schedule of various projects, including the active test of the Rokkasho Reprocessing Plant, the determination of the site of geological repository for high-level waste, restart of Monju, ITER project, etc. may cause a doubt in the public mind on the reliability and /or sustainability of nuclear power generation in Japan.

The reason of the low average capacity factor of the LWRs in Japan can be seen in this slide. As you can see, average capacity factors of BWRs have been significantly lower than those of PWRs in recent years. This is because some of BWRs have experienced strong earthquakes and thereafter have been forced to take a long outage time for inspection, safety review and modification to improve their seismic safety.

The Nuclear Safety Commission of Japan (NSC) revised its seismic safety evaluation guideline in 2007, of which major points of revision are the need for the evaluation of residual seismic risk and the extension of the return period of the seismic activity of an active fault to be taken into consideration from 50, 000 years to 100, 000 years. The explicit mention of seismic risk means the need for probabilistic treatment of uncertainty in the generation and propagation of seismic wave for each site, utilizing probabilistic seismic risk analysis methodology.

The seismic event at Kashiwazaki-Kariwa NPP in the 2007 Niigata-ken Chuetsu-oki Earthquake that occurred several months after the revision by the NSC clearly indicated the importance of detailed treatment of the characteristics of nearby faults that determine the direction and magnitude of seismic energy generation and the characteristics of the geological structure around the site that determine the propagation of seismic wave from a fault to the site.

Since then each nuclear power plant operator has been promoting the review of the seismic safety of their plants based on the analysis flow schematically shown in this slide, in accordance with the NSC's new seismic safety evaluation guideline. Significant amount of academic, engineering, and managerial resources have been called for in this work of starting from the review of existence of active faults around the site, range of fault parameters of each active fault and seismic wave propagation characteristics of the underground structure around the site, then the probabilistic evaluation of various seismic events at the site utilizing a tool to model and simulate seismic wave generation and propagation from a fault to the site and to the evaluation of design basis seismic input from the viewpoint of specified return-period.

After the completion of the review, plant operators should identify necessary improvement of seismic safety of the plant and establish a plan to implement the improvement and carry out it, utilizing the opportunity of annual planned outage periods. The Commission hopes that these activities will be completed in a year or so.

Of course there are other factors to be taken care of for the improvement of capacity factor of the plant such as the reduction in the frequency of overhaul maintenance activities and the introduction of on-line maintenance activities, and so on. We are hoping that actions in this respect will be taken in parallel with the activities to assure seismic safety of the plant.

One of the notorious delay in the project completion is the delay in completion of commissioning test of the Rokkasho reprocessing plant due to the difficulty in establishing the operation procedure of joule heated ceramic melters that vitrify the high level waste solution, which is located in the center of the vitrification facility.

The AEC suggested that the operator should have sufficient understanding of the behavior of insolvable electricity-conducting Pt impurity during vitrification process in the melter, thinking over their past error of making light of scientific understanding in its design and operation processes. In response, the operator has started a project to establish the operating procedure of the melter, utilizing mock-up facilities and numerical simulation of electro thermo-hydrodynamics of multi-component fluid with non-Newtonian suspension in the melter. Recently the JNFL announced that the active test will be finished in two years based on the analysis of the result of a series of mock-up tests and other measurements and modeling and simulation studies.

As for geologic disposal of high-level radioactive waste, JAEA have been promoting diverse R&D activities including the preparation of two underground research laboratories, one in crystalline rock and one in sedimentary rock.

Difficulty is the determination of the site for a geologic repository for HLW. In 2004, the NUMO, an organization authorized to promote the disposal activity, started to invite mayors of municipalities to apply for site suitability investigation. However, so far no mayor has successfully applied. In one case, though a mayor took action for application, the application was withdrawn as he was defeated in the immediate election. In the election campaign, made was such an appeal as "Can you and your posterity live with 40,000 highly radioactive canisters each of which radioactivity is equivalent to that of 30 Atomic Bomb dropped on Hiroshima-city" in the town that had not experienced any kind of learning concerning nuclear energy or radiation.

Based on lessons learned in this affair, the Government as well as the NUMO has started to strengthen public information activities on the safety and the importance of the disposal facility at both national and municipal levels. However, the recent public opinion survey has shown that, though a half of the public has started to recognize the responsibility of current generation to decide the site of the geologic repository, about 80% of the public disagree to the invitation of the site by their town and or neighboring ones.

At this juncture, the AEC has made three recommendations to the Government and industry, as a precaution to the possible creeping crisis in the public's confidence in and acceptance of nuclear energy. They are

- To continue to inform the public the fact of nuclear energy with troubles we are faced with, as well as the importance of nuclear energy for both assuring energy security and combating global warming.
- To maintain the public's confidence in both nuclear facility operators, nuclear energy administrator and nuclear safety regulator, engaging openly and transparently with the public so that the public can participate in decision making processes meaningfully.
- To strengthen the business risk management with a view to maintaining the stable supply of electricity from nuclear power plants even if the projects related with fuel

cycle are delayed and further increasing the robustness of nuclear power generation against various unexpected technical and institutional occurrences.

Before closing, I would like to briefly touch upon the strategic objectives for pursuing Japan's contribution to the shaping of international environment for safe, secure, safeguarded and sustainable utilization of nuclear energy in any part of the world.

The first is to share with international community, knowledge, experience and lessons learned from continuous deployment of LWRs and their operation and from diffusion of radiation utilization in various fields.

For that purpose, Japan is continuing the contribution to various activities of the IAEA and encouraging domestic research organizations to promote exchange of experts and cooperative research projects with international organizations. Japan is also supporting developing countries' activities of human resource development and capacity building for facilitating beneficial utilization of nuclear energy, within the framework of regional cooperative activities.

The second objective we are pursuing is to promote mutually beneficial bi- and multilateral cooperative activities with a view to effective and efficient execution of nuclear energy R&D activities. Examples are ITER, GIF, and other bi-lateral and multilateral cooperative R&D programs.

The third objective, which has been elaborated in detail in recent days, is to shape environment for Japanese nuclear firms to be able to export not only manufactured products but also nuclear power plant systems so as to increase Japan's contribution to the welfare of the global community. Keeping this objective in mind, the JAEA is to start NUDEC or nuclear HRD center for the comprehensive promotion of cooperative human resource development activities and JAIF has started JICC as one stop interface to international community for inviting emerging countries for consultation as to the deployment of nuclear power plant and education and training for that purpose.

In conclusion, I have emphasized in my talk that

a. Pursuing safe, secure, safeguarded and sustainable utilization of nuclear energy, Japan is promoting basic, near-term, mid-term and long-term R&D activities in

parallel and underscoring the importance of science, front-loading and spiral development approach.

b. Science-based modeling and simulation with high fidelity and ease are playing an important role in many parts of these efforts for brighter nuclear energy future.

c. In order to overcome difficulties faced with, the AEC is asking the Government and operators to inform the public the fact of the situation and the importance of nuclear energy for both assuring energy security and combating global warming, on the one hand, and strengthen comprehensive business risk management activities, with a view to maintaining the stable supply of electricity from nuclear power plants whatever technical and institutional delay or surprise may happen.

d. It is essential under any circumstances to maintain the public's confidence in nuclear facility operators, nuclear energy administrator and nuclear safety regulator, engaging openly and transparently with the public so that the public can participate in their decision making processes meaningfully.

Thank you for your attention and I hope you have a very successful and productive conference.