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A Strategy of the Research and Development of Nuclear Reactor Systems for Future Generations

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Thank you, Gail. Taking this opportunity, I would like to express, on behalf of Japanese delegation to this conference, our heartfelt thanks to you and your colleague for outstanding leadership and services to making this conference a real success. I also would like to extend my congratulations to the 50th anniversary of the founding of American Nuclear Society, which has been and will be an instrumental to the continuous success of the Pacific Nuclear Council and the PBNV conference series.

Ladies and Gentlemen, it is a great pleasure for me to have this opportunity of presenting to you my personal thought on the strategy for the research and development of nuclear reactor systems for future generations.

1. INTRODUCTION

When we discuss the future of nuclear power, it is important to have common understanding of its current status. From my viewpoint, the current state of nuclear power in the world is a very mixed picture. At the end of last year there were 440 nuclear power units operating world wide and together they supplied 16% of the world's electricity in 2003. That percentage has remained relatively steady for some time, meaning that nuclear electricity generation has grown at essentially the same rate as total electricity generation worldwide. It is often claimed that this is because world events such as the oil embargoes of the 1970s and the political unrest in the Middle East have influenced energy policy in many countries. In recent years, it is also pointed out that environmental concerns also have a growing impact on the energy choices made by nations worldwide. However, current expansion and growth prospects for nuclear power are weak and centered in Asia. Of the 31 units under construction worldwide,

18 are located in China, Taiwan, India, Japan and Korea. For Western Europe and North America, no new construction of nuclear power unit has started for some time and only a few constructions are expected to start in 10 years.

IEA predicted in its World Energy Outlook of 2002 that more than 40 percent of 5,000GW new capacity of electricity generation that will be built in 2000-2030 worldwide would be gas-fired, which is relatively cheap and environmentally friendly. The new capacity of nuclear predicted to be constructed is below 200GWe or one-tenth of gas-fired capacity. Nevertheless, in several important documents of long-term energy demand-supply forecast including IPCC Special Report on Emission Scenario (SRES), it is pointed out that nuclear energy should be a major component of global energy supply mix of the world in the latter half of this century to curve the accumulation of greenhouse gas in the atmosphere.

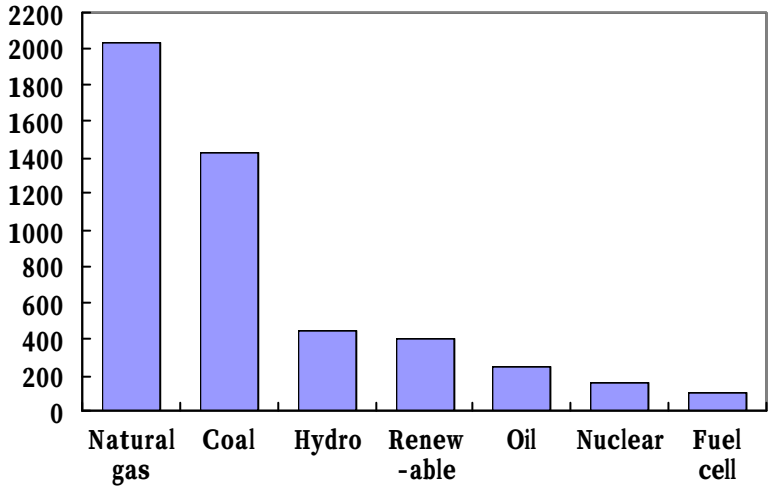

Fig 1. Predicted power generation capacity constructed during 2000-2030
Source: IEA Energy Outlook 2002.

Considering this situation, it is important for the world nuclear community to have a common vision that safe, economical, and reliable nuclear energy technology will contributes as a mainstay electricity and heat generation technology to fostering economic growth, providing security and fuel diversity, and enhancing environmental quality in many parts of the world in future. The major issue then is how we should move forward with this vision. I think it important to pursue a three-tier strategy, or a well-coordinated mix of near-term, mid-term, and long-term plan of actions. The purpose of my presentation is to give you my personal thinking on such strategy of the development of nuclear reactor systems for future generation consistent with our vision.

2. NEAR-TERM PLAN

As indicated by the recently published performance data, the existing nuclear power plants based on LWR technology are recognized as a safe, reliable and competitive power source in many countries. These characteristics should be maintained and improved in the long run to assure high levels of public investor and regulatory confidence in the nuclear power supply sector. At the same time, utilities in several countries including Japan are expected to continuously increase the nuclear power supply capacity based on LWRs, utilizing in LWRs the plutonium recovered from spent fuels by reprocessing, securing adequate interim storage capacity for spent fuel waiting for the reprocessing, utilizing at-reactor and away-from-reactor storage facilities, and preparing for the selection of the site for execution of geological disposal of vitrified high-level radioactive wastes from the reprocessing.

Therefore the goal of the near-term plan should be to continue the most effective utilization of these existing nuclear power plants and fuel cycle technologies by developing a broad range of technologies that promises the enhancement of their long-term performance. Objectives of the plan of actions to pursue this goal include;

(1) Develop and apply advanced technologies for increased output of existing unit:
(2) Develop and apply technologies for longer-term reliable operation of existing units:
(3) Develop and implement technologies for high burn-up fuel:
(4) Improve the economy of operation, adopting risk-informed maintenance rules and an accountability-conscious quality management system so as to maintain a high level of safety;
(5) Improve the economy of the construction and operation of fuel cycle facilities.
(6) Develop and apply technologies for economical dismantling of the nuclear facilities and economical management of radioactive waste generated in the process.

It is needless to say that the activities for these objectives should be promoted with toughness, resolution, and the consideration to details, as they will directly affect the performance of the existing plants and facilities.

3. MID-TERM PLAN

In the age of technological innovation, the competitive operation of current design units and facilities does by no means guarantee the adoption of the same type of plants and facilities for the replacement of retiring units or for the addition of the capacity. Generally speaking, deregulation of electricity market has sharply altered the financial landscape for utilities, which are no longer guaranteed a fixed return on investment. Therefore justifying the construction of such capital-intensive plant of current designs to stockholders is extremely difficult in times of emergence of innovative and neighbor –friendly modular power generation technologies such as renewable energy sources and fuel cells hybrids with gas and/or steam turbines for stationary power and more cost competitive advanced energy supply technologies like combined heat and power, etc.

The goal of medium-term plan therefore is to make more economical plants than the existing ones ready for construction on the one hand and to make their designs more human-conscious on the other so that they can compete with such emerging non-nuclear power technologies for replacement and addition of generation capacity. Accordingly objectives for the plan are;

(1) Reduce their capital cost by shortening licensing and construction time through standardization of design, sharing one-time engineering and licensing cost, developing modular cost-effective construction technologies, and developing associated planning and information management tools that reduce the labor intensity of these complex construction projects.
(2) Improve robustness in maintaining safety and reliability by adoption of passive safety features, enhance easiness of inspection, and minimize environmental impact by reducing volume of radioactive waste during both operation and decommissioning of the facilities.
(3) Improve their human consciousness by pursuing low occupational exposure; low work load in operation, maintenance, and emergency situation; and low man power need for inspection and maintenance.

Although major investment for these R&D activities should be performed by the private sectors that operate the plants and facilities, government should participate in the R&D of long-term nature and/ or generic nature to ensure that a broad range of technologies is developed that promises to enhance the long-term performance of existing facilities.

It should be kept in mind that without successful continuation of construction activities by fostering competitive plant design, it will become very difficult to maintain qualified suppliers

of nuclear equipment and components, contractor and architect engineer/engineering organizations with the personnel, skill, and experience in nuclear design, engineering, and construction.

4. LONG-TERM PLAN

P. Drucker sees in his book titled as “Management Challenges for The 21st Century” that the period we are living in as one of "PROFOUND TRANSITION” and the changes are more radical perhaps than even the structural changes triggered by the Great Depression and the Second World War". In the midst of all this change, he contends, there are five social and political certainties that will shape business strategy in the not-too-distant future:

- the collapsing birth rate in the developed world;
- shifts in distribution of disposable income;
- a redefinition of corporate performance;
- increased requirement of global competitiveness;
- the growing incongruence between economic and political reality.

The evidences to support his assertion are not few: followings are a few examples of events or indications related to these points recently found in Japan:

(1) In the discussion of future energy demand outlook, the final energy consumption in Japan is predicted to start decrease before 2030 and most likely before 2020, after a period of very low growth rate at around 0.1%/year, as shown in Figure 2.

(2) The pursuance of “zero emission society” through reduce, reuse, recycle and refuse movement has started to take momentum by the enactment of Basic Law for Establishing a Recycling-based Society In Japan and the sale of hybrid cars has started and the market are steadily expanding.

(3) Distributed electricity generations have successfully started to obtain several niche markets.

(4) The local governments that locate nuclear power plants are increasing the rate of tax on nuclear fuel, claiming that the cost of administration related to the plants have increased significantly in these days.

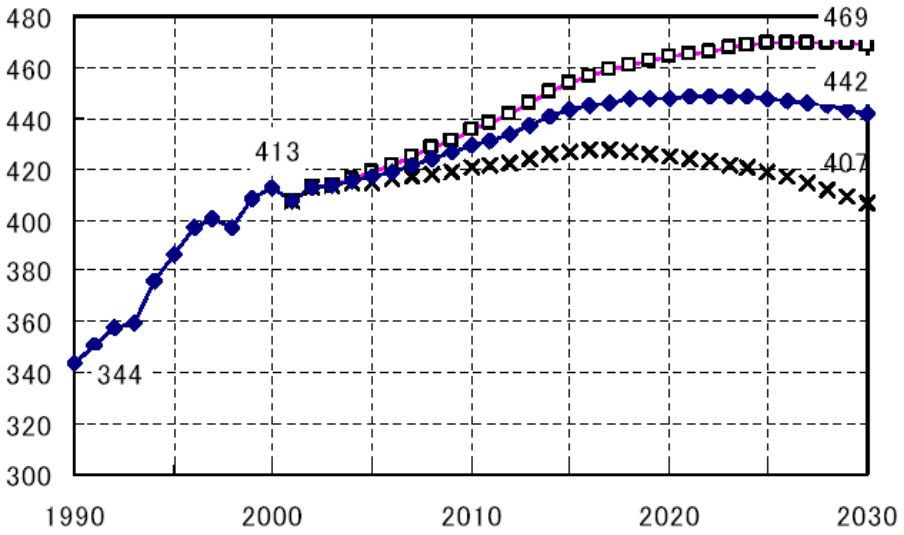

Figure 2. Preliminary Forecast of Final Energy Consumption in Japan (M kloe) prepared by METI for the Energy Supply-Demand Committee in 2004.

We should take it for granted in the strategic planning that over the long-term, not just new but truly radical new energy technologies will appear and address effectively the challenges of air pollution, climate change and energy supply insecurity while expanding energy service availability to all on the globe and that during the second quarter of this century technologies like photovoltaic power, fuel cell cars, hydrogen derived from fossil fuels with sequestration of carbon dioxide in geological reservoirs, and di-methyl ether or similar synthetic fuel derived from biomass become as commonplace as gasoline cars and coal-fired power plants are today.

Therefore the goal of long-term plan should be to explore innovative nuclear energy supply system concepts which can compete in such new energy market, making nuclear energy technology sustainable in terms of social acceptability as well as safety, economy and environmental protection. Objectives of the plan should include;

(1) to devise future reactor systems which are consistent with 3R or reduce-reuse-recycle, by burning not only most of U-238 excavating but also minor actinides generated during operation in order to minimize the amount of high-level radioactive waste to be disposed of so as to be able to contribute to the improvement of the human and environmental condition with smaller ecological footprint like clean car.

(2) to devise future reactor systems not only from technology base but also from better marketing plans and better support networks and all the kind of things necessary to sustain its

industry. One example is to pay due attention to the possibility that the demand for modular nuclear heat source reactors that can synergistically coexist with facilities to generate hydrogen from hydro-carbon material will be significant, taking into consideration the prediction that distributed grid and hydrogen economy will find not a small niche market in the center of this century, we should

The textbook on the technology development policy tells us that there are two primary gateways to control the development and flow of technology from either a push or pull standpoint. The push of technology is basically scientific discoveries. However, few, if any, successful products emerge only because of technology push. The pull of technology, or the marketplace, is basically the pull of the basic human needs; physiological, safety, belongingness, esteem, and self-actualization needs.

It should be kept in mind that the growing universality of technology now makes successful innovation much more frequently driven by market pull than it is technological push. Therefore it is important for us to determine in this exploration to survive the Darwinian Sea of evolution of technologies. Needless to say, government should invest their resource for this endeavor, though it is important for government to establish a level playing field to assure fair treatment of various options, nuclear and non-nuclear, and achieve higher transparency and accountability in decision making to prevent emergence of public mistrust on the advanced reactor R&D program due to lack of accountability.

5. CONCLUSION

The R&D of advanced reactor systems should be a part of strategic initiatives for making nuclear energy one of the most important energy technologies in the world where people use energy wisely and cleanly, protecting our environment. A well-thought mixture of near-term, mid-term and long-term plan of actions for sustainable development of nuclear energy utilization should be pursued with a common objective of pursuing the development of a from-the-cradle-to-the-grave infrastructure for the utilization of nuclear energy adapted to the society of coming age. It is a must for us nuclear community in this endeavor to be flexible to adapt our product of advanced nuclear reactor systems to a new paradigm to be emerged in future as we want nuclear energy to survive as expected in our vision. This is because though our knowledge on characteristics and costs of future technologies is limited, it is sure that the technologies survived are provided with new societal paradigm.