31st Fukushima Prefecture Energy Policy Review Committee

(Summary)

Date: **31 May 2004**

Venue: **Fukushima, Japan**

INTRODUCTION

The Moderator opened the 31st Energy Policy Study Group Meeting. He introduced Prof. Steve Fetter from the School of Public Policy at the University of Maryland. The Moderator then explained that Prof. Fetter is a physicist with research interests including nuclear arms control and non-proliferation, nuclear energy and health effects of radiation, and climate change, and energy supply.

OPENING REMARKS

Governor Eisaku Sato of Fukushima Prefecture began by noting that Fukushima was the largest power generating prefecture in Japan and supplies a quarter of the energy consumed in the greater Tokyo metropolitan area. Fukushima has hydro, thermal, geothermal and nuclear power plants.

The Fukushima prefectural government has been cooperating with the national government and power utilities with the understanding that the energy policy is a solid national policy. More recently, however, the national government has rescinded on its agreement regarding the transport of spent fuel and there have been attempts to bulldoze the program to burn MOX fuel in light water reactors (LWRs) despite waning public support. Furthermore, a program to build new power plant projects has been suspended unilaterally.

A growing sense of crisis prompted the Fukushima prefectural government to set up the Energy Policy Study Group in May of 2001, which I chair. In the process of our work, various questions arose regarding the national government's energy policy, and in September 2002, we put together an interim report in which it was recommended that on the question of nuclear fuel cycle, the government should seek the will of the nation while disclosing necessary information.

There are many questions raised about the fuel cycle. In relation to saving resources, economics, the plutonium balance, and the feasibility of fast breeder reactors (FBRs), there is a growing call to revisit and review the issue.

LECTURE

Prof. Steve Fetter of the School of Public Policy, University of Maryland, explained that the purpose of his lecture was to present work he had done with colleagues at Harvard University in comparing the economics of reprocessing and recycle to the economics of direct disposal of spent fuel. The basic question is whether it is better to dispose spent fuel directly in geologic repositories or to reprocess the spent fuel to recover and recycle plutonium and uranium. This question has been receiving increased attention in the world for several reasons: the accumulations of spent fuel at nuclear reactors and separated plutonium at reprocessing plants, a concern about the capacity of geologic repositories, the long-term future of nuclear power, and concerns about the link between the civilian nuclear fuel cycle and the proliferation of nuclear weapons and the relative proliferation-resistance of various fuel cycle options.

Our study focuses largely on costs. Currently, there is general agreement that reprocessing and recycle is more expensive than direct disposal but the dispute is how significant this cost difference is and how long it is likely to persist. Our conclusion is that this cost difference is significant and that it is likely to persist for a very long time—75 to 100 years.

In comparing direct disposal to reprocessing and recycle in light water reactors, this economic calculation takes the point of view of a utility that has discharged spent fuel and is deciding whether to dispose of it directly in a geologic repository or to reprocess the spent fuel. For the direct disposal fuel cycle, prices are quite stable and well known because there are free and competitive markets for uranium mining. The cost for the reprocessing fuel cycle is much more uncertain because there is not a competitive market for reprocessing and MOX fuel fabrication services. The costs in Japan are estimated to be significantly higher. The cost of reprocessing at Rokkasho is $3,000 per kilogram while the total operational cost in relation to the total amount of MOX to be reprocessed is $2,700 per kilogram. Hence, our analysis is very optimistic for reprocessing.

In regard to breakeven prices, even if reprocessing only costs $1,000 per kilogram, MOX fuel fabrication costs $1,500 per kilogram, interim storage of spent fuel costs $200 per kilogram, and reprocessing saves $200 per kilogram in the cost of geologic disposal, then in order for the reprocessing fuel cycle to be equal to direct disposal, the price of uranium would have to rise to $370 per kilogram, approximately ten times the price today. For Rokkasho, even if for every parameter we make the most favorable assumption for reprocessing, the breakeven uranium price would be very high if the price of reprocessing is $2,000 or $3,000. Rokkasho adds about ten percent per to the cost of nuclear generated electricity. As the price of uranium increases, that cost difference decreases, but if reprocessing is expensive, then the price of uranium must increase very greatly to attain the same cost of electricity.

We next compared direct disposal in light water reactors to fast breeder reactors, which make the most efficient use of uranium. Although fast breeder reactors are considerably more expensive than light water reactors, our study assumes only a ten percent difference. Holding all of other values fixed at their central values, the breakeven uranium price used in a fast breeder reactor is $340 per kilogram. So the price of uranium would have to rise substantially before breeder reactors would be economically competitive with light water reactors on a once-through cycle. In fact, with uranium at $50 per kilogram, the breeder reactor would have to be five percent cheaper than a light water reactor in order to be competitive with the light water reactor due to the additional cost of reprocessing.

The difference in the capital cost between the breeder reactor and the light water reactor on the breakeven uranium price depends on the ownership of the reactor because the cost of capital is lower for a government than for a regulated utility, and the cost of capital is lower for a regulated utility than for a private power producer. However, even if there is no difference in cost between breeder reactors and light water reactors, then the breakeven uranium price is still $130 a kilogram, which is very high. In terms of electricity, as the price of uranium increases, the cost difference decreases because the breeder reactor is much more efficient in its use of uranium, but the price of uranium must increase to $340 per kilogram before the cost of electricity is equal in both cases.

The main case for reprocessing as well as for breeder reactors is that with direct disposal, supplies of uranium will soon run out. The OECD estimates in its Red Book that 16 million tons of uranium are available at a price of $130 per kilogram. This is a great understatement, however, because countries rich in low-cost uranium do not bother to estimate their total supply and very little effort has been made to find new supplies. Other estimates are 40 million tons by geologists at Princeton University; 100 million tons, based on a ten-fold increase in doubling price, by the World Nuclear Organization; and 34 million tons, based on a price of $130 per kilogram, by the US Department of Energy.

Using energy scenarios developed by the International Institute of Applied Systems Analysis (IIASA) and the World Energy Council that measure annual consumption of nuclear electricity for the next 100 years, we have studied the amount of uranium that would be used worldwide in a once-through fuel cycle. The highest growth nuclear scenarios would consume the 17 million tons of uranium reported by the OECD at $130 per kilogram in about 75 years, but since these OECD estimates are too low, the amount of uranium ultimately available at this price is at least twice as great. Hence, even under the highest growth scenario, we will not consume the available uranium in the next 100 years. This $130 per kilogram cost is well below the breakeven price for reprocessing and so the study concluded that based on economics alone, reprocessing and recycle in the light water or breeder reactors will not be attractive for most of this century and we can postpone reprocessing and breeder reactors for at least 50 if not 100 years.

Economics are not the only consideration. There are others such as the effects of reprocessing on the requirements for geological repository, energy security considerations, non-proliferation considerations, and public and environmental health considerations. The impact of reprocessing on repository requirements has become very salient in the US recently because of concerns that Yucca Mountain might not be able to contain all the fuel that will be generated by US nuclear reactors. In the Advanced Fuel Cycle Initiative, the US has begun to see if reprocessing might make it possible to store more waste in Yucca Mountain. However, Prof. Fetter emphasized that reprocessing and recycle as it is currently practiced would not have this effect because of minor actinides, which increase the heat output of high-level waste. To increase the capacity of repositories, all the minor actinides would have to be recycled, making reprocessing and fuel fabrication even more expensive.

Energy security has been an important original consideration in Japan, but now the uranium market has become much more diverse and there should be no problem with buying uranium at competitive prices in the foreseeable future. But if there were such supply concerns, Japan could establish a strategic uranium reserve and this would cost less than reprocessing. Non-proliferation has also been a major consideration in fuel cycle choice because reprocessing and accumulation of separated plutonium in non-nuclear weapon states can generate concern. Reprocessing plants are also difficult to safeguard and there is a concern about maintaining different standards for different countries. Finally, for public and environmental health, both fuel cycles are adequately safe if operated properly but reprocessing does increase the possibility of accidents because highly radioactive material is being handled in the presence of chemical sources of energy.

QUESTION AND ANSWER SESSION

Governor Sato asked Prof. Fetter if he had had any opportunity during his trip to meet with Japanese experts in the nuclear industry. Prof. Fetter replied that he hoped to have a chance to meet them the following Tuesday.

Governor Sato asked how far had the discussion in the US gone in relation to reprocessing versus direct disposal. He then noted that Mathew Bun had said uranium could perhaps be recovered from seawater as well as granite and asked for a comment on that remark. Finally, Governor Sato asked for more elaboration about possible accidents at reprocessing plants.

Prof. Fetter responded that a vast amount of uranium was stored in seawater, but it was available at a very low concentration and the cost of extraction remained highly uncertain, perhaps at a price of about $300 per kilogram. Prof. Fetter commented that he was not an expert on the safety of reprocessing plants, but several types of accidents were possible, such as criticality accidents if there was plutonium in one place. Yet, he continued, in a modern plant like Rokkasho, this would be virtually impossible. For the discussion in the US regarding reprocessing versus direct disposal, Prof. Fetter explained that the original policy to adopt a once-through fuel cycle was made in 1975 by the Ford administration. The Bush administration has opened the door to advanced fuel cycles, introducing the Generation IV effort to explore new reactors beyond the light water reactor. In relation, there is a separate effort on the Advanced Fuel Cycle Initiative, which has a focus of exploring the degree to which reprocessing and the use of fast reactors could increase the capacity of Yucca Mountain.

The Moderator then asked if it was still necessary to consider the natural reserve of uranium, and asked for additional comments on trace elements like neptunium. Prof. Fetter replied that the uranium market was much more open and much more competitive today than in the late 1960s, when Japan first formulated its nuclear energy policy. Hence, he concluded that there was no need to worry about the supply of uranium. Concerning minor actinides, in a thermal reactor that relies on slow neutrons, the plutonium tends to absorb those neutrons and create heavier elements, leading to the buildup of other elements. These are a concern, he continued, because some have long half-lives and generate heat. The net increase in heat output of the spent fuel adds burdens for waste disposal. Hence, although these minor actinides can be efficient in a fast reactor, separating these and fabricating fuel that contains these elements would be more expensive and more radioactive.

A participant asked if changes in US political leadership caused changes in thinking about nuclear fuel cycle policy. In addition, he asked what was the US view on Japan's nuclear policy. Prof. Fetter responded that official government policy had become less and less important for the future of nuclear energy, which was being increasingly shaped by market forces and competition. Prof. Fetter then said the US government's views toward Japan depended on who you asked. Non-proliferation people, he explained, would prefer that reprocessing end everywhere, while those in the area of nuclear energy policy tended to look more favorably on reprocessing in Japan.

A participant asked if the disposal method of spent fuel for a once-through fuel cycle was better as compared to recycled fuel. Prof. Fetter replied that the disposal of spent fuel was about as safe and cost effective as the disposal of high-level waste. He added that there was no reason why reprocessing should have very significant advantages, either economic or related to long term public health and safety, or security considerations. If anything, the disposal of spent fuel was somewhat more convenient since it did not have to been processed before disposal.

A participant asked whether the cost comparison from the presentation could be applied to Japan due to the various differences between the US and Japan. Prof. Fetter replied that the cost figures were derived for the US, but if the analysis were done for Japan, direct disposal would be an even more favorable method since reprocessing costs in Japan were very much greater than in the US. For non-economic considerations, he continued, the comparison was more difficult. Prof. Fetter then explained that he gave very high weight to not reprocessing because he did not want countries such as North Korea to have the opportunity to claim it was only doing civil reprocessing like other countries when in fact it was diverting material for other purposes.

A participant asked Prof. Fetter what nuclear fuel cycle he was referring to. Then, he asked when fast breeder reactors would be made commercial, such as in 100 years time or several year's time, and asked what sort of investments were needed to commercialize FBRs. Prof. Fetter replied that the only nuclear fuel cycle today was the light water fuel cycle, either with direct disposal or reprocessing in light water reactors. He then stated that it was difficult to predict when fast reactors might become commercially available. In order for fast reactors to become competitive with light water reactors, they need to be as cheap as light water reactors, and that is difficult. In addition, even if that is true, fast breeder reactors will only be attractive if the price of uranium rises. Hence, it is my own view that the price will not rise that high for at least 75 or 100 or more years.

A participant asked if spent fuel direct disposal related to the interim or final disposal. Prof. Fetter responded that he was referring to the final disposal. Under this condition, he explained, the disposal of nuclear fuel would be in exactly the same condition as it was when removed from the reactor. The fuel rods would be placed in a cask and would be placed in Yucca Mountain. The problem is that there are currently no repositories available anywhere in the world and it will be perhaps 20 years before Yucca Mountain opens. In that time, the reactors will run out of storage space so we may need to temporarily put the spent fuel rods into dry cask storage. This is extremely safe and relatively cheap and I would strongly encourage Japan to consider this option for its own spent fuel. The decision on reprocessing can be deferred by 40 to 60 years by placing the spent fuel in dry cask storage. The cost of that is about $200 per kilogram, which is still much less than the cost of reprocessing.

CLOSING

Governor Sato noted the Prof. Fetter presentation was very easy to follow and answered many of the questions the Energy Policy Study Group had. With regard to the final disposal, it may be a more difficult issue here in Japan compared to the US because we have less land and Aomori and Hokkaido have already decided not to host a disposal site. Without a final repository site, we have had no other choice but to consider nuclear fuel recycling. I received a letter from the nuclear authority in Japan, stating that if Fukushima Prefecture does not promote the recycling of nuclear fuel, then there is nowhere for the spent fuel to go. The postponement of a decision on a final repository has forced us to consider more seriously this nuclear fuel cycle. Finally, I would like to encourage Prof. Fetter to share his views with his Japanese counterparts while he is here in Japan.