clear reactors to Europe for reprocessing, and then plutonium extracted from this spent fuel is shipped back to Japan for use as fuel in its reactors. Dr. Ihara emphasized that Japan is committed to the completion of its own industrial reprocessing facilities.

Conventional light water reactors utilize uranium nuclear fuel, which is extracted from naturally occurring deposits of uranium ore. The uranium is then enriched so that it contains more of the more fissionable isotope, uranium-235. In the fission process within the light water reactor, some of the remaining uranium-238 isotope is transmuted into the element plutonium-239. It is this plutonium that is extracted from the spent fuel rods in the current reprocessing program. Plutonium-239 is highly fissionable, like uranium-235, and can thus provide fuel for reactors. But conventional light water reactors only "breed" a fraction of the total fuel that they burn up. Thus, these systems require continued inputs of uranium fuel. A fast breeder, however, generates more nuclear fuel than it consumes. This excess fuel can then be utilized either to start up new breeder reactors or to fuel existing light water reactors.

Japan's prototype fast breeder, Monju, was built by the Japan Power Reactor and Nuclear Fuel Development Corporation (PNC), and began transmitting electrical power in August 1995. The Monju is the R&D prototype for the development of future commercial fast breeder nuclear power plants. In a fast breeder, the nuclear core operates at higher energy densities, which maintain the released neutrons at much higher velocities within the core than those of a conventional light water reactor. These fast neutrons permit such a reactor to breed more nuclear fuel then it consumes.

To maintain such a higher energy density, the fast breeder utilizes more efficient heat transfer fluids than ordinary water. In Monju, liquid metal sodium provides the means of extracting heat from the reactor core (**Figure 2**). (In conventional light water reactors as well as in the fast breeder, this extracted heat is used to generate high-temperature steam, which is then used to turn a turbine which generates electricity.)

In the Monju type of fast breeder, two heat transfer sodium loops are utilized: There is a primary loop that extracts heat from the core and a secondary loop that transfers this heat to water heat exchangers. The 1995 incident involved a leak in the secondary loop. Such incidents are not unexpected in such complicated systems involving high-temperature liquid metal, especially in an R&D prototype.

Eventually, the best method of breeding fission fuel will be via nuclear fusion reactors. Hydrogen fusion reactions, like those which power the Sun, do not consume neutrons. And in fact, the easiest fusion reaction to harness actually generates neutrons as its chief product. These "free" fusion neutrons can be utilized to breed copious quantities of fission fuel. For example, a 1,000-megawatt fusion reactor could provide enough fuel to run five to ten 1,000-megawatt fission reactors.

Nuclear energy needed for the 21st century

by Yoshinori Ihara

Dr. Ihara is vice chairman of the Atomic Energy Commission of Japan. This is a slightly edited version of the talk he presented on March 20, in Washington, D.C., to a meeting of the Washington chapter of the American Nuclear Society.

At the beginning of this century, the population of the world was only 1.6 billion, and now it has reached nearly 6 billion. It is expected to climb up to 10 billion in the middle of the 21st century. The tremendous increase in the number of human beings on this small spaceship "Earth" occurs in only two centuries. Our essential concerns are to be:

- How can we establish and transfer a wealthy advanced society to the next generations?
- What can nuclear energy contribute to these efforts?

The economic growth of OECD [Organization of Economic Cooperation and Development] countries remains at a low level. However, in developing countries such as those in Asia, economic growth and population explosion are causing a rapid increase in the demand for energy. These situations also bring the growing necessity to solve global environmental problems.

Recently, the Atomic Energy Commission of Japan held the Eighth International Conference for Nuclear Cooperation in Asia. In this conference, many representatives from nine Asian and Pacific countries expressed their strong commitment to the use of nuclear energy in order to solve these problems. I am confident that the utilization of nuclear energy is the intellectual challenge that will allow us to cope with common issues of all the crew on spaceship "Earth."

Japanese policy

There is no question that we must reconcile the development and utilization of nuclear energy with nuclear safety and non-proliferation. The Nuclear Safety Summit was held in April of last year in Moscow. It was significant that the heads of state from all attending nations, including Japan, endorsed the fact that safety should have the highest priority in the development and utilization of nuclear energy, and that a general consensus was reached to strengthen nuclear materials management.

The first international safety agreement, "The Convention on Nuclear Safety," came into force in October of last year, and should contribute significantly toward improving nuclear safety around the world. Japan will do its utmost to ensure

that the Convention is implemented as smoothly as possible.

The Non-Proliferation Treaty for Nuclear Weapons provides an important international framework in terms of reconciling nuclear energy development and utilization with nuclear non-proliferation. It is important for us to discharge our duties based on the Treaty while improving its universality. At the same time, voluntary non-proliferation efforts such as improving and maintaining transparency are required as we implement nuclear fuel recycling. In this regard, Japan has the basic principle that we have no surplus plutonium. Under this principle, we will do all that we can to improve transparency.

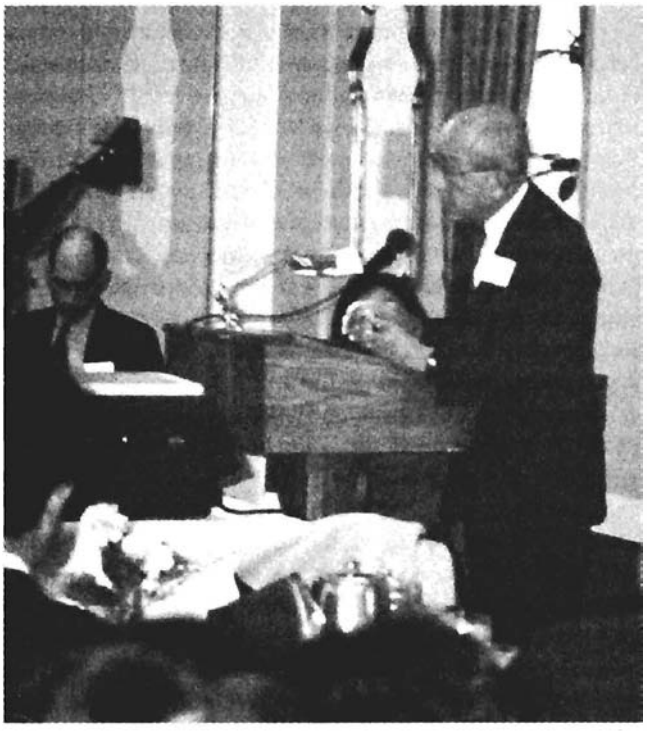
As the result of Japan's steady implementation of nuclear power generation, which is supplying over 30% of our total electricity, we are in a time where we need to harmonize nuclear energy with our communities. As nuclear reactors that can enormously enhance the efficiency of utilization of uranium resources, fast breeder reactors have been regarded to be a keystone to the nuclear energy utilization. Since 1985, the Power Reactor and Nuclear Fuel Development Corporation (PNC) has proceeded to build a prototype fast breeder reactor, Monju, at Tsuruga in Fukui Prefecture, and the reactor reached initial criticality in 1994. In August 1995, PNC managed to make the first transmission of power generated by that reactor, and it has been continuing trial operation since then.

In December 1995, a sodium leak occurred at the reactor Monju. No one was injured and no radioactive materials were released to the environment. Even so, considerable anxiety among the general public has been stirred up from the incident because of the inappropriate way information was released after the incident. This confirmed the fact that our efforts to make nuclear power a part of our communities were not sufficient. We had to take a serious look at the situation and renew our efforts to make nuclear power a part of the community. This in turn led to roundtable discussions on nuclear power policy.

Roundtable talks on nuclear energy policy were held 11 times between April and September of last year, among not only nuclear specialists, but also with a broad spectrum of researchers from the humanities and sociology, local governors, and intellectuals, as well as those critical of nuclear power, in order to ensure that policy issues were thoroughly debated.

Roundtable talks have raised such questions as nuclear power's position among our energy supplies, social acceptance in terms of how far nuclear safety should be pursued to make the general public comfortable, the so-called NIMBY—"Not In My Backyard"—issue, where people recognize the need for nuclear power, but refuse to have nuclear facilities located in their vicinity.

What remains a concern, is how we can evaluate and place Japan's 40 years of experience with nuclear energy development and utilization within the context of our maturing society. In the debate, from a worldwide perspective, we should also consider our society not only historically, but also based on a common understanding of the situation. In this context, roundtable talks have provided venues where anyone in Japan can argue various aspects of nuclear technology from their own viewpoint. The Atomic Energy Commission strives to ensure more open two-way communication between those who are in charge of nuclear development and the public.



Dr. Yoshinori Ihara: "I am confident that the utilization of nuclear energy is the intellectual challenge that will allow us to cope with the common issues of all the crew on 'spaceship Earth.' "

The Atomic Energy Commission made a decision titled "The Immediate Specific Policies on Nuclear Fuel Recycling," after considering the discussions made at the roundtable talks as well as proposals from the roundtable moderators. Over the course of the deliberations, it was reconfirmed that the development of nuclear fuel recycling is indispensable, as we continue working toward stable, long-term nuclear power supplies. This reality takes into account both the limited resources of and the need for environmental protection in Japan, which have been the basic underpinnings of our nuclear energy development and utilization effort since its inception.

The importance of setting up a nuclear fuel cycle system in Japan, including ongoing construction of a commercial reprocessing plant, was confirmed; specific policies related to urgent matters, such as the use of plutonium in light water reactors as well as the management of spent fuel, were established; and ideas about the future, related to back-end policies and fast breeder reactor development, were to be examined.

The use of plutonium in light water reactors is the most certain method from the standpoint of safety and economics at this point in time. First, plutonium recovered in overseas reprocessing is fabricated into MOX [mixed oxide] fuel in Europe and is then transported back to Japan, so that four reactors will be loaded with MOX fuel by the year 2000. When promoting this program, we will make every effort to gain the acceptance of the general public, and we are aiming at the use of plutonium in light water reactors by all the utility companies operating nuclear power reactors by the year 2010. In this way, the total number of MOX-fuel-loaded power reactors is expected to be 16 to 18.

Nuclear fuel cycle back-end policies are an important part of the development and utilization of nuclear energy as well, and since our generation has reaped the benefits of nuclear energy, we must take the responsibility to close the cycle. Especially when it comes to the disposal of high-level radioactive waste, we are studying these issues with respect to the technological, social, and economic aspects, through two special committees set up within the Atomic Energy Commission. These meetings are open to the public. One of the committes published a draft report of its recommendations at the end of last year, spent a month soliciting opinions from the general public, and is summarizing the final report incorporating the solicited opinions.

As far as fast breeder reactors are concerned, studies were completed in February of this year on the cause of the incident at Monju, and comprehensive safety inspections will be implemented. The experimental fast breeder reactor, Joyo, has been operating successfully for about 20 years, and continues irradiation experiments on fuel and materials. In the development of fast breeder reactors, although our belief in the long-term importance of these reactors has not changed, a new special subcommittee has been set up in the Atomic Energy Commission to address various issues arising since the Monju incident. Studies were initiated across a broad range of disciplines, on the direction of fast breeder reactor development, and the results of these studies will be faithfully incorporated in development policy.

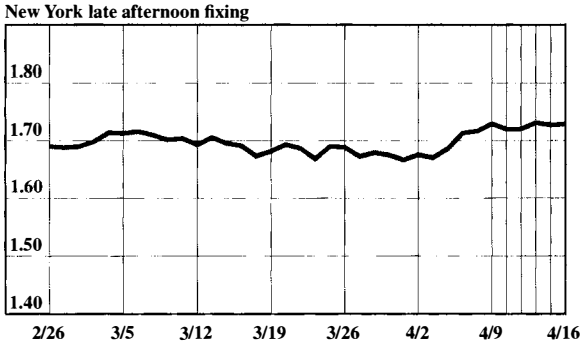
As one of the advanced countries in the field of the peaceful uses of nuclear energy, we consider it important to respond appropriately to the growing world's energy demands, and also to make efforts to resolve common issues we face such as integrating environmental protection with the use of nuclear energy. Only if we do so, I believe, can we establish a prosperous society in the 21st century. "A Vision for the Second Fifty Years of Nuclear Energy—Vision and Strategies" [a policy statement issued by and] reported by the International Nuclear Societies Council last year, will contribute to this purpose.

Now the Atomic Energy Commission is concentrating all of its efforts toward making nuclear energy a part of the community. I hope our experience, in turn, helps develop the peaceful uses of nuclear energy in the world for the coming century.

Currency Rates

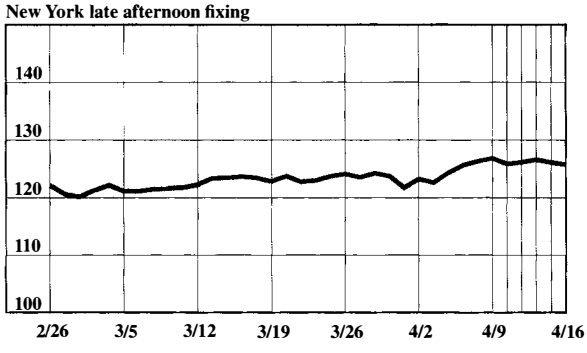
The dollar in deutschemarks

New York late afternoon fixing



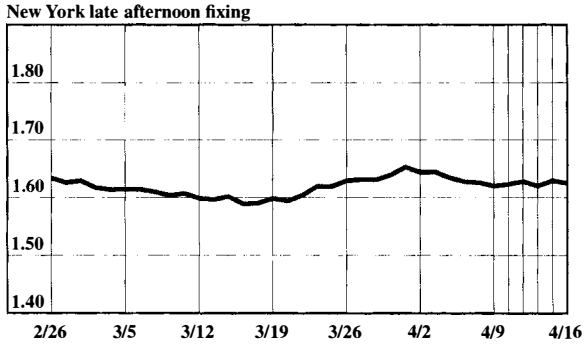
The dollar in yen

New York late afternoon fixing



The British pound in dollars

New York late afternoon fixing



The dollar in Swiss francs

New York late afternoon fixing