The OMEGA programme in Japan: A base for international co-operation

An overview of Japan's programme in transmutation and partitioning

by S. Kawarada

Alongside assurances of plant safety, the management of high-level radioactive waste (HLW) generated from the reprocessing of spent fuel ranks among the most important factors influencing the further development of nuclear electricity generation.

In Japan, national policy for managing this HLW is to solidify it in a stable form, store it for 30-50 years to allow cooling, and then dispose of it in deep geological formations. In addition, Japan's Atomic Energy Commission has expressed interest in technologies to convert HLW into useful resources and to maximize the efficiency of disposal. In support of programmes, two reports were issued in October 1988: *Long-Term Programme for Research and Development on Nuclide Partitioning and Transmutation (P-T)*, and *Development in Nuclide Partitioning and Transmutation*. The programme plots a course for technological development up to the year 2000. It is called "OMEGA", which stands for Options for Making Extra Gains from Actinides and fission products.

The programme was jointly stimulated by the collaborative efforts of the Japan Atomic Energy Research Institute (JAERI) and the Power Reactor and Nuclear Fuel Development Corporation (PNC). In the private sector, the Central Research Institute of the Electric Power Industry (CRIEPI) also has been carrying out R&D on this subject.

In January 1989, the Japanese government (represented by the Science and Technology Agency) proposed an international co-operative effort for the exchange of information relevant to partitioning and transmutation technology. It was proposed under the framework of the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (NEA/OECD). The first meeting on this subject was held in Japan in November 1990. Eleven OECD member countries and two international organizations, namely the IAEA and the Joint Research Center of the Commission of European Communities (CEC), participated.

Mr Kawarada is Director of the Nuclear Fuel Cycle Back End Policy at the Atomic Energy Bureau of the Science and Technology Agency in Japan.

The OMEGA programme in Japan

The OMEGA programme is to proceed in two phases. Phase-1 covers a period up to about 1996 and Phase-2 covers a period from about 1997 to 2000. In general, the basic studies and testing are to be conducted in Phase-1 to evaluate various concepts and to develop required technologies. In Phase-2, engineering tests of technologies and/or demonstration of concepts are planned. After the year 2000, pilot facilities will be built to demonstrate the P-T technology.

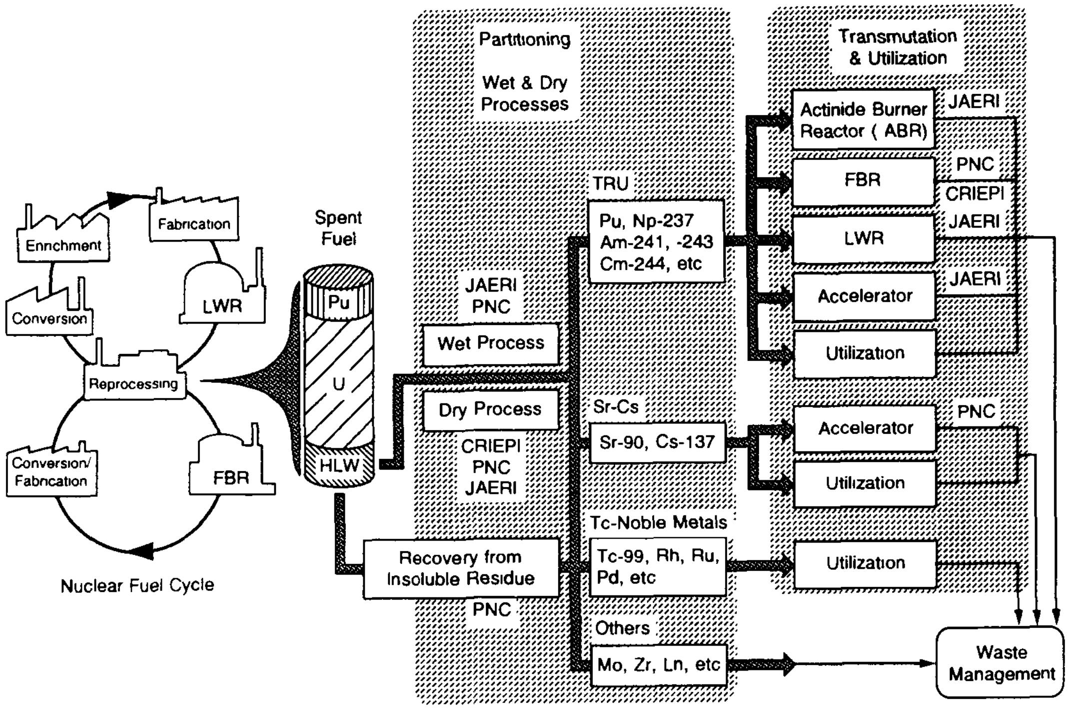
Partitioning. The principal technologies to be developed are in the following three subjects:

- partitioning technology for HLW;
- technology for recovering useful metals in insoluble residues from reprocessing; and
- technology for utilizing the separated elements.

The partitioning is to separate HLW into four groups: transuranic (TRU) elements; strontium/caesium elements; technetium/palladium elements; and others.

A harmonized and optimized system is to be studied to integrate the partitioning process with the PUREX process and to best utilize and manage nuclear resources contained in spent fuel. The feasibility and applicability of the dry process with molten salt, and sublimation/volatilization processes, also are to be studied.

The recovery technology is to be developed to obtain useful elements, such as ruthenium, rhodium, and palladium, from insoluble residues of dissolved solutions from reprocessing. Purification and isolation techniques also are to be developed, for example, for removing long-lived palladium-107 from the recovered palladium element.



R&D activities under the OMEGA programme in partitioning and transmutation

The fabrication technology of the separated TRU and fission products is to be developed for their further use or disposal. Immobilization of the separated strontium and caesium is needed for either their utilization or disposal.

Transmutation. The principal technologies to be developed are directed at the application of nuclear reactors and of accelerators.

Nuclear reactors provide an extremely rational means for the possible earlier realization of transmutation technology for TRU nuclides. The sodium-cooled fast-breeder reactor with mixed-oxide (MOX) or metallic fuel can be applied for transmutation of many kinds of TRU nuclides due to its relatively large high-energy fissioning. A fast-reactor that burns TRU is another candidate for development due to its more efficient transmutation capability compared to a conventional fast reactor. Another alternative is the thermal neutron reactor, when plutonium is used as nuclear fuel.

Owing to the recent remarkable development of accelerator technology, the application of accelerators is becoming more attractive as a means of transmutation. The proton accelerator is to be developed to transmute TRU and long-lived fission products by spallation reaction and the associated large number of emitted neutrons. The electron accelerator also is to be developed to transmute the nuclides having a small neutron cross-section, such as strontium-90 and caesium-137, by photo-nuclear reaction. A hybrid system combining an accelerator with a subcritical assembly will be studied to improve the overall energy balance of the transmutation system.

Related basic research. A reliable database of TRU and long-lived fission products is indispensable to the OMEGA programme. Underlying studies on physical and chemical properties of TRU and fission products will improve the understanding of the science and technology for separation and recovery of these nuclides from HLW; for fabrication of TRU fuel for recycling to reactors or accelerator-driven systems for transmutation; and for utilization of these nuclides. Nuclear data and thermodynamic data of these nuclides will be measured, compiled, and evaluated for reactor physics and material development. *(See figure.)*

Activities of NEA/OECD

In 1990, the NEA set up the International Information Exchange Programme on Actinide Fission Product Separation and Transmutation, following a proposal from Japan for the OMEGA programme. The Nuclear Development Committee of the NEA has been paying special attention to the promotion of information exchange on P-T among NEA member countries. This is because it is important to pursue the basic research of P-T and to increase the efficiency of such research. The programmes and activities in countries can be connected systematically by sharing information and pooling resources in a global framework.

Following the first information-exchange meeting in 1990, specialist meetings were held in November 1991 and March 1992; several others are planned. The second information-exchange meeting is planned in the USA in November this year.

Additionally, the newly organized NEA Nuclear Science Committee, which evolved from three previously existing committees, met in December 1991 for the first time and adopted a new programme devoted to studying the basic scientific aspects of P-T.

Main national research activities

In Japan and other countries, a variety of research and development activities are in progress that draw upon this international co-operative framework.

Japan. JAERI has been carrying out research on P-T in the following areas: partitioning technology; study of an actinide burner reactor; study of a transmutation system driver by means of an intense proton accelerator; and basic research related to TRU technology. The concept of double strata nuclear fuel cycle has been developed. *(See figure.)* The first cycle is the conventional fuel cycle and the second is the P-T cycle.

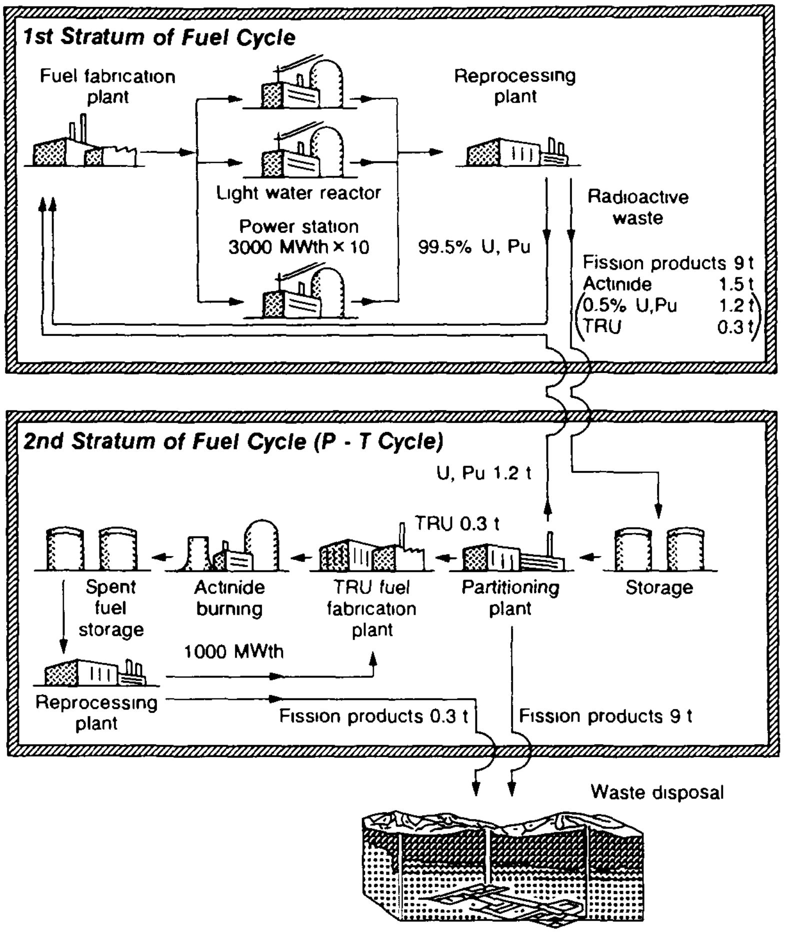
PNC has been carrying out research on P-T in the following areas: partitioning technology (wet and dry process); study of the transmutation system in a liquid-metal fast-breeder reactor using mixed-oxide fuel; study of the transmutation system by use of an accelerator; and related basic research.

France. The Commissariat a l'Energie Atomique (CEA) has been carrying out research on actinide partitioning since the 1970s. It has particularly looked at the extraction of neptunium and other long-lived elements from high-level waste solutions, in joint projects with the CEC. CEA is also investigating the transmutation of actinides contained in fuel elements in light-water reactors and in the PHENIX fast-breeder reactor.

Germany. The nuclear research centre at Karlsruhe is carrying on a research programme to extract actinides from used reactor fuel. It is also intending to examine various possibilities for consuming actinides in thermal reactors.

United Kingdom. British Nuclear Fuels (BNFL) is concentrating on improving its industrial fuel reprocessing process by the removal of neptunium and americium actinides from the recycled uranium and plutonium.

United States. The Oak Ridge National Laboratory (ORNL) is carrying out basic research on the characteristics of actinides by irradiating oxide fuels. Meanwhile, the Argonne National Laboratory is exploring the use of an Integral Fuel Cycle Reactor (IFR) based on metallic fuel. One of the characteristics of this metal fuel cycle is that all actinide elements would be recovered, recycled, and consumed. Several universities have put forward concepts for using high-energy particle accelerators in transmuting actinides and fission products.



Annual flow of radioactive waste through double-strata fuel cycle combined with partitioning and transmutation

A long-term research effort

Countries have been carrying out various R&D activities under the framework of the OMEGA programme. The P-T technology will become more and more valuable for reducing the long-term burdens of nuclear waste disposal and for enhancing the effective utilization of resources.

However, it should be recognized that the OMEGA programme does not aim to seek short-term alternatives for established or planned fuel cycle back-end policies. Rather, it is conceived as a research effort to pursue benefits for future generations through long-term basic R&D. It should also be noted that P-T will not replace the need to manage and dispose of HLW in the future. It will contribute to revitalizing nuclear-related R&D, thereby helping to bring the innovative technology into the 21st century in a healthy state. ❐