Japan Atomic Energy Research Institute in the 21st century

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Abstract. Major nuclear research institutes in Japan are the Japan Atomic Energy Research Institute (JAERI), Nuclear Cycle Development Institute (JNC), National Research Institute of Radiological Science (NIRS), and the Institute of Physical and Chemical Research (RIKEN). In the 50s and 60s JAERI concentrated on the introduction of nuclear technology from overseas. Energy security issues led to the development of a strong nuclear power programme in the next two decades resulting in Japan having 50 light water cooled nuclear power plants in operation. Japan also worked on other reactor concepts. The current emphasis of JAERI is on advanced reactors and nuclear fusion. Its budget of 270 million US$ supports five research establishments. JAERI has strong collaboration with industry and university system on nuclear and other advanced research topics (neutron science, photon science). In many areas Japan has strong international links. JAERI has also been transferring know-how on radioisotope and radiation applications to the developing countries particularly through IAEA-RCA mechanisms.

Introduction

Major nuclear research institutes in Japan were established in the late 50s, when Japan embarked upon research and development into the use of nuclear energy for peaceful purposes after US President Eisenhower's Speech at the United Nation on Atoms for Peace. These are the Japan Atomic Energy Research Institute (1956), the Atomic Fuel Corporation (1956, reorganized to Power Reactor and Nuclear Fuel Development Corporation in 1967), the National Research Institute of Radiological Science (1957), and the Institute of Physical and Chemical Research (1958).

The above four institutes have been under the jurisdiction of the Science and Technology Agency (STA) of the Japanese Government which is responsible for, among others, planning, formulation and promotion of policies on the utilization of atomic energy in consultation with the Atomic Energy Commission (AEC). AEC decides on the long term programme for Research, development and utilization of Nuclear Energy to meet the requirements and needs of the Japanese Government and society.

The promotion of research and development in nuclear related fields with active international co-operation, as well as proper introduction of advanced technologies from foreign countries, has greatly contributed to the enhancement of the Japan's technological level in these fields. In the course of the progress in research and development in Japan, these research organizations have been engaged in a variety of research and development activities in their respective fields.

The Japan Atomic Energy Research Institute (JAERI) has promoted diverse research and development, e.g. safety of nuclear facilities, high temperature engineering, nuclear fusion, radiation applications. It has established basic studies related to these activities, along with the development of fundamental technologies. JAERI has also made available its large research facilities such as accelerators, research reactors and material test reactors to outside researchers.

The key role of the Japan Nuclear Cycle Development Institute (JNC), which was renamed from Power Reactor and Nuclear Fuel Development Corporation (PNC) in October 1998, is to develop a wide range of technologies on, light water reactors (LWR), spent fuel management, conversion of Mixed Oxide (MOX) fuel, and the development of fast breeder reactor (FBR).

The National Institute of Radiological Sciences (NIRS) carries out researches related to radiology such as prevention of radiation harm to people and medical application of radiation including cancer treatment. NIRS applies a considerable portion of its budget to utilization of the Heavy-Ion Accelerator for Medical Applications (HIMAC) which is in service to treat various types of cancer.

In the Institute of Physical and Chemical Research (RIKEN), which carries out research and development on a wide range of scientific fields, nuclear research forms one part of research activities. While RIKEN is undertaking joint researches based on overseas research facilities in basic nuclear science like muon science, RIKEN has started to construct the RI beam factory which will exploit new science and technology for RI utilization. A major portion of the nuclear research funds in RIKEN goes to the 8 Gev Super Photon Ring which was constructed jointly with JAERI.

The budget of the Japanese Government for nuclear energy R&D in JFY 1999 is 347 billion yen (approx. US$ 3.3 billion). About 43% of its budget is allocated to JNC, whereas 34% is allocated to JAERI. Thus, from viewpoints of financial resources for R&D as well as scope and variety of research activities, JAERI has played a major role in research and development of nuclear energy in Japan.

General description of JAERI

Trends and priorities of research in relation to the Government policy

Since its establishment in 1956, JAERI has endeavored to fulfill its role as a core research organization in the nuclear field by engaging in advanced research and development activities. Guidelines for nuclear energy research in Japan have been given in the long term program formulated by AEC, which outlines the Government policy in the nuclear field. The policy is based on the principles of peaceful use, safety first, democratic management, independency, public disclosure of results and international contribution. AEC has revised the long term program approximately every 5 years to meet scientific, technological and social needs of the times.

1950s and 60s

In this period, the intention of the Government was to introduce technology which had been developed overseas so that Japanese research could catch up with the rest of the world. The highest priority was the development of facilities, such as research reactors, radiation facilities, and basic research facilities. The largest portion of the budget was supplied by the Government. Despite low funding for reactors other than light water reactors, research activities ranged widely from fission to fusion, including waste management.

1970s and 80s

Energy security has led to the promotion of nuclear energy development, and to the construction of nuclear power plants. By the end of this period, about 50 nuclear power plants

had been put into operation, including the advanced thermal reactor, "FUGEN". Safety research was the first priority for nuclear power plants. Nuclear research programs were expanded to the fields of radiation utilization, computer application, new concepts for nuclear reactors, the fuel cycle, and high temperature gas cooled reactors to meet the various requirements from the Government.

1990s

The long term program was revised by the AEC in 1994 to form the guidelines for nuclear research and development into the next century. This program recognizes the fact that the understanding and co-operation of the Japanese public and of the international community are indispensable for the smooth promotion of nuclear energy.

At present, JAERI's research and development aims at the further improvement of the reliability and safety of light water reactors as well as the increase in the choice of energy systems through the R&D of advanced reactors, nuclear fusion reactors, and so on. In addition to these research and developments, JAERI has recently begun advanced research which would lead to the overall development of science and technology in such fields as neutron science, science of the photon and synchrotron radiation, research on the utilization of radiation, environmental science, high grade calculation science, advanced basic research, and so on.

Current status of JAERI

JAERI's budget:

27 billion yen for the fiscal year(FY) 1999 A major portion (89%) of the budget comes from the STA and 5% of the budget from private sectors. The total operating budget escalated during the 1980s but has become relatively stable in recent years.

Number of employees:

2347 as of FY 1999. This consists of; 1105 researchers (47%), 844 engineers + technicians (36%) and 398 administrative staff (17%) The total number of employees escalated during the 1960s and since 1980, has decreased at a rate of 1% per year.

Number of research establishments: 5

Tokai-Establishment: 1071 employees as of FY 1998, consisting of 459 researchers (43%), 499 engineers + technicians (47%) ,and 113 administrative staff (11%).Activities: A wide range of research and development has been carried out using various test facilities including research reactors, safety research facilities, and accelerators. Basic research and technology fulfill the establishment's role as a comprehensive research centre in JAERI.

Oarai-Establishment: 318 employees, consisting of 154 researchers (48%), 131 engineers + technicians (42%),and 33 administrative staff (10%) activities: The development of fuel and materials for nuclear reactors is carried out using the Japan Material Test Reactor (JMTR). The high temperature Test Reactor (HTTR) reached first criticality in November 1998 to meet the necessity of diversification of the use of nuclear heat and high temperature technology.

Takasaki Radiation Chemistry-Establishment: 141 employees consisting of 78 researchers (55%), 27 engineers + technicians (19%), and 36 administrative staff (26%). Activities: radiation applications are conducted using the large Co-60 irradiation facilities and accelerators for electrons and ions. Many useful results have been obtained in the field of environmental conservation and upgrading of polymers.

Naka Fusion Research Establishment: 321 employees, consisting of 241 researchers (75%), 55 engineers + technicians (17%),and 25 administrative staff (8%). Activities: Experiment with a large Tokamak device (JT-60) is in progress for plasma physics. Related technologies have also been developed for a fusion reactor. Engineering design activities (EDA) for the International Thermonuclear Experimental Reactor (ITER) are being carried out for the next stage of fusion reactor.

Kansai Research Establishment: 96 employees, consisting of 79 researchers (82%), 5 engineers + technicians (5%), and12 administrative staff (13%). Activities: advanced photon sources (Spring-8) have been developed and their application to X ray lasers, 3D microscope ultra fine machining and medical diagnostics/treatment are being promoted. The development of ultra short pulsed lasers with high peak power and innovative applications in various fields will be carried out.

Mutu Establishment: 36 employees, consisting of two researchers (6%), 24 engineers + technicians (66%), and 10 administrative staff (28%). Activities: Storage of the reactor room from the decommissioned nuclear ship MUTU. Marine environmental research has been started.

New situations surrounding JAERI

Governmental reform

In the Government reorganization which is to be enforced at the beginning of the year 2001. The STA and the Ministry of Education will be combined into a new Ministry of Education and Science. Under the new ministry, JAERI will be expected to continue its current research activities as Japan's core research organization in both nuclear and advanced scientific research. Most of the present research activities are planned to continue into the 21st century. However, the jurisdiction over nuclear activities related to commercial power reactors will be transferred from the STA to new Ministry of Economy and Industry. This would entail changes in and abolishment of certain research subjects, reorganization and reshuffling of personnel, concentration of research resources on priority matters, etc., in accordance with the Government's reorganization.

Preservation of expertise

JAERI has always played a major role in nurturing a highly skilled and knowledgeable workforce in the field of nuclear research in Japan through the integration of young scientists and engineers in its nuclear research programs. At the outset of nuclear research in Japan, industries and other governmental organizations recruited their specialized staff from JAERI.

JAERI's ample facilities such as research reactors, accelerators and associated staff attract various researchers of universities and industries. Early on, JAERI's collaboration with other organizations was restricted to the nuclear field. With the diversification of research and development in JAERI, however, collaboration has been gradually extended to advanced sciences.

Collaboration with universities and industries helps JAERI maintain high scientific level. Now JAERI is attempting to recruit young scientists from universities and industry to meet the diversification of research subjects.

New relationship with industry

In the past years, major projects in nuclear research have been conducted by government sponsored institutes such as JAERI primarily as national projects. However, nowadays, the various nuclear power industries and utilities have already accumulated experience and technology in the utilization of nuclear energy. It is expected, therefore, that those industries and utilities will be capable of resolving on their own technical problems in the practical application of nuclear energy.

It can be foreseen that diversification of nuclear research will occur at nuclear research institutes. As mentioned above, JAERI has already diversified its activities even into such non-nuclear basic research as neutron science and advanced photon science.

Advanced technology and science which may have potentialities for commercial application will be transferred to the private sector for industrial application. The purification of ventilated air by electron beam irradiation is a typical example of technology which has been transferred to industry. JAERI researchers have developed an elimination technology for the effective removal of toxic volatile organic compounds from wastewater and exhaust gas.

International collaboration

International collaboration is highly emphasized in such projects as nuclear fusion, fast reactor and large accelerator development because they are too big for one country to maintain in the current world trend of slowing down of nuclear activities in developed countries. The role of international organizations will become more and more important in international collaboration.

JAERI will construct a facility for high-grade environmental analysis, " Clean Chemical analysis laboratory", through which Japan will positively contribute to fulfill its international roles with regard to strengthening safeguards in (93 + 2) plan. Chemical analysis of radioactive nuclide in the atmosphere in the form of super-microscopic substance will be improved to meet the requirements of Comprehensive Test Ban Treaty (CTBT).

JAERI will continue to promote international collaboration in the field of radiation utilization with Asian countries through RCA projects and also bilateral agreements.

Accident at nuclear fuel conversion facility at Tokai-Mura

On 30 September 1999 at 10:35 local time, a criticality accident occurred in the fuel conversion building at the uranium conversion facility of JCO Company Limited, Tokai-mura, Ibaraki, Japan. Uranium solution with an enrichment level of 18.8% uranium-235 and a mass exceeding several times the pre-specified limit was fed into a precipitation tank, resulting in a contravention of the legally approved criticality control. The outcome was that three workers were exposed to dangerous levels of radiation and several staff working in the facility and the public in the surrounding area were exposed to radiation, 161 people living within 350 m or so from the facility were evacuated, and some 310 000 people were advised to stay indoors as a precautionary measure.

An extensive investigation was carried out, of the following:

a) the facilities, including the design, managerial organization and operation,
b) regulatory control, including licensing and inspection,
c) emergency preparedness and response, including new laws and modifications to existing laws for nuclear accidents in the government,
d) medical care of the three workers suffering from radiation sickness and of the neighboring public,
e) the accident itself, including a detailed description of the procedures which were carried out at the time,
f) the safety network in the local community.

Government activities in connection with this accident were supported by JAERI because of its accumulated expertise in handling nuclear accidents. Research and development in nuclear field cannot be continued without the acceptance of the general public and the local governments. JAERI, together with other nuclear related organizations, is expected to make efforts to ameliorate the present situation and recuperate public acceptance.

Projections for the future

New situations described above will promote diversification of research subjects and expansion of collaboration with both universities and industries as well as with international organizations. However, no major drastic changes are foreseen in the tasks JAERI will undertake in the near future. The main categories of current research and development will be continued are:

1) Energy research:

- Improvements in the reliability and safety of light water reactors for long life fuel and cladding material and aging evaluation on main reactor components will be investigated in the field of nuclear safety research.

- High temperature gas technology and utilization of nuclear heat, and also high temperature advanced technology will be examined during the HTTR power up test in the field of high temperature gas cooled reactors.

- In fusion research, extensive research on plasma physics and fusion technology will be done through the activities of JT-60 and ITER. engineering design activities (EDA) of the ITER project will play a key role in fusion research for the next century.

- Light water reactors with a new design which will feature a high breeding ratio. Liwithwia compact reactor core, could be one candidate reactor for the next generation.

2) Advanced scientific research:

- A systematic approach using combination of neutrons, ions, electrons, photons, and laser beams will accelerate basic research in physics, chemistry and material science.

- In the field of the neutron science, technologies for nuclear transmutation with high-power proton linac will be developed for R&D of material science.

- Radiation application will be expanded in biotechnology and environmental conservation through the development of environment-friendly organic compounds. Basic research and related technologies for Table-Top-Terawatt laser, X ray laser in photon science and Spring-8 in synchrotron radiation will be continued.

Research and development will continue in JAERI in line with the long term program in which the role of the Government sponsored research institutes are clearly defined to enhance the system for promotion of nuclear research and development. It is emphasized that exploring new possible uses of nuclear energy to meet diverse needs is an important area of research to be pursued by the government sponsored institutes. Other important areas are education of young students and training of engineers, and public acceptance. Currently the long term program is under review, and a new version of the long term program is expected to be finalized at the dawn of the 21st century.