Nuclear R&D trend and the latest technical issues in Japan

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1. Introduction

As the Fukushima nuclear accident (March, 2011) and the Paris Climate Convention (Dec., 2015) impacted nuclear policies of nuclear power countries. Some of the countries maintained their national energy policy while others started phase-out stage of nuclear power utilization. The changed national energy policy affected to topic and tasks of nuclear research and development (R&D). Although the direction of energy policy did not changed, individual research theme was changed to focus on safety, spent fuel management, decommissioning, and so on.

Therefore, we investigated and analyzed the environment and topic/tasks of nuclear R&D of targeted countries (China, France, UK, Japan, Germany, and Switzerland) along with their national nuclear policy. In addition, the latest nuclear and radiological technology R&D trends of major international organizations, IAEA, OECD/NEA, and the EU, were investigated to supplement national analysis and understand global trends. In this paper, the investigation results about Japan will be shown. The original paper of our project (Analysis of Foreign Nuclear R&D Trends, T.J. LEE, et al., NRF-2018M2B3A1091132, 2019) details full results which covers the R&D trends of various countries and organizations [1].

In this paper, the main contents will be explained in two parts. One is the nuclear R&D trend of Japan and the other is the latest technical issues. In the first part, the Japanese national plan will be explained comparing with the Korean national plan. In addition, major nuclear related organization will be shown along with their roles.

Since the tragic Fukushima accident of 2011 was a big shock which affected the Japanese and the world energy policy, the policy and the governance which were announced after the accident will be shown. Furthermore, the current status of accident remediation will be explained because it has caught the attention of many people.

In the second part of the paper, the latest technical issues will be introduced. There are two major issues related to the accident, the removal of fuel debris and natural disaster countermeasures. They will be explained as specific research theme of Japan. In addition, two technical issues about spent fuel management, construction of the final deposition site and volume reduction of spent fuel will be introduced. To reduce the volume of high level waste, accelerator driven system (ADS) which can be used for partitioning and transmutation will be introduced as a Japanese frontier research. It can change high level waste to low level waste by using accelerator.

Followings are methods and results of this paper.

2. Methods and Results

This paper will be explained in two parts: the nuclear R&D trend of Japan and the latest technical issues. Despite two parts deal with different topics, they share the same research methods. Since the goal of this research is analysis of world nuclear R&D trends, enormous background study and expert interviews were required. In case of Japan, we contacted several domestic and foreign experts and arranged meetings with six experts in Japan. Also, we attended the Japan atomic industrial forum (JAIF) which was held on 9-10 April, 2019 to investigate industrial trend as well. For result, results of two parts will be explained separately in each sub-part of this section.

2.1 The nuclear R&D trend of Japan

2.1.1. National energy plan and related organizations

There are two major national basic energy plans: The basic policy for nuclear energy and the strategic energy plan.

- The basic policy for nuclear
  (原子力利用に関する基本的考え方)

This policy was created to provide long-term directions for nuclear energy in place of the Long-term Program for Research, Development and Utilization of Nuclear Energy and Framework for Nuclear Energy Policy, which had been established every five years before the Fukushima accident. The latest policy was published on July 2017.

- The strategic energy plan

This plan consists of realization of optimal energy mix in 2030 and scenario design for 2050 to establish long-term plan for energy overall. The latest (5th) plan was published on July 2018 and it inherited the policy basis of 4th plan (3E+S) and the goal of energy mix of 2030 (**Fig. 1.**). In addition, the realization plan was established in this plan.

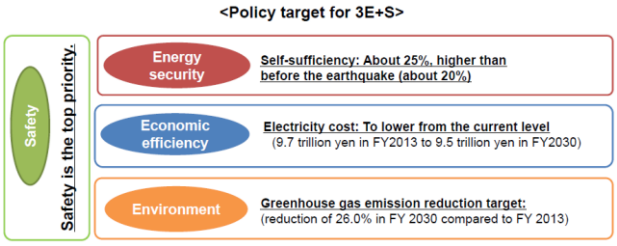

Fig. 1. Policy target for 3E+S

- Nuclear related organizations

Departments of the government, MEXT and METI, decide the direction of national R&D similar to structure of Korea. They also makes national plans and policies. To support central government, there are national research institutes JAEA and QST similar to KAERI. They cover overall nuclear and radiological technology R&D themes and lead the national R&D trend. After the Fukushima accident, the nuclear regulation authority (NRA) was established to regulate nuclear power plants (NPPs) within the country.

2.1.2. Statistics for nuclear power plants

Before the accident, the nuclear share in energy supply was 31.4% from 54 units. However, all the plants have been stopped after the accident and all of them were under the safety inspection. Some units were decided to be operated while most of them are under review, not filed, or to be decomissioned. Detailed information is depicted in **Fig. 2**[3]**.**

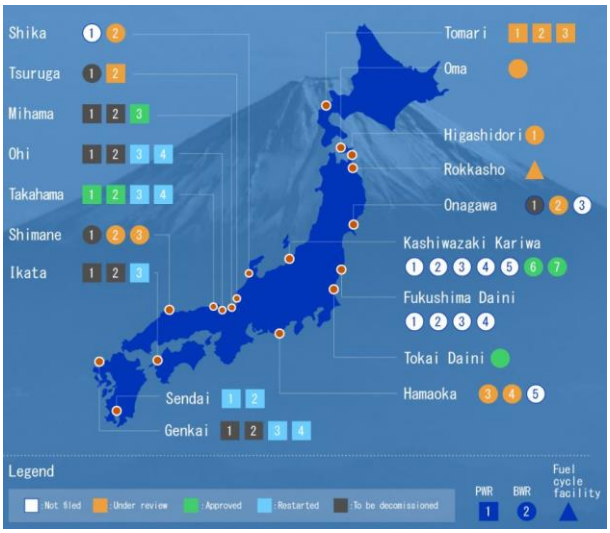

Fig. 2. Current operation status of NPPs in Japan (As of May 2019)

There are 25 units of NPPs which were filed their reoperation among 57 units. Also, 15 units were successfully authorized, and 9 units were re-operated. 18 units will be decommissioned including under review of decommissioning [2].

Because of low operation rate of NPPs, the energy self-sufficiency rate decreased from 20% (2011) to 6% (2019). Therefore, the energy self-sufficiency was targeted to 24.3% in the 4th strategic energy plan. Furthermore, fossil fuel dependency also increased to 32.3% comparing with 1.7% of nuclear share in power generation. From the 5th strategic energy plan, it is targeted to 20~22% of nuclear share. To meet this goal, more than 30 units of NPPs should be operated or constructed. Construction of new nuclear power plants (Simane-3 and Higashidori) has been resumed for the first time after the accident.

2.1.3. The policy and governance after the accident

After the accident, the Japanese government has published a variety of policies, organizations and institutions that reflect international conditions and address incidents and prevent recurrence. Japanese major policies in chronological order will be shown in presentation slides [4].

2.1.4. The current status of accident remediation

The accident is still retrieved by the government and TEPCO. In preparation for further earthquakes, seismic facilities of nuclear power plants are being strengthened. Nuclear fuel removal operations are in progress for units 1-4 and research is underway to remove fuel debris from the reactor by removing it from the containment. In addition, dismantling the reactor is investigated.

2.2 The latest technical issues
2.2.1 Removal of fuel debris

About the Fukushima accident, pulling out the fuel debris from the reactors is the main issue. To solve this problem, three conceptual ideas were suggested and it was stared to remove some fuels from specific units. The methods are different according to the status of each unit (**Fig. 3.** [5]).

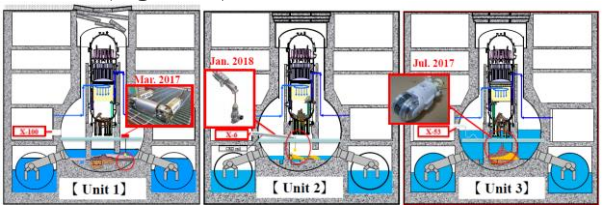

Fig. 3. Removal of fuel debris

2.2.2 Natural disaster countermeasures

As a part of natural disaster countermeasures, the strata structure is actively investigated. They are studying a reflection of soft and hard strata which can amplify the amplitude of vibration.

2.2.3 Spent fuel management

The NUMO is in charge of management of high level waste. Since they have investigated proper site for final

deposition and volume reduction of spent fuel, they released their research results.

- Construction of the final deposition site

The Japanese government is currently searching for candidate sites for final disposal, and they recently released the results of the geological survey for the construction of the final disposal site (**Fig. 4.** [6]).

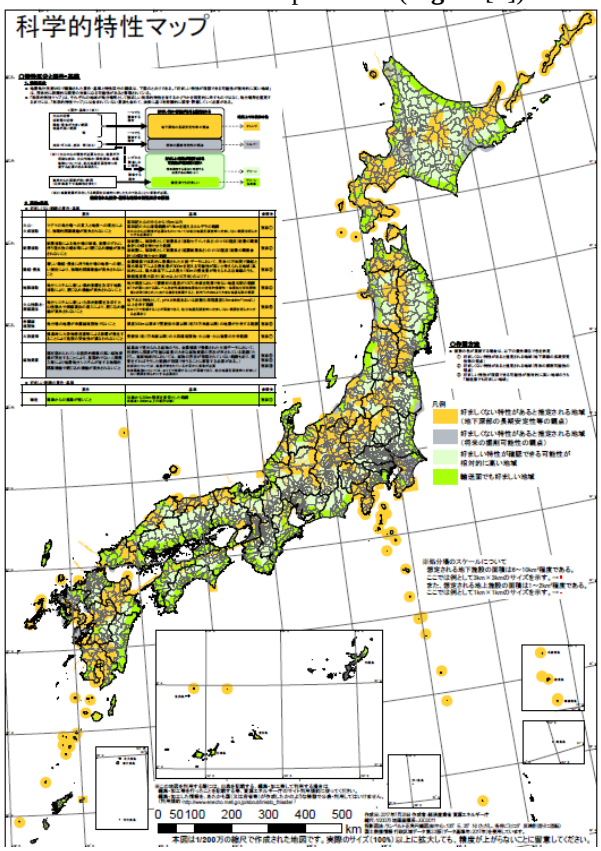

Fig. 4. Geological map for final depository of spent fuel

- Volume reduction of spent fuel

Since the interim storage facility of high level waste in Rokkashomura met its capacity limit, volume reduction research was started. The JAEA and ImPACT program are investigating the new transmutation technology by using accelerator.

3. Conclusions

After the Fukushima accident, Japan remodeled their R&D theme to prepare the future. Although they have faced social and technical issues related to accident remediation, they are struggling to achieve the best result. They still conduct research which is related to safety of NPPs, spent fuel management, and so on.

These result can be used in the development and strategic planning of nuclear R&D policy for nuclear technology innovation under the energy transition policy. The government can discover a research topic which we did not consider to establish our national plan through this study.

4. Acknowledgement

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