

STUDY AND PROPOSAL OF THE NUCLEAR POWER PLANT TECHNOLOGY FOR THE NINH THUAN 2 PROJECT

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ABSTRACT: The Ninh Thuan 1&2 Nuclear Power Plant Projects were approved on November 25th, 2009. At present, the task of NPP technology selection of these projects is an important and complex task. This report will show the acceptable method to create a set of criterion for selecting technology for Ninh Thuan 2 NPP project. The result of evaluation of three NPP technologies, such as ATMEA1, AP1000 and MPWR+ introduced in the Feasibility Study Reports of this project, will be discussed. In conclusion, the AP1000 technology is the first candidate for the Ninh Thuan 2 NPP Project.

Keywords: NPP, AP1000, ATMEA1, MPWR+, set of criterion.

I- INTRODUCTION

On November 25th, 2009 Vietnam's National Assembly approved the Government Plan on the implementation of the Ninh Thuan Nuclear Power Plant (NPP) Project composed of two NPPs called Ninh Thuan 1 and Ninh Thuan 2. Russia and Japan have been chosen as partners of the Ninh Thuan 1 and Ninh Thuan 2 NPPs Projects, respectively. At the first stage, each Project consists of 2 units of about 1000 MWe capacity.

At the end of 2011, the Feasibility Study (FS) reports of two Ninh Thuan NPPs had been implemented with Russian partner (E4 Company) and Japanese partner (JAPC - Japanese Atomic Power Company). One of the important tasks of the feasibility study report is the technology selection for Ninh Thuan 1 & 2 Nuclear Power Plant Projects. For the Ninh Thuan 1 NPP, the Russian VVER (Vodo-Vodyanoi Energetichesky Reaktor or Water-Water Power Reactor) technology will be selected. However there are several different versions of the VVER design, such as AES-91, AES-92, AES-2006/V491, AES-2006/V392M.... For Ninh Thuan 2 NPP, the NPP technologies of the appropriate vendors are considered as potential technologies for this project. Therefore, the task of technology selection for Ninh Thuan 2 is an important and complex task, especially the after of the Fukushima nuclear accident, the enhanced nuclear safety for designing nuclear power plant is required.

To contribute to process of technology selection for Ninh Thuan 2 NPP, Viet Nam Atomic Energy Institute (VINATOM) had proposed to study the design requirements, nuclear safety and create a set of criterion for selecting technology. At the beginning of 2013, research project had been performed in one year. However, because technology selection for a NPP project is complicated, as well as, lack of significant documents of technologies, then the project was behind schedule, it was finished in the early 2014. Its results have been now applied for nuclear power projects. The results of this project have used to make the Decision on the criteria for selecting technology for Ninh Thuan 1 NPP. This decision was forced on August 29th, 2014 (No. 7790/QD-BTC). For Ninh Thuan 2 NPP, the set of criterion for selecting technology currently is used by Ministry of Industry and Trade (MOIT) to make the decision in near future.

II- METHOD OF TECHNOLOGY SELECTION FOR NINH THUAN 2 NPP

The criterion for selecting technology for Ninh Thuan 2 NPP Project is built using the IAEA guides “Common User Considerations by Developing Countries for Future Nuclear Energy Systems” (No. NP-T-2.1) [1] and the European Utility Requirements (EUR) for LWR Nuclear Power Plants Volume 1 & Volume 2, Issued April 2001 [2]. The nuclear accident happened on March 11, 2011 at Fukushima nuclear power station in Japan gave the big lesson for the all countries which are planning to develop nuclear power program. Therefore, in the process of creating the criterion for Ninh Thuan 2 NPP, the requirements for nuclear safety design must be included clearly in the set of criterion of technology selection (according to documents were summarized by American and Japanese experts, established in more than 3 years ago) [3,4].

Especially, the specific requirements of Viet Nam must have a weighty factor which will contribute a significant role during the process of the set of criterion. Specific requirements of Viet Nam include the climate condition, nature environment, and culture condition, human... and they are suitable with the policy of nuclear power plant development in long term in future (50 – 100 years).

In other aspect, the Ninh Thuan NPP projects, at the beginning time Viet Nam should only use one NPP technology, and is the advanced pressurized water reactor, such as the NPP technology chosen for Ninh Thuan 1 NPP (type of VVER).

Basically, the steps to perform the creation of the criteria for selecting technology are provided below:

Step 1: Creating the set of criterion for selecting technology

According to this method, firstly the set of criterion for selecting NPP technology must be established. The steps to create the set of criterion for selecting specific technology for Viet Nam are presented on Figure 1.

These steps to create the set of criterion for selecting technology are followed:

1. Creating the brief criteria based on the requirements of Viet Nam, study the guidelines of IAEA, and consider the safety design requirements after Fukushima nuclear accident of other countries;
2. Taking feedback from independent experts on the criteria
3. Modifying the criteria based on the feedback of independent experts
4. Defining the weight of criteria based on evaluation of experts.

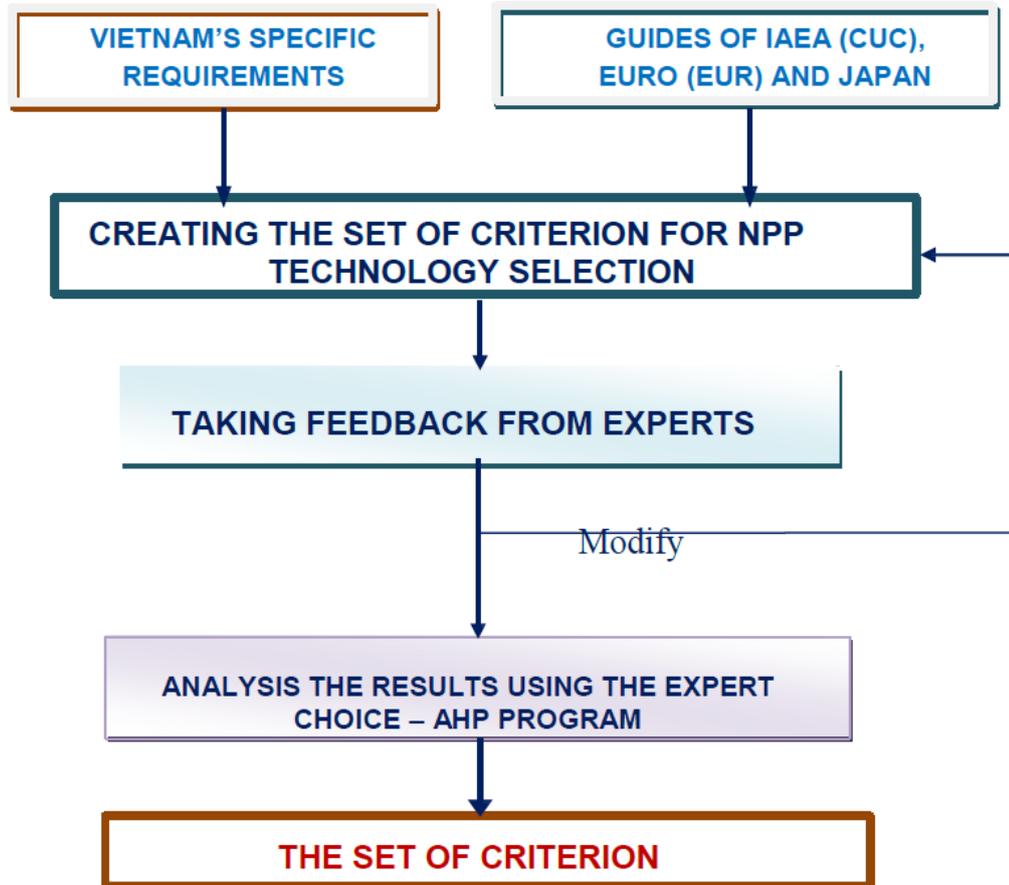


Figure 1: The steps of creation of the criteria for selecting nuclear power plant technology.

Step 2: Creating the database of nuclear power plant technologies

For Ninh Thuan 2 NPP, the four types of NPP technology given in FS by JAPC are ABWR (Hitachi - Advanced Boiling Water Reactor), MPWR+ (Mitsubishi Pressurized Water Reactor), AP1000 (Westinghouse – Toshiba) and ATMEA1 (Areva and Mitsubishi) [5].

Step 3: Experts’ opinion

After creating the criteria for selecting technology and collecting enough data base of the four types of NPP technology, the team held technique seminars with experts to present the technical information of these NPP technologies and the set of criteria. Then, the team obtained the experts’ independent opinion about the criteria.

In the analysis process, the weight factor of the experts defined by experiences, knowledge and major field of experts is included.

Step 4: Analysis the assessment results using the Expert Choice program - AHP and ranking technology

The next step of the technology selection method is to resolve the assessment results of four types of NPP technology of the independent-experts. This process is based on the Expert Choice program using hierarchical analysis method - Analytic Hierarchy Process (AHP) [6, 7]. Ranking table of the NPP technologies was organized in priority order, from high grade to low grade that will be obtained after processing comments about the four types of technology following the criteria.

In this step, the sensitivity analysis with the weight factor of the criteria is performed with different scenarios. The sensitivity analysis is necessary when studying the effect of each particular criterion to the final rank results of the types of technology.

Step 5: Selecting NPP technology for the project and technology development

The technology selection not only to take into account the long-term orientation of Vietnamese NPP program, but also to support for the development program of NPP technology under the basis of technology transfer policies and localizing process (including technology, equipment, human resources, management systems, regulatory, scientific capacity, consultation etc.).

III- CREATION OF THE CRITERIA FOR SELECTING TECHNOLOGY

As mentioned in Section 1, the creation of the criteria is based on the specific requirements for selection the best NPP technology for the investment project of Ninh Thuan 2 NPP. The criteria are suitable with the new requirements of the nuclear safety from the Lessons Learned from the Fukushima Nuclear Accident. Based on the given requirements, the criterion was built on the basis of selecting the most important elements, major groups, and that will be used to evaluate and select the NPP technology for Vietnam.

Based on the methodology proposed in Section 1, the criteria have been proposed, discussed, consulted experts' opinion, ranked, modified and integrated into the final version. The experts include experts from VINATOM and other units under the Ministry of Science and Technology, Ministry of Industry and Trade. The main areas (common criteria) were divided into 5 group, the small criteria in each area are integrated into the criteria for selecting the Ninh Thuan 2 nuclear power technology. The specific content of the criteria after performing the steps outlined in Section 1 are shown in the following pages.

The main fields of assessment, technology selection of Ninh Thuan 2 nuclear power plant Project and its weight are shown in Table as below:

No.	Requirements	Weight	Criterion	Abbreviation
1	Advanced Technology	20	The modernity and advance of technology	AD
2	Proven Technology	20	The provenness of technology	PT
3	Safety Requirements	25	The design of safety system	SD
4	Economic Requirements	20	Economic criterion	EC
5	Vietnam's Specific Requirements	15	Specific criterion	VS
	Total	100		

Method of grade for evaluating and selecting technology

The criteria are divided into five main fields and the experts evaluate the weight factor for each field. This process does not depend on the considered and evaluated type of NPP technology. Total weight factor is 100.

Considered and assessed technologies will be graded according to each main domain based on the total grade of the criteria. Grade for considered and assessed technology will be by production of weight factor and score for each area.

The NPP technology that has higher grade will be proposed as first candidate for Ninh Thuan 2 NPP Project.

IV- EVALUATION OF NPP TECHNOLOGY FOR NINH THUAN 2

The Expert Choice program [6, 7] was used by many experts in the world when they want to determine the priority for the sites or problems while they have a lot of candidates. This program was also used by experts of Institute of Energy, MOIT for evaluating potential of sites for renewable energy project and for planned sites of first nuclear project in Viet Nam, and to arrange order for sites located in the site plan to build nuclear power plant projects in future. Recently, Expert Choice program was used by VINATOM to propose the site in the preliminary report of construction site selection for the new Center for Science and Nuclear Technology.

The expert team of VINATOM used the Expert Choice program with permission of copyright from Institute of Energy to evaluate the set of criterion for selecting technology for Ninh Thuan NPP projects.

As above mentioned, the viewpoint for selecting technology of Viet Nam is to focus on the pressurized water reactor (PWR) technology. This type of technology has been applied for Ninh Thuan 1 NPP project in the co-operation with ROSATOM (Russian Federation). Therefore, the experts only evaluate and compare three types of PWR technology applied for Ninh Thuan 2 NPP, such as the AP1000, ATMEA1 and MPWR+. The following results only represent evaluation and comparison between three types of NPP technology.

Figures 2&3 show the results of the evaluation and rank of three technologies. The results showed that AP1000 has highest rank and is the best technology with 38%, MPWR+ was the second with 31.4% and the last one is ATMEA1 with 30.6%.

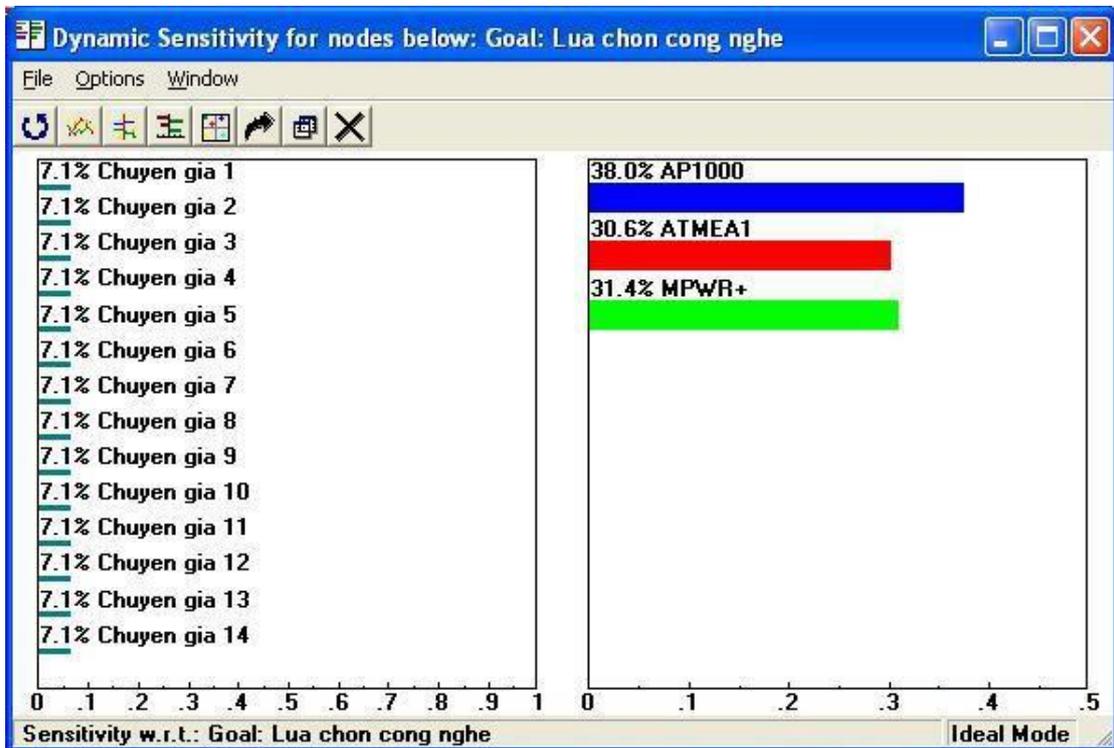


Figure 2: The evaluation results for ranking technology for Ninh Thuan 2 NPP project.

Because the ATMEA1 technology has not been proven yet, therefore this technology is located at the position with the lowest rank. The design of ATMEA1 is the theoretical model. Although this design was assessed preliminarily, but this design has not been certified/or licensing, and has not been constructed in any country yet (No country selected this technology except for Turkey planned to build with capital provided by Japan). The MPWR+ technology is considered and it doesn't meet the safety requirements, especially the new requirements after Fukushima accident. Additionally, MPWR+ is considered as "less advanced and modern" technology. However, this technology has been operated for a period of considerable time, so MPWR+ got a high score based on the assessment of proven feature. AP1000 technology is advanced and modern technology with the passive safety systems (Passive safety are essential criteria for Viet Nam, especially in specific conditions of Viet Nam). The feature of passive safety system will assure the long grace time (at least 72 hours) for the operators with un-damaged core. Although AP1000 technology has not been operated in any places of the world yet, but this technology is used to construct the NPP Projects in China, USA and UK. Many countries on the world select AP1000 technology for their nuclear power program now and in the future.

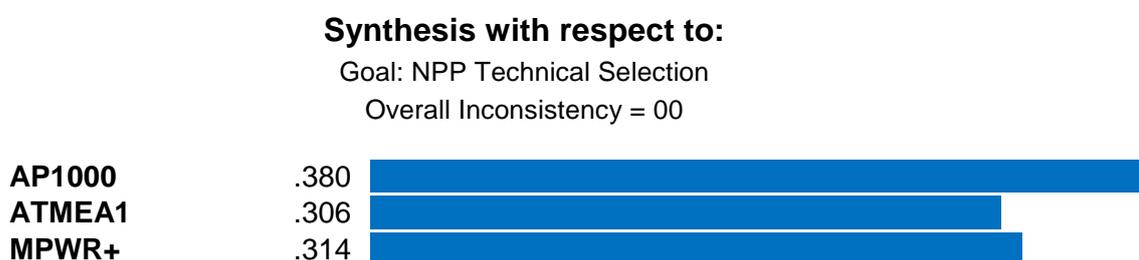


Figure 3: The evaluation results of technology rank with basic method.

V- CONCLUSIONS

The research project named "Study and Assessment the selection technologies for the Ninh Thuan 2 Nuclear Power Plant Project" is performed and analyzed by the Vietnamese experts. The result of this project is the set of criterion for selecting technology that purposed by JAPC partner for the Ninh Thuan 2 NPP Project. In this report, these three PWR technologies such as ATMEA1, AP1000 and MPWR+ are evaluated and ranked. The following steps have been performed in the research project:

- Study about the requirements for evaluating and selecting technology of IAEA, Europe;
- Study new requirements on nuclear safety that were recommended to apply after Fukushima accident;
- Study on methods and requirements as well as effects of nuclear technology selection to economic, social, and other aspects;
- Study specific requirements of Viet Nam in technology selection problems;
- Create set of criterion for selecting technology for Ninh Thuan 2, consists of 5 group of criteria, with its weight factor;
- Study and discuss on the NPP technology designs; create the databases of the NPP technologies introduced for Ninh Thuan 2 based on the basic requirements using the criteria;
- Develop the methods and apply the appropriate tools for evaluating and ranking NPP technologies for Ninh Thuan 2 (three NPP technologies);
- Evaluate and rank three NPP technologies according to the Expert Method; perform the sensitivity analysis with the weight factor of criteria.

From the results, we see that the AP1000 technology occupies the first position in comparison with the other NPP technologies (ATMEA1 and MPWR+). Thus, according to the judgment of experts, AP1000 technology is the first candidate for the Ninh Thuan 2 NPP Project.

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