

Nuclear Safety Culture Assessment for a Newcomer Country: Case Study of Jordan

Khalid KHASAWNEH^a, Yun Woon PARK^{b*}

^a*Nuclear and Quantum Engineering Department, KAIST, 291 Daehak-ro, Yuseong-gu, Daejeon 3015-701*

^b*BEES, Inc. L508 KAIST Munji Campus 193 Munji-ro, Yuseong-gu, Daejeon 305-732*

**Corresponding author: khalidk@kaist.ac.kr*

1. Introduction

Following the Fukushima Daiichi nuclear power plant accident, an increasing attention, followed by shifts and changes on the governments' policies, was directed toward the human factor and the safety culture and their effect on the safe operation of the nuclear power plants. For countries initiating or considering to start their nuclear power programs; developing a successful safety culture is of a great challenge, owing to lack of experience and the sensitive nature of the nuclear industry in general.

The Jordanian case was chosen since Jordan is in the early stages of its nuclear program and the establishment of an effective safety culture is crucial to guarantee the safe operation of its future nuclear facilities. It also should be noted that Fukushima accident has adversely affected the progress of the Jordanian nuclear program driven by the negative public opinion. The government shifts the policies toward enhancing the nuclear safety by enforcing the communication between the engaged parties and openness and transparency with public. In the wake of Fukushima accident the Jordanian government reassured the appropriate siting criteria and siting review, the leadership and the organizations commitment to nuclear safety by adopting advanced reactor technology, the consideration of modern operator accident mitigation strategies and the increased and close cooperation with IAEA and adherence to evolving international safety standards. [1]

Due to its significance, the safety aspects of the Jordanian nuclear program have been evaluated according to the IAEA safety culture recommendation. The Jordanian nuclear progress toward the fulfillment of the IAEA safety culture recommendations was evaluated and quantified based on IAEA missions, such as the Integrated Nuclear Infrastructure Review (INIR) and Integrated Regulatory Review Service (IRRS) missions.

A similar approach can be taken to evaluate the safety culture aspects of other countries, like the UAE, which has already started its nuclear power program, and even it can be applied to countries, like South Korea, which already has a well-developed program. The aim is to evaluate the safety culture aspects within the program and notice the drawbacks or the urgent items to be enhanced in order to guarantee the safe operation of the nuclear power plants.

2. Assessment Background

The safety culture status of the Jordanian nuclear program was evaluated based on the IAEA missions to Jordan, namely, the IRRS and the INIR missions [2][3]. Also the safety culture aspects of the Jordanian project were compared to the IAEA safety report no.74 (Safety culture in pre-operational phases of nuclear power project)[4]. A description of each document is provided on this section.

2.1 IRRS Mission

Upon the request of the Jordanian government an international team of senior safety experts conducted an Integrated Regulatory Review Service (IRRS) mission in June 2014. The purpose of the peer review was to review the Jordanian regulatory framework for nuclear and radiation safety to be consistent with IAEA safety standards. The mission was also used exchange information and experience between the IRRS review team and members and Jordanian counterparts in the areas covered by the IRRS.

The IRRS team carried out the review in different areas; including the responsibilities and functions of the government, responsibilities and functions of the regulatory body, the management system and the activities of the regulatory body and so on. Although there was no specific item for the safety culture and a detailed evaluation of the safety culture aspects within the regulatory body, the IAEA team concluded that the regulatory body, Energy and Regulatory Commission (EMRC), in Jordan is promoting safety culture in an inventive and constructive way by sending daily safety messages to all staff. Training sessions are held on safety culture and a survey is planned. This contributes to a common understanding of the key aspects of safety culture across the organization.

2.2 INIR Mission

Jordan Atomic Energy Commission (JAEC), on behalf of the Jordanian government, has requested two times the IAEA to carry out an Integrated Nuclear Infrastructure Review (INIR), the first one was in 2009 to evaluate the activities related to the decision-making process for the initiation of the nuclear program and the

second, in 2014, to evaluate the activities related to the second phase of the nuclear program.

As in the INIR mission report, Jordan has made notable progress in the development of its national infrastructure for nuclear power through the years. The INIR team found that JAEC is leading the development of nuclear power and is aware of the main actions necessary to implement the program.

The INIR main objective is to evaluate the development status of the 19 infrastructure issue described in the IAEA's Nuclear Energy series guide "Milestones in the development of a national infrastructure for nuclear power" (NG-G-3.1), and give recommendations and suggestions to Jordan regarding infrastructure development. As in the IRRS mission, there is no specific item or detailed evaluation of the safety culture aspects within the Jordanian nuclear project, however related information and analysis can be found in order to address the safety culture aspects of the project.

The INIR team recommended the urgent establishment of a nuclear power company which operates the planned nuclear power plants. In November 2015, the Jordanian government has established the Jordan Nuclear Power Company (JNPC). The INIR team recommended the JNPC and the EMRC (the regulatory body) to develop formal safety culture programs that are promoted by senior leadership. The programs should include empowering staff to raise safety concerns to senior leadership.

2.3 IAEA Safety Report no. 74: Safety culture in pre-operational phases of nuclear power plant projects

This report emphasizes on the early stage of a nuclear power project due to its importance and influence on safety culture. It is directed to the newcomer countries and illustrates the significance of the commitment to safety from the early stage. 11 main challenges, regarding establishment of the safety culture, expected to be faced by the newcomer countries have been defined. Those challenges cover different aspects as:

- 1- Multicultural and multi-national elements
- 2- General challenges for new comer countries
- 3- Leadership
- 4- Learning and feedback
- 5- Communication
- 6- Competence
- 7- Vendors and manufacturers
- 8- Regulatory body
- 9- Understanding nuclear safety and safety culture
- 10- Management system
- 11- Culture assessment

3. Evaluation and Ranking Method

The safety culture aspects and the commitment of JAEC, on behalf of the Jordanian government, and the EMRC, the regulatory body, have been evaluated based on the

IAEA safety report No.74 items. Each item and its sub-elements have been evaluated and compared to the progress done by the Jordanian government. The IRRS and the INIR mission reports and their recommendations were the bases of the evaluation of the Jordanian government progress to face with the challenges in the appropriate methods and approaches as suggested in the safety report No.74.

Based on the assessment and the information from the IAEA missions, each item in the safety report No.74 was evaluated and quantified, then the items have been ranked in terms of the progress done by Jordan to face with the challenges related to the safety culture aspects and its implantation. The detailed description of elements' ranking and quantification is in this section.

3.1 Method Description

In order to decide the current status of the Jordanian nuclear program in accordance with the IAEA safety report No.74; based on the IRRS and INRS reports of Jordan each challenge was classified as **X** (not faced, or a good progress was already performed), **Δ** (it's partially faced, or a little progress was performed; but more progress is required in order to satisfy the IAEA requirements), and **O** (this challenge is faced and no significant effort to fulfill the IAEA requirements was observed).

So that by comparing each element with the relevant section of the IRRS or the INIR reports, we judged it by comparing the actions done by the Jordanian government (regulatory body or the nuclear energy commission) with the IAEA requirement. If a little or no progress was noticed we marked the challenge as being faced, that's mean the government should consider it highly in its future planning. If the government already had some effort to partially satisfy the IAEA requirement, or some experience on this particular element was gained through the Jordan Research and Training Reactor (JRTR) project, the element was marked as partially satisfied and the government should improve it or consider it in its plaining for the project. Lastly, if we noticed that the government already considered the element and satisfied the IAEA requirement, we considered that this challenge as not being faced anymore and the government successfully addressed it on the past.

Here is an example of the evaluation process. General challenges for new comer countries have been listed in the IAEA safety report No.74, the challenge and its sub-elements are:

	General Challenges for newcomer countries		Evaluation basis
1	Early development of an independent, effective regulatory body	x	In 2007 an independent regulatory body was established JNRC
2	Lack of nuclear support organizations and	Δ	The government depends on the international parties to provide

	infrastructure		the required support, however the need to establish national organizations to provide the required support
3	Train national personnel	△	Several training programs with international organizations and countries
4	Development of long term, fully integrated strategies (A-Z)	△	The general policies have been defined, however the policies related to nuclear fuel cycle and for radioactive waste management are not fully developed
5	Global competition for nuclear expertise and suppliers of technology, services and components.	x	Jordan has assigned the bid for the NPP for a Russian consortium and the RR for a Korean consortium

	11	1	1	9	55	8	14.54
	4	2	2	0	20	16	80
	5	1	3	1	25	14	56
	9	1	4	4	45	17	37.78
	5	0	1	4	25	3	12
	6	1	3	2	30	14	46.66
	3	0	0	3	15	0	0
	7	0	5	2	35	15	42.85

For the first element, early development of an independent effective regulatory body, we marked it with X; that is, this element is not considered a challenge to the nuclear program of Jordan, since the Jordanian government has succeeded to establish its independent regulatory body (JNRC) in 2007. For the second element, lack of nuclear support organizations and infrastructure, we marked it as △; that is, this element is partially considered as a challenge facing the government in order to satisfy the IAEA safety requirements. Even though the government depends on the international parties to provide the required support, national organizations should be established to provide the local program with the needed assistance. So that, the government should work on this in order to fully satisfy the IAEA requirements and then to consider this element is not challenging anymore. As seen in the above table, each element was reviewed, evaluated and marked as a challenge (O), partially challenging (△) or not challenging anymore (x). The same process was repeated for all the challenges and their sub-elements mentioned in the IAEA safety report No.74.

3.2 Evaluation Table

In order to quantify the process done by the Jordanian government and the degree of the matching the IAEA documents a ranking table was constructed. Each challenge and its sub-elements (11 challenges with a total of 71 sub-elements) was given a specific weight depending on its contribution to the total challenges. Each sub-element was given a total value of 5, and based on the evaluation it was given a partial point, that is if X=5 point, △=3 points and O= 0 points.

	Total	X	△	O	Wt. total	Value	%
	5	2	3	0	25	19	76
	10	1	3	6	50	14	28
	6	0	3	3	30	9	30

The numerical values were given based on the evaluation procedure defined earlier. For example, for the aforementioned general challenges for newcomer countries, the IAEA defined 5 elements included in this criteria, as shown in the previous section. We found that 2 elements are not described as challenges to the Jordanian nuclear program, that is marked by X, and the other 3 elements was described as partial challenges; that is marked as △. As mentioned earlier, the elements marked with X will be given 5 point, and with △ will be given 2 points. And since there are 5 elements the total points for this challenge is 25. So that 19 points (2x5+3x3) out of 25 (5x5) are satisfied and the percentage of the requirement fulfillment is 76%.

Other example for our evaluation, is for the cultural assessment challenge defined in the IAEA safety report No.74. The IAEA defined 3 elements related to this challenge, namely;

- 1- Developing and maintaining an accurate picture of safety culture strengths and opportunities for improvement in a multi-organizational and dynamic project environment.
- 2- Current safety culture assessment methods and approaches may not support the identification of safety culture deficiencies in the pre-operational phases.
- 3- Performance indicators established for major projects often focus on the quantitative measures of industrial safety, schedule and cost.

During our evaluation, we decided that those three elements are not satisfied by the Jordanian government and we marked them as (O). Since O was assigned a zero points, the percentage of the satisfaction of this challenge to the IAEA requirements is 0%.

As another illustration for our evaluation process an example for the communication challenge is presented as follow. There are 7 sub-challenges defined by the IAEA safety report no.74, in which 5 of them were found partially satisfied (△) and 2 of them are fully not satisfied (O), based on the INIR and the IRRS missions reports. So that 15 points (5x3+2x0) out of 35 points

(7x5) are satisfied and the percentage of the requirement fulfillment is 42.85%. This method applied to all challenges as shown in the table above. Due to the lengthy description of each challenge and its sub-elements evaluation we presented here only few examples for illustration.

4. Ranking Table

Table: Ranking Table

	Challenge	percentage
1	Multicultural and multi-national elements	80
2	General challenges for newcomer countries	76
3	Leadership	56
4	Learning and Feedback	46.66
5	Communication	42.85
6	Competence	37.78
7	Vendors and manufacturers	30
8	Regulatory body	28
9	Understanding nuclear safety and safety culture	14.54
10	Management system	12
11	Culture assessment	0

From the evaluation table, the percentage of the fulfillment of the IAEA requirements for each challenge was obtained and then ranked, from the highest percentage to the lowest as shown in the previous table.

The challenges can be grouped into 4 groups, the first in which the Jordanian government highly satisfied the IAEA requirements. It includes the multicultural and multinational aspects and the general challenges for the newcomer countries.

The second group is somehow satisfied, however needs to be considered in the future planning, which includes the leadership, learning and feedback and communication. The third group includes the items that only slightly covered or satisfied by the Jordanian government. This group includes the competence aspects, vendors and manufactures and the regulatory body development. The last group includes the items that is totally not satisfied by the Jordan government and does not meet the IAEA requirements, and it should be included shortly in the short term planning and enhanced. Those item are related to the understanding of the nuclear safety and the safety culture, the management system development and the cultural assessment.

5. Conclusion

Based on the IAEA safety report no.74 (Safety culture in pre-operational phases of nuclear power project), the IAEA Integrated Nuclear Infrastructure Review (INIR) mission report and the IAEA Integrated Regulatory Review Service (IRRS) mission report; the Jordanian nuclear power program was evaluated in terms of the

extent in which the safety culture aspects were considered during the planning phase of the project.

The progress in the Jordanian nuclear power project in order to satisfy the IAEA requirements was quantified and ranked. A good progress was shown in some aspects, for example in the multicultural and multinational elements and the establishment of an independent and effective regulatory body. However, some elements, concerning the understanding of the safety culture, management system of the regulatory body and the cultural assessment was not satisfied and an urgent need to focus on and enhance those aspects are required by the Jordanian government. Some elements, for example the leadership, communication and competence, have partial fulfillment of the IAEA requirements. However enhancing those aspects is required in the short and the mid-term in order to guarantee a well-established nuclear power program.

A similar analysis could be done to other countries who are initiating there nuclear power programs, like the UAE and Saudi Arabia. And a comparison between the different cases of several countries with different degree of progress in their national nuclear program can be made, for example between the UAE-which already has a significant progress- and Jordan- just in the early stage of planning.

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