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The National Infrastructure and Public Perceptions Survey Towards Introduction of a Research Reactor in the United Republic of Tanzania

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1. Introduction

The history of research reactors (RR) dates back to 1942 when the first reactor was assembled by scientists under Enrico Fermi at Chicago Pile-1 (CP-1) in the United States. During that time, the self-sustaining nuclear chain reaction was achieved and controlled, thereby initiating the controlled release of nuclear energy [1]. Research reactors are either civil or commercial, used to provide a neutron source for research and other purposes. Their power rating is relatively small and designed to produce megawatts with an output which can range from zero (i.e. critical assembly, up to 200 MW(th). Also, according to the IAEA, research reactor infrastructure and understanding of the public's viewpoint are important considerations for any new research reactor as this can influence safety, security, public cooperation and direction of future nuclear activities. Considering the requirements and vision stated in the National Nuclear Policy of Tanzania 2013 of the URT [2], our country is planning to introduce a research reactor (RR) to accomplish many objectives ranging from radioisotope production and nuclear medicine to neutron beam research and applications as well as materials characterization and testing, computer code validation, and various elemental analysis and new developments in nuclear power. However, introducing a new research reactor to a country brings different challenges and issues ranging from public perceptions to research reactor infrastructure. Therefore, conducting an extensive and thorough survey is important to our country which lacks previous research in this field. This survey therefore, primarily intends to collect and analyze public opinions from the URT. Secondly, gather data from the available research reactor infrastructures in the United Republic of Tanzania (URT) and compare it with international standard documents such as the Specific Considerations and Milestones for a Research Reactor Project, International Atomic Energy Agency [3].

2. Literature review

The URT's approach is to utilize the IAEA for advice on how to improve the RR infrastructures as our first major nuclear investment and opportunity to benefit from the peaceful uses of nuclear technology. The introduction of the first research reactor in a country requires the establishment of an adequate national infrastructure, which covers a wide range of technical areas to ensure that national and international commitments and obligations, particularly regarding safety, security, safeguards and emergency preparedness, are met during the construction, operation and decommissioning phases [4].

On the other hand, the IAEA has published the milestone approach in which they differentiated among 19 national infrastructure issues to be addressed by countries considering the introduction of a nuclear power program. Having an RR or other facilities that involve nuclear material, means that country has already become familiar with these issues, for example, nuclear security, safeguards accountability, and regulatory oversight. RR programs need nuclear safety cultures that can be applied to a more advanced nuclear power program [3]. Therefore, the URT will require an extensive and thorough survey to validate the existing infrastructures for a new research reactor.

Just like other countries in the world, the URT will greatly emphasize social aspects when the introduction of a research reactor in the country is complete and its contributions are realized. In a country like Brazil, where nuclear activity is geared toward peaceful purposes, any organization operating a research reactor should emphasize its commitment to social, environmental, economic and institutional aspects. Social aspects include research and development, production and supply of radiopharmaceuticals, radiation safety and special training for the nuclear sector [5]. These aspects are of particular importance in the URT's development of a research reactor.

3. Methods and Results

3.1 Methodology

In order to achieve better results from this survey with limited time and financial resources, two different data collection methods were employed. Firstly, the survey regarding infrastructures for a research reactor facility in the URT was performed by collecting the available information from the Tanzania Atomic Energy

Commission (TAEC) and the Ministry of Education, Science and Technology (MEST) in the URT. Secondly, a questionnaire was distributed and a subsequent statistical analysis was performed to capture and analyze public opinion on five issues. The questionnaire was used to gather the negative and positive opinions of the government officials in the URT with regards to the introduction of a research reactor**.** However, for the purpose of this paper, only social opinions have been analysed and discussed.

3.2 Results of the study

The developed questionnaire consists of 21 questions divided into five sections (A-E). The sections include Tanzania National Nuclear Technology Vision & Policy of the URT, the expectations and roles of domestic research reactor to the URT, nuclear safety improvement in the URT following introduction of the domestic research reactor, human resource management with regards to the introduction of a research reactor in the URT, and the research reactor national infrastructure currently available in the URT and their expected improvement in the future.

Table 1: Proposed Questionnaire

No.	Questions
	Section A: The URT's National Nuclear Technology Vision &Policy.
1	The URT government should consider developing nuclear research reactor program.
2	The current technological situation places a research reactor as a necessity in the URT.
3	A research reactor will be a useful research tool in the URT.
4	The public is concerned about research reactor development as a major issue in the URT.
5	The URT government recognize the challenges of introducing and sustaining a nuclear research reactor.
	Section B: The expectations and roles of domestic research reactor to the URT.
6	A research reactor is a premier research tool for achieving Millennium Development Goals and the National Vision 2025.
7	The URT can highly benefit from the utilization of domestic research reactor.
8	Multi-purpose of domestic research reactor would improve URT people's quality of life.
9	A research reactor will serve as a valuable resource for scientists from across a broad spectrum.
	Section C: The URT after introduction of the domestic research reactor.
10	A research reactor will improve safety infrastructure for advanced nuclear facilities and activities in the URT.
11	A research reactor program can help to shape nuclear safety culture in URT.
12	Direct introduction of a research reactor program without social awareness impairs trust in safety.
	Section D: The Human Resource Management.
13	The URT has enough human resources to develop a nuclear RR program.
14	A research reactor program will be a useful training center for scientists and researchers.
15	A research reactor can secure human resource development in the URT.
	Section E: The RR national infrastructure currently available in the URT.
16	The URT have enough infrastructure to accommodate the expected research reactor program.
17	A research reactor would improve the nuclear legal framework.
18	A research reactor would improve the regulatory framework.
19	A research reactor will strengthen the national position.
20	Introduction of a research reactor program will enhance Regulatory Body independence.
21	The presence of a domestic research reactor will improve the economics sector for URT.

In this survey, officers and staff members of the Tanzania Atomic Energy Commission (TAEC) were asked to provide their responses. A total number of 40 questionnaires with a total of 840 responses were collected from 60 initially distributed questionnaires. **Table 2** shows the designations and number of participants.

Table 2: Designation of and number of responders

Designation	Number of responders
Principle Scientific Officers	5
Senior Scientific Officers	10
Senior Engineer	4
Scientific Officers	3
Assistance Engineer	8
Scientific Assistant	10
TOTAL	**40**

The score ranging from 5(Strongly Agree) to 1(Strongly Disagree) were used. The former indicates positive perception and the later indicates negative perception. A neutral score of 3(Neutral) was given when the participant remained centred such that he/she neither agreed nor disagreed. This indicates that the participant had no opinion about the context (Bradley et al 1999). Finally, a one sample t-test was performed using SPSS 22.0.0.0 for all analyses to check the significance of the received responses. The result showed that Q5, Q7, Q9, and Q19 are non-significant as participants gave neutral responses

against these questions whereas Q10, Q13 and Q14 are significant relative to other questions.

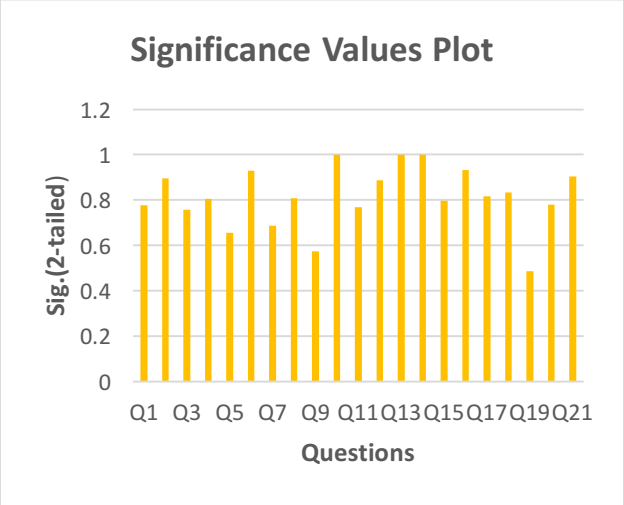

Figure 1: Significance values against questions.

4. Conclusion

This paper has analyzed and brought us to the realization of the inputs of the public on research reactor introduction in the URT. A questionnaire was used as the means to investigate this area. Despite the difference in opinions among the consulted government officials, it was generally revealed that the public is positive at large. Our analysis shows that most questions received strongly agree responses relative to the strongly disagree responses and neutral responses. For instance, a question on whether a research reactor will be a useful research tool in the URT received highest score of strongly agree responses relative to a question on whether the URT has enough human resources to develop a nuclear RR program which received highest score of strongly disagree responses. Furthermore, a question on whether the public is concerned about research reactor development as a major issue in the URT received highest score of neutral responses which indicated that the knowledge of the respondents related to RR development was either limited or might not have understood the questions.

We suggest that policy and decision making related to new research reactor development should seek to understand and account for the various factors behind the public's perception of research reactors. Transparency and stakeholder participation in the decision-making process is crucial. This study shows that integrating views of the public in research reactor development is one contributing mechanism to aid design and introduction of a socially more acceptable research reactor in the URT.

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