

# Self-assessment of the Sudanese Nuclear Infrastructure for the First Research Reactor Project

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## 1. Introduction

Sudan has commenced applications of radiation since the Radiation and Isotopes Center of Khartoum (RICK) was established in 1967. Nowadays, many applications of radiation have been expanded and developed in a variety of sectors such as: medical, industrial, research, training, and security. Recently, Sudan has planned to establish its first research reactor project with the four goals as follows: 1) strengthening infrastructure for nuclear science and technology, 2) providing technical facilities with equipment and research tools to support advanced studies and professional training programs for research centers and Sudanese universities, 3) furnishing appropriate training and experience for nuclear power plant projects, 4) producing radionuclides that have short or medium half-lives for national applications [1].

According to IAEA documents [2] three sequential phases and corresponding infrastructure issues should be resolved in order to support a research reactor project. However, Sudan has been developing mainly a legislative and regulatory framework for applications of radiation.

This study discusses a self-assessment of Sudanese infrastructure for the first research reactor project by utilizing IAEA's assessment methodology in order to identify gaps between the existing Sudanese infrastructure and IAEA requirements [2]. The Sudanese government has just planned to establish a first research reactor project. Therefore, this paper focuses on the four selected infrastructure issues of the first phase, Pre-Project phase, as follows: legislative framework, regulatory framework, radiation protection as well as emergency preparedness and response. The results are expected to be very useful in advancing work to fill in the gaps between the current national infrastructure of Sudan and IAEA requirements for the research reactor project.

## 2. Methodology

When a country embarks on their research reactor project, a specific infrastructure supporting the project shall be implemented. The development of the national infrastructure for supporting a research reactor project can be divided into three sequential phases, and each phase concludes an infrastructure milestone as shown in Fig I.

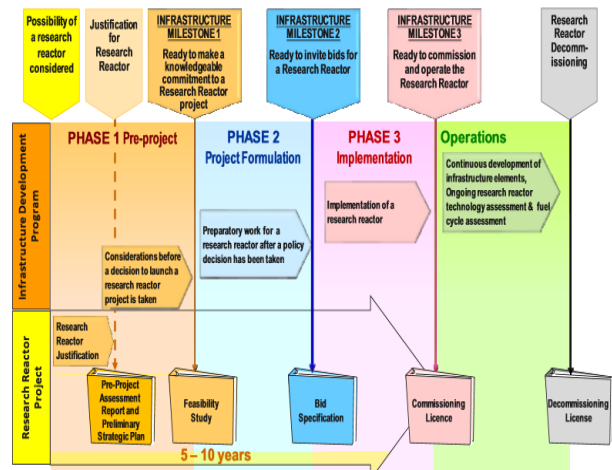


Figure 1: Milestone for a research reactor project [2]

The first phase is to describe justification of the research reactor and earlier considerations, as outcome of this phase a country must be ready to make a well-informed commitment to the research reactor project. Second phase is to discuss preparation for research reactor construction after policies and strategies have been put in place, as a result of this phase the country has to be ready to request vendor bids for research reactors. The final phase is to implement the project; therefore, the country must be ready to construct and operate the research reactor [2].

IAEA guideline [2] describes the 19 infrastructure milestone issues that have to be considered at each phase of developing nuclear infrastructure for the research reactor project. In addition, IAEA provides the self-assessment methodology which is essential to ascertain the current overall national infrastructure status and identify weakness and additional works needed to be developed that will help a country to implement a new research reactor project [3].

As shown in Table 1, each infrastructure issue for each phase consists of one or more conditions, which are defined based on the—provisions for each infrastructure issue at that phase. Each condition contains several specific questions regarding the essential aspects that should be considered. Observations were conducted for each condition based on the specific evidence. Specific evidence can include: laws and decrees, formalized agreements, meeting notes, etc. Consequently, three options were proposed dependent upon the degree of actions

required as evaluation of each condition: significant action needed, minor action needed, and no action needed [3]. Recommendations were given to improve the infrastructure issues.

Table1: Example for self-assessment model [3]

<b>1. Legislative framework ←Infrastructure Issue</b>		
<b>1.1 Government plans to develop the required national nuclear legislation are in place ←Condition</b>		
<b>Basis of Evaluation</b>	<b>Evidence</b>	<b>Observation</b>
1.1.1 Establishing independent regulatory body		
<b>Evaluation:</b>		
<b>Recommendations:</b>		

### 3. Results and Discussion

The aim of this self-assessment is to determine the gaps between Sudanese infrastructure and IAEA requirements for a research reactor project.

In this study, as an example, four infrastructure issues were selected for Sudan as follows: legislative

framework, regulatory framework, radiation protection, and emergency preparedness and response with respect to the Pre-Project phase.

As the result of the assessment for some selected infrastructure issues, we could identify significant gaps for radiation protection and EPR issues, and minor gaps for each of the legislative framework and regulatory framework issues. In term of legislative framework, some actions should be taken for global conventions and agreements, and the government needs to make some decisions to support SNRRA for full independency as shown in Table 2 and 3. For the regulatory framework issue, SNRRA must create and develop policies as well as safety and security regulations as represented in Table 4. The radiation protection issue needs considerable action to enhancement the existing capabilities of radiation protection in term of regulations as shown in Table 5. In case of EPR issue, Sudan has to take significant actions for national emergency plan and National EPR Committee in order to be sufficient for research reactors as represented in Table 6.

Table2: Assessment of Sudanese legislative framework, part1

<b>1. Legislative framework</b>		
<b>1.1 International legal instruments identified by RRPIC and adherence discussed and planned with government</b>		
<b>Evaluation Basis</b>	<b>Evidence</b>	<b>Observations</b>
1.1.1 Understanding and implications the international legal instruments in the national legal regulations	- Report of SNRRA's Committee for revising international Conventions - SNRRA safety regulations	The government has signed and assented for some international conventions such as Convention of Nuclear Safety (1994), etc. Other conventions Sudan has not joined yet including joint convention on the safety of spent fuel management and on the safety of radioactive waste management. Code of Conduct has been implicated in the national safety regulations and nuclear regulations under revision by IAEA.
<b>Evaluation :</b>	<input type="checkbox"/> Significant actions needed	<input checked="" type="checkbox"/> Minor actions needed <input type="checkbox"/> No actions needed
<b>Recommendations</b>		
- The other international conventions and agreements must be signed and assented by Sudanese government which is representative by Foreign Affairs Ministry in order to ensure nuclear safety. - Draft of safety regulations for nuclear activities needed to approve by SNRRA's Board.		

Table 3: Assessment of Sudanese legislative framework, part2

<b>1. Legislative framework</b>		
<b>1.2 Government plans to develop the required national nuclear legislation are in place</b>		
<b>Evaluation Basis</b>	<b>Evidence</b>	<b>observations</b>
1.2.1 Establishing independent regulatory body	The Nuclear and Radiological Regulatory Control (NRRC) Act of Sudan, 2017	Based on The Nuclear and Radiological Regulatory Control Act 2017, the Sudanese regulatory body was established. Currently, the regulatory authority is under the Ministry of Higher Education and Scientific Research. The name of the regulatory authority is Sudanese Nuclear and Radiological Regulatory Authority (SNRRA).
1.2.2 Formulating nuclear safety, radiation safety and nuclear security, safeguards regulations principles, policies and rules for all nuclear and radiation installations	- SNRRA Safety Regulations - Codes of Practice	- SNRRA has been established and updated several safety regulations for radiation activities including safety transportation of radioactive materials and radioactive waste management. - Also, nuclear regulations have been drafted which are ten regulations such as decommissioning of facilities 2016. - Nuclear security and safeguards regulations have not established yet. - Codes of Practice have been established for some the radiation activities such as Protection in Education and Research.
1.2.4 implementing import and export nuclear and	NRRC Act of Sudan, 2017	SNRRA has been implementing import, export, as well as transport all radioactive sources according to The NRRC Act 2017.

radioactive materials			
<b>Evaluation:</b>	<input type="checkbox"/> Significant Actions needed	<input checked="" type="checkbox"/> Minor actions needed	<input type="checkbox"/> No actions needed
<b>Recommendations</b>			
<ul style="list-style-type: none"> <li>- The government shall separate SNRRA from the promoters in order to be effectively independent its decision making and regulatory functions. The government could decide to be SNRRA under Ministry of the Cabinet Affairs that will give full independency to SNRRA.</li> <li>- Nuclear Safety regulations and some code of practices that are drafted must be approved by SNRRA' Board.</li> <li>- SNRRA have to establish committees in order to create nuclear security and safeguards regulations that will to support research reactor and nuclear power plant projects.</li> <li>- Upgrading the safe transport of radioactive material and control and management of radioactive waste regulations by SNRRA so as to including a research reactor project.</li> </ul>			

Table 4: Assessment of Sudanese regulatory framework

2. Regulatory Framework		
2.1 RRPIC understands the need for and the scope of the regulatory framework and the specific plan needs to be developed		
Evaluation Basis	Evidence	Observations
2.1.1 Establishing an authorization, inspection and enforcement processes	NRRC Act of Sudan, 2017	SNRRA has been implementing an authorization, inspection, and an enforcement for all of the radiation activities since Sudan Atomic Energy Commission Act 1996. Recently, SNRRA is more active in term of these functions after Nuclear and Radiological Regulatory Control Act was approved in 2017. NRRC act, chapter three describes principles of the authorization, inspection, and enforcement.
2.1.2 Establishing and developing regulations and guides covering nuclear and radiation safety and nuclear security including spent fuel and radioactive waste management and decommissioning	- NRRC Act 2017 -Safety regulations and Code of Practices	- Radioactive waste, spent fuel are given principles in NRRC act, chapter six. - Nuclear security and transport of radioactive materials are mentioned in chapter eight. - SNRRA has been established and developed safety radiation regulations for radiation activities. Furthermore, SNRRA has been drafted nuclear regulations (ten nuclear safety regulations) covering research reactors. Refer to issue No.1 legislative framework issue. - Radioactive waste management regulation has been established since 1998, and transportation of radioactive material regulation.
2.1.3 Cooperation between a regulatory authority and other national and international authorities	Memoranda of Understanding among SNRRA and government agencies	There are Memoranda of Understanding (MoU) between government agencies and SNRRA such as Ministry of Health 2016, also there some of MoU were drafted.
<b>Evaluation:</b> <input type="checkbox"/> Significant Actions needed <input checked="" type="checkbox"/> Minor actions needed <input type="checkbox"/> No actions needed		
<b>Recommendations:</b>		
<ul style="list-style-type: none"> <li>- Refer to the regulatory framework recommendations.</li> <li>- The Memoranda of Understanding need to approved in order to regulate the radioactive materials that will support research reactor project. Also cooperation has to create by SNRRA with Traffic and Interior Authorities in order to support transportation of radioactive materials.</li> <li>- SNRRA should cooperate with international regulatory authorities in order to accomplish high level of safety and security to the country.</li> </ul>		

Table 5: Assessment of Sudanese radiation protection

3. Radiation Protection		
3.1 RRPIC understands specific radiation hazards of a research reactor and ancillary facilities enhancements to national regulations and infrastructures planned		
Evaluation Basis	Evidence	Observations
3.1.1 Establishing safety regulations for nuclear installations, transport of radioactive materials and spent fuel management	Safety regulations	- Radiation safety regulations and nuclear safety regulations including a research reactor have been formed, and other safety regulations ( <i>see legislative framework issue</i> ). - Spent fuel management policy has not established yet
3.1.2 How could existing safety regulations upgrade to cover research reactor project in term of radiation protection including transport of radioactive materials and spent fuel?	Plans to update safety regulations	- SNRRA has plan to upgrade safety regulations related to radiation protection of transportation radioactive materials and radioactive waste management.
<b>Evaluation:</b> <input checked="" type="checkbox"/> Significant Actions needed <input type="checkbox"/> Minor actions needed <input type="checkbox"/> No actions needed		
<b>Recommendations:</b> Establishment and improvements of the policies and safety regulations by SNRRA in order to ensure radiation protection. Refer to the regulatory framework recommendations.		

Table 6: Assessment of Sudanese emergency preparedness and response

4. Emergency preparedness and response		
4.1 The RRPIC understands the need for emergency planning		
Evaluation Basis	Evidence	observations
4.1.1 Established a national preparedness and response emergency (EPR) plan, including categorization of hazards, allocation of responsibilities, and potential consequences of the considered research reactor project	<ul style="list-style-type: none"> <li>- NRRC Act 2017</li> <li>- Ministerial Decree of the national committee for Radiation and Nuclear emergencies management 2007</li> <li>- Radiation Protection Regulations 2017.</li> <li>- Letters of communication with undersecretary of national council of civil defense</li> <li>- Civil Defense law 2005</li> <li>- Draft EPR Regulation</li> <li>- Draft National Emergency Response Plan</li> </ul>	<ul style="list-style-type: none"> <li>- Chapter six /Section 30 in the nuclear and radiation activities regulatory control 2017 addressed the main provisions of EPR for onsite and offsite.</li> <li>- The licensee is responsible for any emergency case that governed by the regulations issued by NRRC act 2017.</li> <li>- Main responsible for safety of Sudanese public is the National Council for Civil Defense (NCCD). Nonetheless, a National committee was established in 2007 by the head of the NCCD, which was formed from most relative organizations to formed a national radiological emergency response plan.</li> <li>- Allocation of the responsibilities of different national response organizations has been addressed in the drafted national plan for response to radiological emergencies in addition to possible scenarios of radiological emergencies in Sudan. This draft should be approved by council of ministers.</li> <li>- EPR regulation has been drafted and it is under revision now by the committee formed by SNRRA (the final English revised version is ready to be submitted for approval).</li> </ul>
4.1.2 Capabilities needed for EPR, including research reactor project	Report on training conducted under IAEA Projects	Building of capacities within the country has being performed under different IAEA TC projects. Under these projects numbers of personnel from different stakeholders have been trained in various areas of EPR based on IAEA training material
4.1.3 Arrangements to adequate EPR	Decree of the EPR preparatory committee	In order to involve the future operator of the NPP in the national EPR arrangement, a preparatory committee was formed under supervision of the SNRRA from different stakeholders such as: Civil Defense, General administration of Forensic evidence. The responsibilities of this committee are to establish mechanisms for coordination and corporation, developing programs for strengthening the national infrastructure for response to radiation & nuclear emergencies.
<b>Evaluation:</b> <input checked="" type="checkbox"/> Significant Actions Needed <input type="checkbox"/> Minor actions needed <input type="checkbox"/> No actions needed		
<b>Recommendations</b> <ul style="list-style-type: none"> <li>- SNRRA have to finalize and revise the EPR Regulations then submit to approval by SNRRA Board.</li> <li>- National Council of Civil Defense and SNRRA must to activate the National EPR Committee by approve the list of relevant organizations, after that calling representatives, then developing work plan.</li> <li>- National Emergency Committee has to issuance the national emergency plan by presentations to the relevant authorities, feedback and revision, issuance, distribution, as well as drills and exercises.</li> <li>- SNRRA, Civil Defense, Ministry of Health, and Sudan News Agency have to provide training courses for all related stakeholders on EPR of research reactor project, and national training courses on communication with public during radiation situation.</li> <li>- National Emergency Committee has to attempt filled exercise in order to test the national emergency plan.</li> </ul>		

#### 4. Conclusion

The self-assessment gives complete picture of the current national infrastructure to determine the weakness and actions that must be taken by Sudan in order to fulfill the requirements of a research reactor project. Four specific milestone infrastructure issues from 19 IAEA's infrastructure issues have been selected and evaluated by using IAEA self-assessment method. Legislative framework of Sudan has extremely weakness in term of international conventions and regulatory body independency. SNRRA has to be effective to upgrade some existing safety regulations as transportation of radioactive materials and radioactive waste management regulations to be satisfy with the research reactor project. National Emergency Plan has to be effective that can be achieved by making full exercise in order to be appropriate for the project. Suggested recommendations should be taken to fill in the gaps which are identified, and satisfy requirements

of the Sudanese infrastructure for the research reactor project.

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#### REFERENCES

- [1] Report of Sudan, International Meeting on Application of the Code of Conduct on the Safety of Research Reactors, 2017.
- [2] Vienna, IAEA, Specific consideration and milestone for a Research reactor Project, nuclear energy series.No.NP-T-5.1, 2012.
- [3] Vienna, IAEA, Assessment of the National Nuclear Infrastructure to support new Research Reactor Projects (draft), 2016.