# Licensing Process for Decommissioning of Karachi Nuclear Power Plant (KANUPP)

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**Abstract**

Licensing and authorization of nuclear installations is one of the core functions of Pakistan Nuclear Regulatory Authority (PNRA). These are issued at various stages of life cycle of nuclear installations as prescribed in PNRA Regulations for Licensing of Nuclear Installation(s)-PAK/909. Karachi Nuclear Power Plant (KANUPP) was Pakistan’s first CANDU type pressurized heavy water reactor (PHWR) with a total gross energy generation capacity of 137 MWe which achieved its first criticality on August 01, 1971. KANUPP was permanently shut down for decommissioning on August 01 2021 after completing fifty (50) years of operation, which is the final stage in the lifecycle of a NPP. Keeping in view of the licensing process laid down in regulations PAK/909, the licensee submitted a number of documents like Final Decommissioning Plan (FDP), Technical Specifications during decommissioning, Quality Assurance Program for decommissioning, Emergency Preparedness Plan, Physical Protection Program, Radiation Protection Program, Radioactive Waste Management Program and Environmental Monitoring Program for review. Upon satisfactory completion of the regulatory review of licensing submissions against agreed codes and standards, PNRA terminated the operating license and issued license for decommissioning to KANUPP on June 27, 2022. As grant of decommissioning license to a NPP was first of its kind experience, therefore, it provided numerous learning opportunities to PNRA for improvement of its regulatory processes. Similarly, it faced some real challenges during the process such as need for timely submission of documents, first time review of documents, and time period for decommissioning license, etc. This paper presents the PNRA experience and challenges faced during review of KANUPP decommissioning licensing documents.

## INTRODUCTION

The government has mandated PNRA to regulate nuclear installations and radiation facilities in the country. PNRA has devised a formal mechanism of licensing and authorization which is based on regulatory review and assessment of licensing submissions and recommendations of regulatory inspections. Karachi Nuclear Power Plant (KANUPP) was the first Nuclear Power Plant (NPP) commissioned in Pakistan with gross energy generation capacity of 137 MWe which started its commercial operation in 1972. The plant was designed and constructed by Canadian General Electric Company and operated by Pakistan Atomic Energy Commission (PAEC). The plant operated for fifty (50) years including 20 years beyond its design life and was permanently shut-down on August 01 2021 for decommissioning. PNRA issued decommissioning license to KANUPP in June 2022. This paper will briefly describe PNRA experience and challenges faced during review of decommissioning licensing documents of KANUPP.

## KANUPP DECOMMISSIONING LICENSE APPICATION

Karachi Nuclear Power Plant (KANUPP) was a (CANDU) type pressurized heavy water reactor (PHWR) that used natural Uranium as fuel and [heavy water](https://en.wikipedia.org/wiki/Heavy_water) (D2O) as [moderator](https://en.wikipedia.org/wiki/Neutron_moderator) and coolant. KANUPP is situated about 17.7 Km West of Karachi Harbor on Arabian Sea Coast. The plant achieved its first criticality on August 01, 1971 and started commercial operation in 1972. The plant completed its nominal design life of 30 years in December 2002, however, the licensee desired to operate the plant beyond its design life. The licensee carried out numerous up-gradations in plant components known as 17+7 safety issues of high and medium categories in two long shut-down periods in 2003 and 2005-2006. After necessary up-gradations and Plant Life Extension (PLEX) activities, PNRA allowed the licensee to operate the plant beyond its design life for another 20 years. KANUPP operated around 17.378 effective Full Power Operation (FPY) with life time average availability and gross capacity factors approximately 55.90% and 32.17% respectively. After fifty (50) years of operation, KANUPP was permanently shut-down on August 01 2021 for decommissioning. PAEC prepared the following documents to obtain decommissioning license for KANUPP:

1. Final Decommissioning Plan (FDP),
2. Technical Specifications (TS),
3. Quality Assurance Program (QAP),
4. Emergency Preparedness Plan (EPP),
5. Physical Protection Program,
6. Radiation Protection Program (RPP),
7. Radioactive Waste Management Program (RWMP), and
8. Environmental Monitoring Program (EMP).

The licensee opted deferred dismantling strategy for decommissioning of KANUPP. The logic was to allow sufficient time for maximum decay of radionuclides to avoid workers exposure, enable availability of waste disposal facility, acquire appropriate technology for decontamination and dismantling and make available sufficient funds for decommissioning activities. The overall KANUPP decommissioning project split into following three distinct phases:

1. Phase-I (Preparation for Safe Storage-SAFSTOR ~ 15 years),
2. Phase-II (SAFSTOR Surveillance ~ 20-30 years), and
3. Phase-III (Decontamination and Dismantling ~ 5 years).

The FDP provides detail plans, procedures, modification projects and schedules related to the decommissioning activities to be performed during Phase-I. The plan gives limited information of Phase-II and Phase-III activities, as Phase-III activities related to decontamination and dismantling are expected to start after few decades. Accordingly, the licensee will submit the revised FDP before the start of each Phase in the light of SAFSTORE Surveillance, availability of Decontamination and Dismantling technologies at that time. The end state of KANUPP site will be declared as ‘Brownfield’ i.e., the site will be available for restricted industrial use only. The management of operational waste of the plant is a big challenge for the licensee as it is currently stored at the plant waste storage area which is called ‘RAWSA’. The pre-treatment, treatment and conditioning activities of radioactive waste will be performed at KANUPP-2 which is also located at the same site. The licensee has planned to establish a near surface disposal facility called Regional Repository South (RRS) at KANUPP site for the ultimate disposal of operational as well as decommissioning low level waste (LLW). A spent fuel dry storage facility (SFDSF) has also been established at the plant site before its final shut-down for the purpose of storage of spent fuel. In the Phase-I, the licensee has planned to carry out activities like defueling the reactor core, dewatering the systems, retirement of the systems, installation of required new systems and transferring of the spent fuel from wet storage to SFDSF.

## PNRA REGULATORY FRAMEWORK FOR DECOMMISSIONING

PNRA has established a comprehensive regulatory framework which sets both administrative and technical requirements. PNRA regulatory framework is in line with IAEA safety standards. Regulations for Licensing of Nuclear Installations in Pakistan - PAK/909 is an administrative regulation, and set forth requirements and process for the authorizations and licensing of nuclear installations. Similarly, Regulations on Decommissioning of Facilities using Radioactive Material - PAK/930 provide regulatory requirements for decommissioning of facilities. In addition to these two main regulations there are other interface regulations which were utilized for the licensing of decommissioning as listed below:

1. Regulations on Radiation Protection – PAK/904
2. Regulation on safety of Nuclear Power Plants- Quality Assurance – PAK/912
3. [Regulations on Manageme](https://www.pnra.org/upload/legal_basis/regulations/PAK-930.pdf)nt of a Nuclear or Radiological Emergencies – PAK/914
4. [Regulations on Radioactive Waste Management](https://www.pnra.org/upload/legal_basis/PAK-915%20%28Rev.1%29.pdf)– PAK/915
5. [Regulations for the Safe Management of Spent Nuclear Fuel](https://www.pnra.org/upload/legal_basis/regulations/PAK-918.pdf) – PAK/918
6. Regulations on Physical Protection of Nuclear Material and Nuclear Installations – PAK/925

## PNRA Decommissioning REVIEW AND LicensING PROCESS

The regulations PAK/909 describe licensing and authorization stages for a nuclear installation and decommissioning is one of the licensing stages. The regulations require that in case, the licensee intends to permanently shutdown the installation, he shall apply for decommissioning at least three years before terminating the operation of the nuclear installation. Accordingly, the licensee applied to PNRA for the grant of decommissioning license under the regulation 8(10) of PAK/909 in September 2021. PNRA communicated its process and working to be followed for decommissioning of the plant to the licensee. As a first step, PNRA and the licensee mutually agreed to follow certain codes and standards including PNRA regulations, KANUPP safety documents, IAEA safety standards and guides particularly IAEA SRS 45 ‘Standard Format and Content for Safety Related Decommissioning Documents’, and relevant documents of other Member States. Accordingly, the licensee submitted documents as mentioned in section 2 above to PNRA for review and approval.

PNRA constituted a taskforce comprising of experts from different Directorates for the review of licensing submissions. The taskforce included reviewers, lead reviewers, review team coordinator and team leader. Further, a core team of senior PNRA officials was also constituted to evaluate and finalize the queries raised by taskforce or the review team. PNRA prepared a schedule for the review of licensing submissions and shared it with the licensee. This schedule initially spanned over a period of seven (07) months, however, the review was completed in around eight (08) months. The delay was due to late submission of few documents by the licensee owing to Covid-19 pandemic situation. The review of licensing documents was performed in the following two phases:

1. Review of Format and Contents (Phase - I); and
2. Detailed Review on the basis of applicable codes and standards (Phase - II).

The review queries raised by the review team were thoroughly discussed with core team and finalized accordingly. A total of one hundred thirty-three (133) licensing queries including forty-two (42) phase-I queries and ninety-one (91) phase -II queries were communicated to the licensee.

The licensee submitted its responses to these queries to PNRA for review. PNRA thoroughly reviewed the responses and prepared its position against each question. Two review meetings between PNRA and the licensee were held to discuss and resolve the queries/issues in compliance with the agreed codes and standards. In order to record the overall review outcome, action sheet against each licensing query was prepared and signed by PNRA and licensee reviewers and team leaders respectively. The overall review process followed at PNRA is shown in Fig. 1. Upon satisfactory resolution of major safety issues, review team prepared Final Safety Evaluation Report (FSER) and concluded that the information provided in licensing submissions, in conjunction with the actions agreed and commitments made in the action sheets, meet the regulatory requirements of Standard Format and Content for Safety related Decommissioning Documents, IAEA SRS-45, KANUPP Safety Analysis Report (KFSAR) and Operating Policies and Principal (OPP), regulations PAK/930 and other agreed codes & standards. The team accordingly, suggested that PNRA may award the Decommissioning License to the licensee to perform the decommissioning activities according to the mentioned phases.

After completion of the satisfactory review process, PNRA drafted the decommissioning license based on codes and standards, licensing submissions and review outcome. The license was shared internally as well as with the licensee for consensus and further improvement. Thereafter, PNRA terminated the operating license and issued license for decommissioning of KANUPP on June 27, 2022. This license authorized the licensee to decommission the plant, operate KANUPP Spent Fuel Dry Storage Facility (KSFDSF) and manage & store radioactive waste at the designated radioactive waste storage area (RAWSA).

**Receipt of Licensing submissions**

 **for review and assessment (R & A)**

**Core Team**

**Evaluation**

**Licensee**

**Responses**

**Format & Content Review**

**(Phase – I)**

**Communicated to Licensee**

**& followed-up, if needed**

**Detail Review**

**(Phase – II)**

**Queries sent to Licensee**

**Submission**

**Complete?**

**No**

**Yes**

**Documents sent to Taskforce**

**for R&A**

**Review Meetings**

**Actions agreed and Signed**

*Fig. 1, PNRA review Process followed to issue Decommissioning Licensing to KANUPP*

## challenges FACED DURING LICENSING PROCESS

Issuance of decommissioning license to KANUPP was an ice breaking experience for PNRA. It is worth to mention that the review of licensing submissions was performed by an experienced team without any technical assistance from an external organization or regulatory body of any other country. However, PNRA faced some challenges during the whole licensing process which are described below:

1. Implementation of established regulatory framework for decommissioning was one of the challenges. PNRA proactively managed this challenge by formulating a taskforce with the mandate to assure that PNRA is equipped with sufficient regulatory requirements for safe decommissioning, decide the level of implementation of regulatory requirements specifically in the areas of emergency preparedness, physical protection, technical specifications, finalize format and contents of the licensing submissions and determine the gaps in the regulatory framework. The team identified all the relevant regulatory requirements, prepared a list of codes and standards, format and contents for the licensing programs and licensing documents for decommissioning.
2. PNRA Regulations for Licensing of Nuclear Installations in Pakistan-PAK/909 requires that in case, the licensee intends to permanently shutdown the installation, he shall apply for decommissioning license at least three years before termination of the operation of nuclear installation. However, the licensee did not timely apply for decommissioning license of KANUPP despite of continuously taking up the matter by PNRA asking the licensee for preparation of decommissioning, finalizing date for shut down of the plant to ensure compliance of the regulatory requirements. As preparation for decommissioning was first of its kind for the licensee, therefore, the final shut-down decision and announcement of date took considerable time. This delay was caused due to the preparation of FDP and other associated documents as required under PAK/909. As a result, the plant remained under operating license even after permanent shut-down. Thus, establishment of a mechanism is needed under which it must be obligatory for the licensee to make proper planning for shut-down and decommissioning.
3. PNRA Regulations for Licensing of Nuclear Installations in Pakistan-PAK/909 requires that the licensee shall submit licensing documents and states that upon approval of these documents, the Authority may terminate the operating license and issue license for decommissioning of the installation. However, these regulations do not define time period for the decommissioning license which in case of construction license and operation license is ten (10) years. Even the Regulations on Decommissioning of Facilities using Radioactive Material – (PAK/930) do not provide any time frame or validity period for decommissioning license. Non-availability of such requirement certainly pose difficulty in making of decision for the time period of decommissioning license. Keeping this in view, PNRA concluded to make a license condition, requiring that the licensee shall seek PNRA permission for proceeding to next phases of decommissioning (i.e. SAFSTOR surveillance, decontamination & dismantling) by demonstrating that all required activities of previous phase have been completed safely. The application for seeking the permission shall accompany updates of licensing submissions for decommissioning license and shall be submitted by licensee at least one (01) year before the start of the next phase of decommissioning.
4. Regulations on the Safety of Nuclear Power Plants Operation - (PAK/913) requires that a human resource program shall be developed for ensuring that sufficient motivated and qualified personnel are available for the safe operation of the plant up to final shutdown and for carrying out the decommissioning activities of the plant in a safe manner. During the operation of plant, there were six crews duly licensed by PNRA who were responsible for the operation of KANUPP. However, when the decommissioning license was issued, the licensee submitted a new organogram with reduced manpower. It was not clear that whether the licensee has retained experienced crew to perform safety related activities like defueling and dewatering of the plant. Therefore, there is a need that the licensee should consider retaining of experienced professionals for performing safety related activities.

Similarly, the responsibility of safe operation lies with the plant manager under regulations PAK/913 during plant operation. However, the plant manager retired while the plant was still under the operating license and the management assigned the responsibility to the Decommissioning Project Manager which was violation of the regulatory requirements. PNRA raised the issue and the licensee agreed to fulfil the requirements till the issuance of decommissioning license.

1. For the preparation of FDP, IAEA SRS 45 ‘Standard Format and Content for Safety Related Decommissioning Documents’ were considered the main standards, however, SRS 45 does not describe the level of information to be provided in each decommissioning phase. The issue was resolved through frequent dialogues and the licensee agreed to provide complete information of Phase-I activities and also possible available information on Phase-II and Phase-III activities in the FDP.

## Conclusion AND Future ENDEAVOURS

PNRA has established comprehensive regulatory framework for decommissioning of nuclear installation. Further, PNRA has developed a competent review team which worked dedicatedly and indigenously completed the review process within the stipulated time. Thus, PNRA was capable to issue the decommissioning license to KANUPP. During the licensing process, the challenges faced were resolved by utilizing the inhouse resources, international feedback and IAEA guidelines. However, it is recognized that PNRA may face some challenges in future like maintenance of record, retention of staff capabilities, hands on training of staff for decontamination and dismantling techniques & technologies, knowledge of disposal of radioactive waste including high level waste in deep geological disposal facility, etc. Further, PNRA has to make decision to grant license to spent fuel dry storage facility as a separate entity. In this regard, PNRA may seek IAEA support for capacity building of its staff so that all related activities and decisions making may be performed appropriately.