

2021 ANNUAL REPORT

PAKISTAN NUCLEAR REGULATORY AUTHORITY



www.pnra.org

MEMBERS OF THE AUTHORITY

Mr. Faizan Mansoor, SI
Chairman, PNRA

Mr. Muhammad Rahman
Member Executive, PNRA

Mr. Naveed Maqbul
Member Corporate, PNRA

Lt. Gen. Nadeem Zaki Manj, HI(M)
Part-time Member, PNRA

Prof. Dr. Tariq Mahmood
Part-time Member, PNRA

Ms. Farzana Altaf
Part-time Member, PNRA

Mr. Saeed-ur-Rehman, PoP
Part-time Member, PNRA

Dr. Muhammad Aslam, SI
Part-time Member, PNRA

Dr. Rana Muhammad Safdar
Part-time Member, PNRA

Prof. Dr. Anisa Qamar
Part-time Member, PNRA

Our Vision

To become a world class regulatory body with highly trained, competent and dedicated personnel working in unison with a zeal to foster a positive safety culture in their licensees and to regulate nuclear safety to protect the public, the workers and the environment from the harmful effects of radiation in a manner that wins the confidence of all the stakeholders viz. the public, the government and the licensees.

Our Mission

To ensure the safe operation of nuclear facilities and protect the radiation workers, general public and the environment from the harmful effects of radiation by formulating and implementing effective regulations and building a relationship of trust with the licensees and maintaining transparency in actions and decisions taken by the regulatory body.

Our Core Values



Integrity



Transparency



Caring and Compassionate Attitude



Mutual Respect



Competence and Professionalism



Independence in Decision Making

CHAIRMAN'S MESSAGE

Faizan Mansoor, SI



As I reflect upon the heritage and the history of PNRA, I realize that PNRA has always been crystal clear about its aim and goal of protection of people and environment from harmful effects of ionizing radiation. Hence, society's trust is prudent from all vantage points to accomplish our goals. That's why, building a relationship of trust with all stakeholders has always been a top priority for us. Our activities and conduct are bound and directed by our core values. We all aim to hold ourselves to the highest ethical standards, take strides to increase regulatory outreach, tackle complex challenges and do our part as a responsible national nuclear regulator. The culture of transparency and integrity in our financial transactions and administrative processes, which we inherited as our core values, is not only our dictum but our biggest asset that must be preserved. It is my dream to see PNRA as one of the leading organization in Pakistan among the public sector organizations and as a role model for others.

Although, tremendous amount of fortitude is required to drive the change, we still managed to reorganize our organization structure for optimizing and realigning internal resources in order to demonstrate our capabilities with enhanced efficacy. I believe that the beating heart of any organization is its human resource

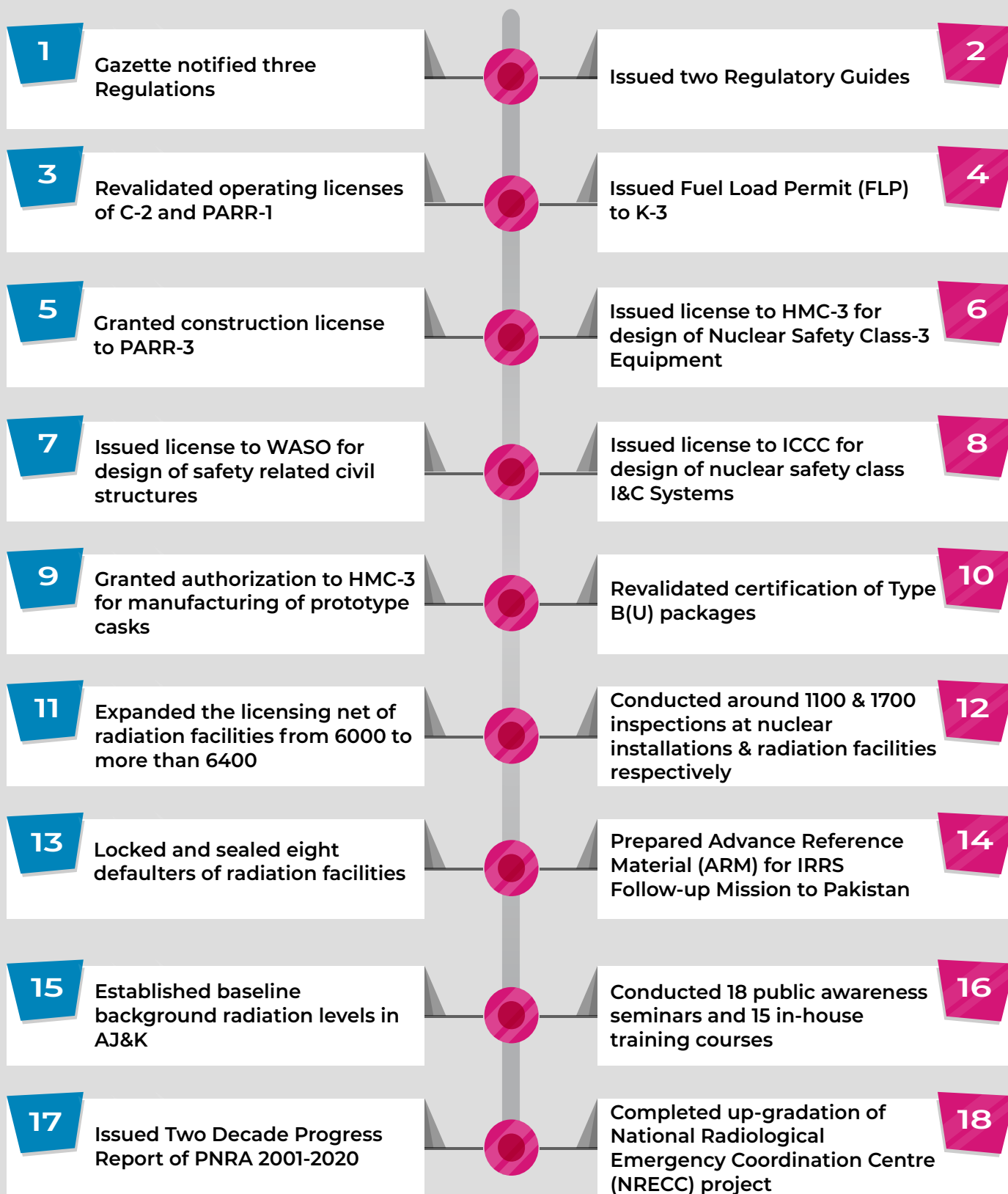
and our colleagues have shown themselves to be adaptable, resilient and able to deliver excellence even under extreme challenging circumstances. We have and will continue to invest significantly on organizational growth with strong learning culture. Leadership Development Programme (LDP) was envisioned in 2005 and we are committed to continue to add specific condiments in LDP to have a sustainable pool of leaders.

Although, PNRA was doing research and development (R&D) activities in the past, but to blaze this work with new paths, need was felt to make this realm seminal. Accordingly, structural changes have been introduced to align our R&D activities with our core and support functions in a systematic way. We are committed to focus in R&D activities to cope with challenges of rapid technological advancements in the world so that well-informed regulatory decisions may be made timely. I am still optimistic that with the active support of my dedicated team and foremost endeavour of every individual, future challenges can be transformed into remarkable achievements.

We are willing and equipped from our side to support the Government of Pakistan in meeting the targets of Sustainable Development Goals (SDGs) set out in the United Nations (UN) 2030 Agenda for Sustainable Development as our mandate contributes directly in number of goals of SDGs. Moreover, we have and will continue to support and work with other national organizations in achieving our national goals. PNRA has and will continuously contribute in furthering the true image of Pakistan through demonstration of our competency in regulatory business at international level. We will continue providing expert services in IAEA activities especially those for developing the regulatory infrastructure and framework of the countries embarking on nuclear power programme.

At the end, I would like to thank the Government, our national and international stakeholders for their continuous support. I also acknowledge my entire team for their binding and dedication which have enabled the organization to move forward and fulfill its national and international obligations.

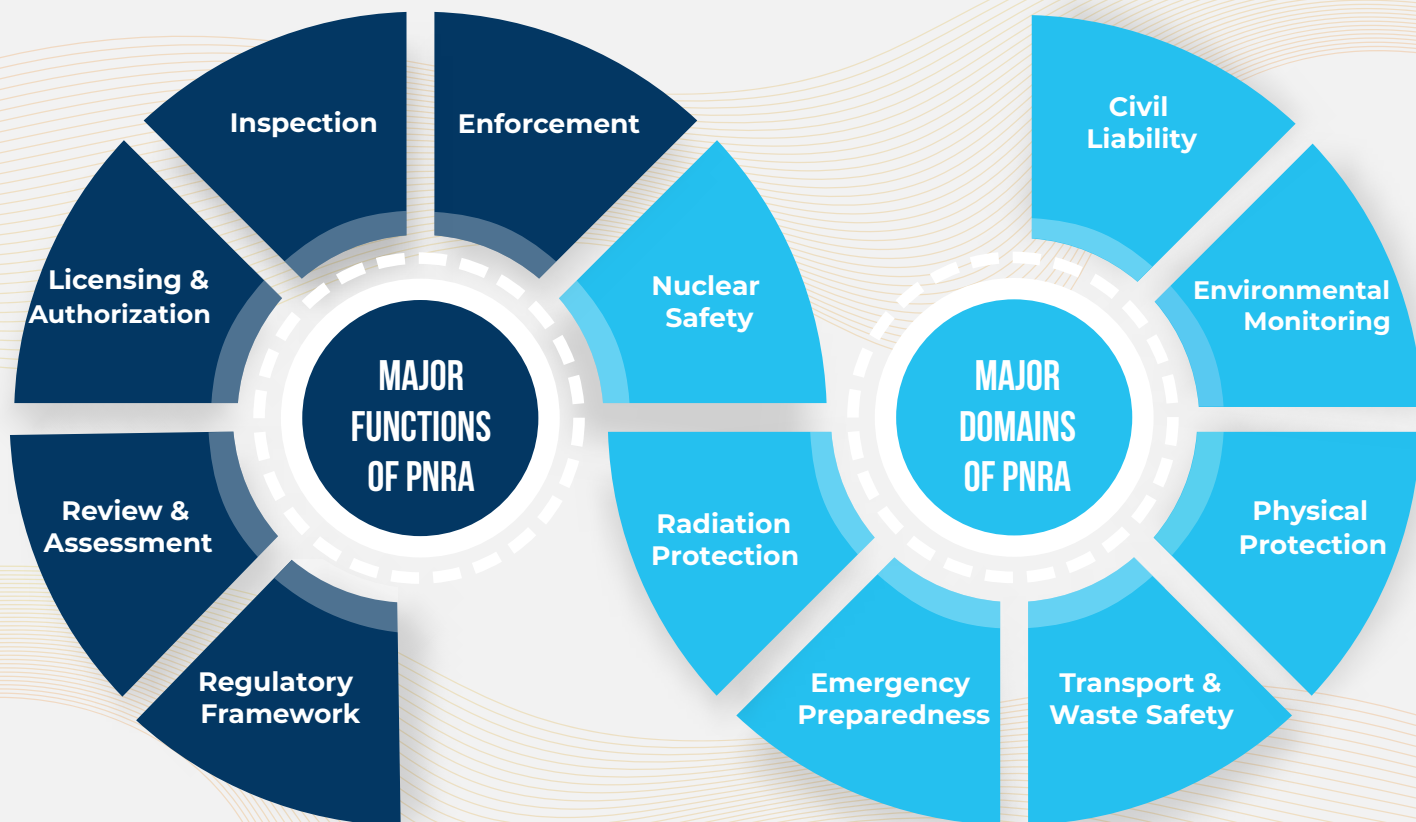
Major Activities Performed by PNRA in 2021



CONTENTS

01 Introduction	01	06 Emergency Preparedness and Response	29
Powers and Functions of PNRA	02	Emergency Preparedness and Response Functions of PNRA	30
Organizational Structure	03	National Radiation Emergency Coordination Centre (NRECC)	31
Presence Across the Country	03	Participation in IAEA's Response and Assistance Network	33
Spectrum of Regulated Installations, Facilities and Associated Activities	03	Sharing of Information about Events Involving Ionizing Radiation	33
02 Legislative and Regulatory Framework	07	Reporting of Radioactive Source Movement	34
Ordinance	08	07 Environmental Monitoring, Dosimetry and Calibration	35
Regulations	08	Evaluation of Radioactivity in the Environment	36
Regulatory Guides	09	Dosimetry and Calibration Services	37
03 Regulating Nuclear Installations	11	08 Capacity Building	39
K-Series NPPs	12	Competence Development through In-House Resources	40
C-Series NPPs	12	Competence Development through National Organizations	41
Research Reactors	13	Competence Development through International Organizations	41
Molybdenum Production Facilities	15	Capacity Building through Public Sector Development Programme (PSDP) Projects	43
Occupational Exposures of Workers at Nuclear Installations	15	09 Research and Development	45
Radioactive Waste Generation and Effluent Releases at Nuclear Installations	16	Regulatory Research Activities	46
Spent Fuel Storage Facilities	16	IAEA Coordinated Research Project	48
Disposal Facilities	17	Research Collaboration with National Institutes	48
Licensing of Plant Operating Personnel	17	Publications	48
04 Regulating Radiation Facilities	19	10 National and International Cooperation	49
Medical Radiation Facilities	20	Cooperation and Coordination at National Level	50
Industrial Radiation Facilities	21	Cooperation and Coordination at International Level	51
Research and Educational Institutions	21	11 Performance Review	55
Other Applications (import, export, scanners, etc.)	22	Management System	56
Permits and NOCs	22	Performance Monitoring	56
Radioactive Waste and Disused Radiation Sources	23	Self Assessments	56
Occupational Exposures	23	Independent Assessments	57
05 Regulating Manufacturers, Designers and Service Providers	25	Performance Indicators-2021	57
Designers of Safety Related Structures and Equipment	26		
Manufacturers of Safety Class Equipment	26		
Service Providers	27		

INTRODUCTION



Radioactive material is used worldwide for the benefit of mankind in the fields of medicine, industry, agriculture, research and electricity generation. Its use has become part of our daily life in many ways. For example, it is used for diagnostic purposes in hospitals to produce images of human body and subsequent treatments; and treatment of food items to increase shelf life and sterilization of medical equipment. It is also used in industries, research and development for variety of purposes.

Despite its enormous benefits, the use of ionizing radiation can be hazardous for human health and the environment, if not handled carefully. Therefore, there is always a need for a mechanism to strictly control, regulate and supervise the use of ionizing radiation for protection of human, society and the environment.

Pakistan Nuclear Regulatory Authority (PNRA), being a national regulator, is involved in implementing the provisions of the Ordinance to ensure protection of public and environment from the hazards of ionizing radiation.

PNRA presents its progress on annual basis and publishes it in the form of a report. The current report presents an overview of the progress of activities performed by PNRA during the year 2021.

1.1 Powers and Functions of PNRA

PNRA is delegated with the responsibility to control, regulate and supervise all matters related to nuclear safety and radiation protection in Pakistan. It is authorized to develop rules and regulations, issue regulatory guides for nuclear safety and radiation protection; develop and execute policies and programmes for the protection of life, health and property against the risk arising from ionizing radiation. PNRA is empowered to grant authorizations, issue licenses to nuclear installations and radiation facilities; and conduct inspections of all such facilities to ensure compliance with regulatory requirements and take enforcement actions when any non-compliance is observed.

In addition, PNRA is responsible for ensuring availability of arrangements for effective preparedness and coordination for managing nuclear accident or a radiological emergency.

PNRA, on behalf of the Government of Pakistan, acts as a national contact point for the implementation of obligations arising from international conventions.

Further, PNRA is responsible to fix the extent of civil liability for nuclear damage resulting from nuclear incidents.



63rd Meeting of the Authority held at RNSD-III, Karachi

1.2 Organizational Structure

The Authority comprises a Chairman, two full-time Members and seven part-time Members representing individuals from public and private sectors. The organizational structure of PNRA comprises Executive and Corporate wings. The executive wing is mainly responsible for performing activities related to licensing, authorizations, inspections and enforcement. Whereas, the corporate wing is mainly responsible for supervision and coordination of development of regulatory framework, strategic planning, competence development of manpower and providing technical support to the executive wing through its technical support centres.

Under the respective wings, PNRA has established a number of organizational units which have been assigned with different regulatory responsibilities.

During the year 2021, Mr. Faizan Mansoor (SI) took the charge as Chairman PNRA and initiated organizational reforms in order to enhance effectiveness of PNRA working and to improve various reporting channels. Accordingly, the

organizational structure of PNRA was reviewed and revised. Figure-1 shows the current organizational structure of PNRA.

1.3 Presence Across the Country

PNRA has established its offices throughout the country with its Headquarters in Islamabad along with three regional nuclear safety directorates and four regional nuclear safety inspectorates located in different cities across the country.

Figure-2 reflects the locations of PNRA offices across the country.

1.4 Spectrum of Regulated Installations, Facilities and Associated Activities

The spectrum of installations, facilities and associated activities being regulated by PNRA includes but not limited to nuclear power plants, research reactors, isotope production facilities, safety class equipment manufacturers, service providers, designers of safety related equipment and components and radiation facilities.

At present, PNRA regulates seven Nuclear Power Plants (NPPs) out of which five NPPs are operational. One NPP is in commissioning



Former Chairman, Mr. Zaheer Ayub Baig (HI) Handing Over Charge of Chairman PNRA to Current Chairman, Mr. Faizan Mansoor (SI)

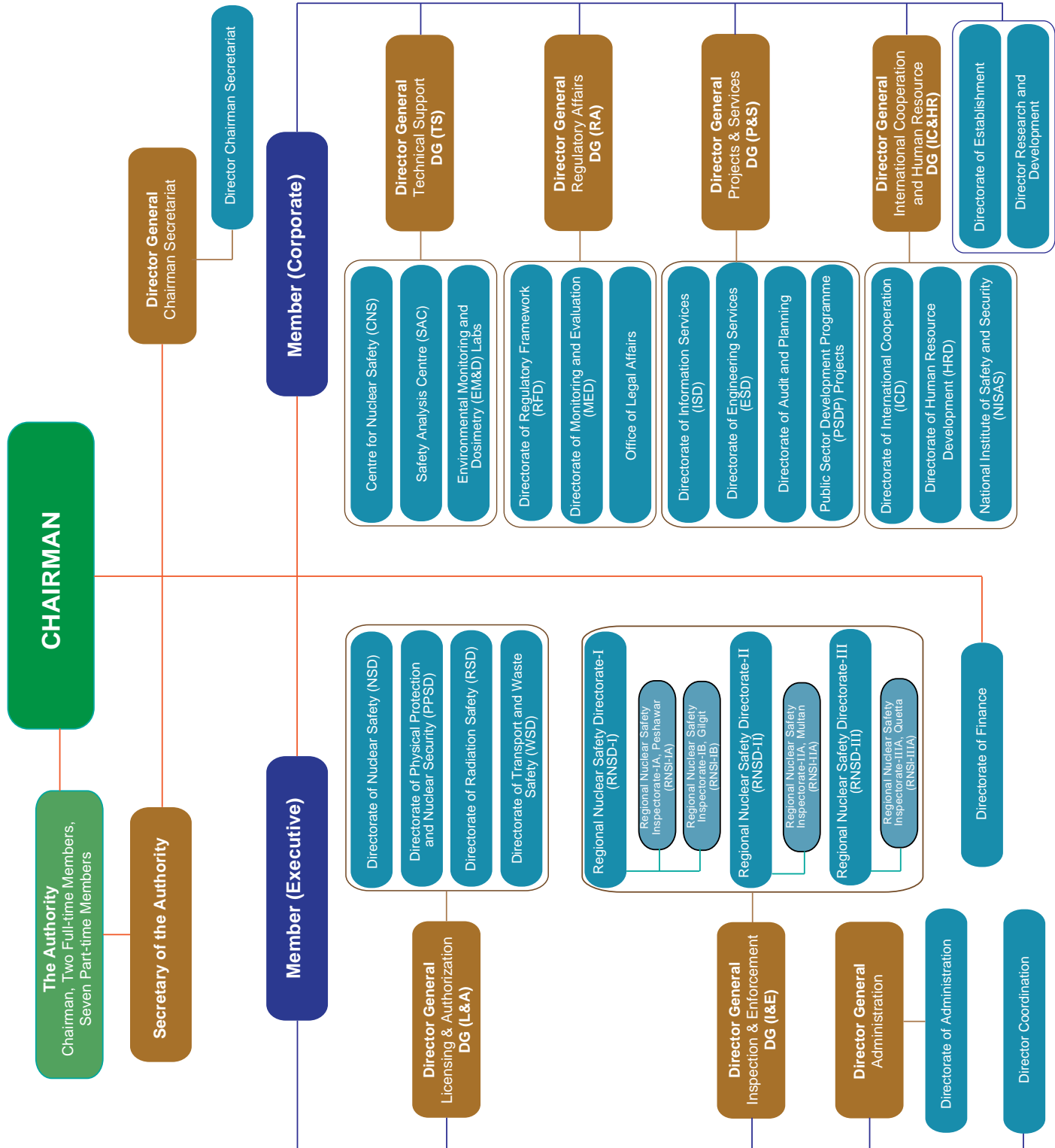


Figure-1: Organizational Structure of PNRA



PNRA Headquarters, Islamabad

 **Regional Nuclear Safety Directorate-I** Islamabad
Regional Nuclear Safety Directorate-II Kundian
Regional Nuclear Safety Directorate-III Karachi

 **Regional Nuclear Safety Inspectorate-IA** Peshawar
Regional Nuclear Safety Inspectorate-IB Gilgit-Baltistan
Regional Nuclear Safety Inspectorate-IIA Multan
Regional Nuclear Safety Inspectorate-IIIA Quetta

Figure-2: Location of PNRA Offices

phase which is expected to start operation soon. In addition, one NPP has completed its useful operating life and is currently in permanent shutdown state.

Furthermore, two research reactors are operational in the country while a third one is under construction. A Molybdenum Production Facility (MPF) is also operational while the second MPF is under construction. PNRA also regulates two spent nuclear fuel dry storage facilities, one is operational while another is under construction. Further, PNRA has licensed one Pre-disposal Radioactive Waste Management Facility.

In addition, two Nuclear Safety Class-1 (NSC-1) equipment manufacturers are licensed while licensing process of one NSC-1 equipment

manufacturer is in progress. Furthermore, three organizations have been licensed as designers of nuclear safety related structures and components.

Moreover, one organization is authorized to provide non-destructive examination services to nuclear installations.

There are more than 6400 radiation facilities in the regulatory net of PNRA. These include 5713 medical facilities, 230 industrial facilities, 74 educational & research institutes and 388 other facilities.

The regulated installations, facilities and associated activities are reflected in Figure-3.

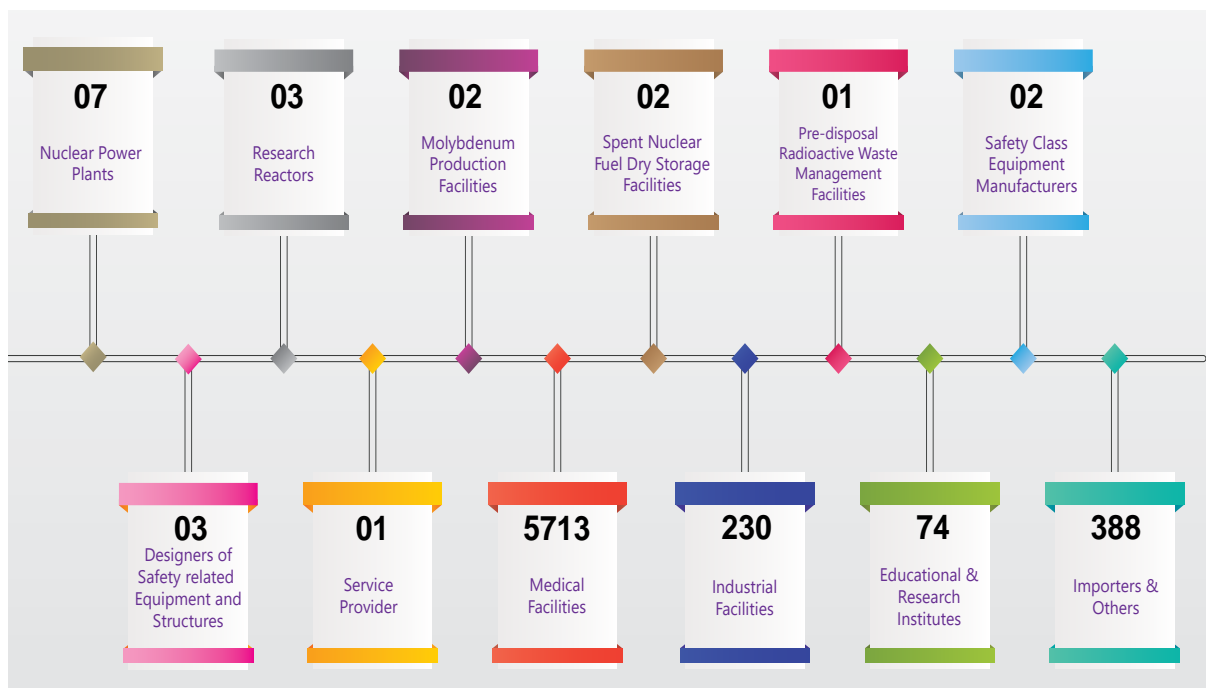


Figure-3: Spectrum of Regulated Installations, Facilities and Associated Activities

LEGISLATIVE AND REGULATORY FRAMEWORK

Regulations and Regulatory Guides (2021)

Gazette Notified
PAK/900 (Rev. 3)

Regulations on Licensing Fee by Pakistan Nuclear Regulatory Authority (Amendment)

Gazette Notified
PAK/904 (Rev. 1)

Regulations on Radiation Protection

Gazette Notified
PAK/913 (Rev. 2)

Regulations on the Safety of Nuclear Power Plants Operation

Issued
PNRA-RG-914.03

RG on Management of Contaminated and Overexposed Individuals during a Nuclear or Radiological Emergency

Issued
PNRA-RG-926.01

RG on Format and Content of Physical Protection Plan for Radiation Facilities having Radioactive Sources



The Government of Pakistan has established legislative framework for nuclear and radiation safety through promulgation of the Pakistan Nuclear Regulatory Authority Ordinance in 2001.

One of the obligations of PNRA, under the Ordinance, is to establish and enforce regulatory framework for nuclear safety and radiation protection in the country.

The legislative and regulatory pyramid of PNRA comprises three tiers namely Ordinance, Regulations and Regulatory Guides as depicted in Figure-4.

2.1 Ordinance

PNRA Ordinance is the first tier in the hierarchy of legislative and regulatory framework. The Ordinance provides mandate, composition, functions and powers of the Authority.

It empowers PNRA to devise, adopt, make and enforce necessary rules, regulations, orders, policies and codes of practice for ensuring nuclear safety and radiation protection in the country.

2.2 Regulations

Regulations form the second tier of the pyramid which specifies regulatory requirements that must be fulfilled to ensure nuclear safety and radiation protection.

Section 56 of the Ordinance empowers PNRA to issue regulations. These regulations are mandatory for licensees of nuclear installations, radiation facilities and associated activities.

PNRA regulations establish administrative and technical regulatory requirements in the areas of nuclear safety, radiation protection, radioactive waste management & transport safety and physical protection in order to protect the workers, public and the environment from harmful effects of ionizing radiation.

The regulations are developed by following a rigorous process and are mainly based on latest IAEA safety standards, national and international experience feedback and inputs from concerned stakeholders.

During the development process, the draft regulations are also uploaded on PNRA website

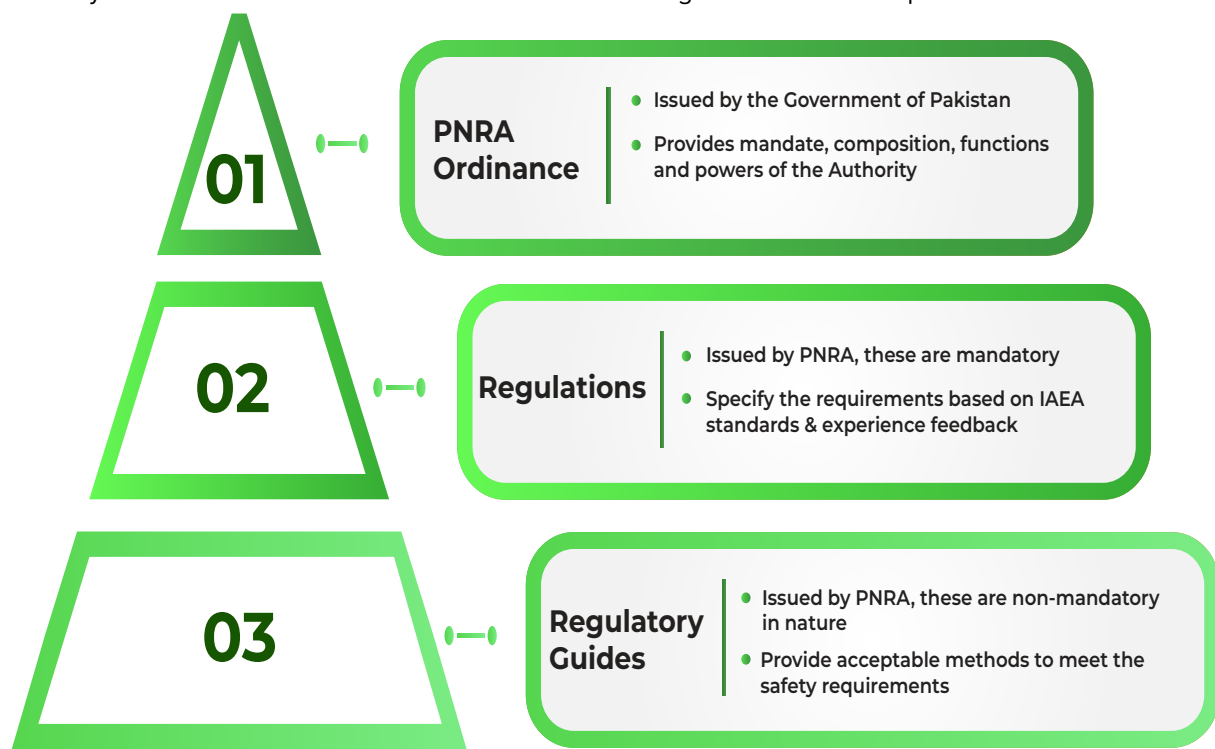


Figure-4: Legislative and Regulatory Framework of PNRA

for seeking input from licensees, public and the interested parties.

In the year 2021, Regulations on Treatment of Food by Ionizing Radiation - (PAK/931) and “Regulations on Leadership and Management for Safety - (PAK/921)” were shared with stakeholders by uploading on PNRA website.

PNRA informs the general public about uploading the draft regulations on its website for public comments through advertisement in the national press.

The regulations once approved by the Authority are notified in the official gazette of Pakistan and are placed on PNRA website (www.pnra.org) for information and compliance by all concerned.

During the year 2021, amendment in the Regulations on Licensing Fee by PNRA - PAK/900 (Rev.3), the Regulations on Radiation Protection - PAK/904 (Rev.1) and the Regulations on the Safety of Nuclear Power Plants Operation - PAK/913 (Rev.2) were gazette notified.

During the reporting period, development of following five new regulations remained in progress:

- i. Regulations for Authorization of Service Providers to Nuclear Installations and Radiation Facilities - (PAK/906);
- ii. Regulations on Safety of Nuclear Fuel Cycle Facilities - (PAK/917);
- iii. Regulations on Leadership and Management for Safety - (PAK/921);
- iv. Regulations on Licensing of Design Organizations - (PAK/927); and
- v. Regulations on Safety of Research Reactors - (PAK/932).

Whereas, following six regulations remained under revision on the basis of experience feedback and outcome of periodic review:

- i. Regulations on Licensing Fee by Pakistan Nuclear Regulatory Authority - (PAK/900) (Rev.4);
- ii. Regulations for Licensing of Nuclear Installations in Pakistan - (PAK/909) (Rev.2);
- iii. Regulations on Management of a Nuclear

or Radiological Emergency - (PAK/914) (Rev.1);

- iv. Regulations for the Safe Transport of Radioactive Material - (PAK/916) (Rev.1);
- v. Regulations on Treatment of Food by Ionizing Radiation - (PAK/931); and
- vi. Pakistan Nuclear Regulatory Authority Enforcement Regulations - (PAK/950) (Rev.1).

2.3 Regulatory Guides

Regulatory Guides (RGs) form the third tier of legislative and regulatory pyramid. The RGs are non-mandatory and are issued to describe the measures acceptable to PNRA for use in implementing specific parts of its regulations.

The RGs play a vital role for developing better understanding of regulatory requirements set forth in PNRA regulations.

Although, RGs describe the acceptable methodology for fulfilling regulatory requirements, however, licensees may choose any alternate approach by demonstrating that the adopted approach provides similar or higher level of safety and quality as that of the methodology presented in the RGs.

The RGs are developed by following a detailed process which also involves feedback from the stakeholders including general public by uploading the draft RGs on PNRA website for seeking input from licensees, public and the interested parties.

The approved RGs are placed on PNRA website (www.pnra.org) for information and compliance by all concerned.

PNRA issued following two RGs during the reported year:

- i. RG on Management of Contaminated and Overexposed Individuals during a Nuclear or Radiological Emergency (PNRA-RG-914.03); and
- ii. RG on Format and Content of Physical Protection Plan for Radiation Facilities having Radioactive Sources (PNRA-RG-926.01).

Moreover, development of following new regulatory guides remained in progress during the reported year:

- i. RG on Radiation Protection and Safety in Medical Diagnostic X-ray Facilities (PNRA-RG-904.08);
- ii. RG on Format and Content of SAR of Radiation Facilities (PNRA-RG-908.02);
- iii. RG on Preparation of License and Authorization Applications for Radiation Facilities (PNRA-RG-908.03);
- iv. RG on Format and Content of PSI / ISI Programme for NPPs (PNRA-RG-909.04);

- v. RG on Management of Nuclear Security Events Involving Radioactive Sources (PNRA-RG-926.02); and

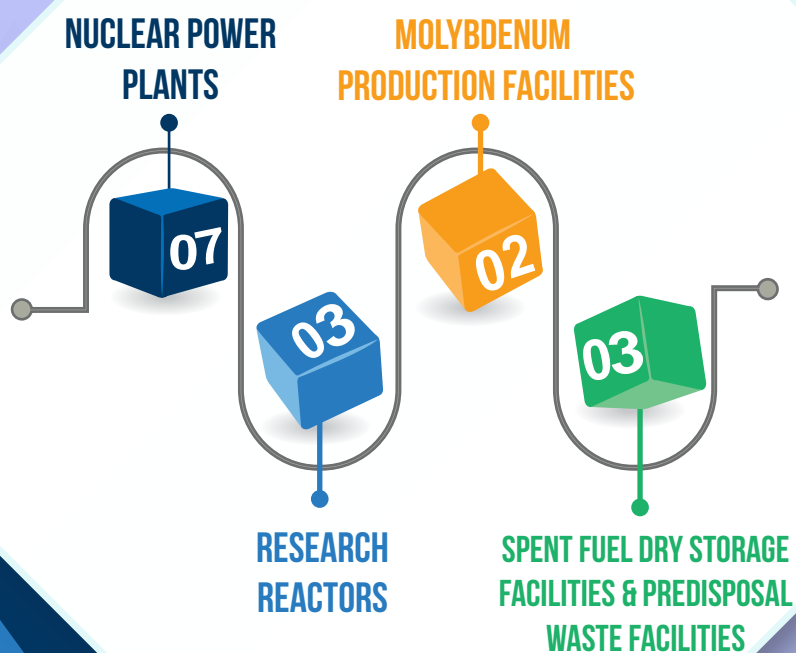
- vi. RG on Format and Content of Decommissioning Plan of Radiation Facilities (PNRA-RG-930.01).

PNRA continued its working for the development and enhancement of regulatory framework in emerging and existing areas of nuclear safety and radiation protection to regulate the use of nuclear energy and application of ionizing radiation and ensure protection of public and environment from the risks of ionizing radiations in Pakistan.



Review Meeting of Task Force on Draft Regulations

REGULATING NUCLEAR INSTALLATIONS



PNRA has been mandated for regulating nuclear installations to ensure safe operation in order to protect radiation workers, public and the environment from harmful effects and risks arising from ionizing radiations. In order to achieve this objective, PNRA grants licenses & authorizations, performs inspections and takes necessary enforcement actions throughout the entire life cycle of nuclear installations from site registration till removal from regulatory control. At present, 15 nuclear installations including seven nuclear power plants, three research reactors, two molybdenum production facilities and two spent fuel dry storage facilities and one pre-disposal radioactive waste management facility are under regulatory control of PNRA. In addition, PNRA also issues licenses to operating personnel of NPPs and Research Reactors.

3.1 K-Series NPPs

K-series NPPs i.e. K-1, K-2 and K-3 are located at Karachi. K-1 was the first NPP of Pakistan, a Pressurized Heavy Water Reactor (PHWR), which was made critical in 1971 and commenced its commercial operation in 1972. K-1 remained in operation till August 01, 2021 following which it was permanently shutdown for decommissioning after completion of around 50 years of safe operation. Currently, the application for decommissioning license of K-1 is under review at PNRA.

K-2 and K-3 are three loop Pressurized Water Reactors (PWRs). K-2 was connected to national grid in March, 2021 while first fuel loading of K-3 is completed and the plant is under advance

stage of commissioning phase.

During the year 2021, permission for initial criticality was granted to K-2 upon satisfactory compliance of all regulatory requirements. Subsequently, K-2 was permitted to raise power up to 50% and then to 100% of full power.

K-3 submitted application for Fuel Load Permit (FLP) in 2021 along with 17 programmes to PNRA, the same have been reviewed. Further, PNRA reviewed a number of routine / non-routine submissions of K-series NPPs that mainly include Monthly Technical Reports, Radioactive Waste Management Report, Emergency Preparedness and Response Plans, etc. as shown in Figure-5.

Furthermore, PNRA has reviewed and approved 59 Technical Specifications (TS) modifications of K-2 / K-3 and approved upon satisfactory resolution of all regulatory concerns.

The data of inspections performed at K-1, K-2 & K-3 is shown in Figure-6. These included planned, announced and reactive inspections.

3.2 C-Series NPPs

C-Series NPPs i.e. C-1, C-2, C-3 and C-4 comprise two-loop Pressurized Water Reactors (PWRs) located at Chashma site. These reactors are in operation since 2000, 2011, 2016 & 2017 respectively.

During the reporting period, C-1 underwent its 14th refueling outage (RFO-14) to carry out the planned outage jobs. Upon completion of RFO activities, C-1 submitted an application for



Figure-5: Review and Assessment of K-Series NPPs Submissions

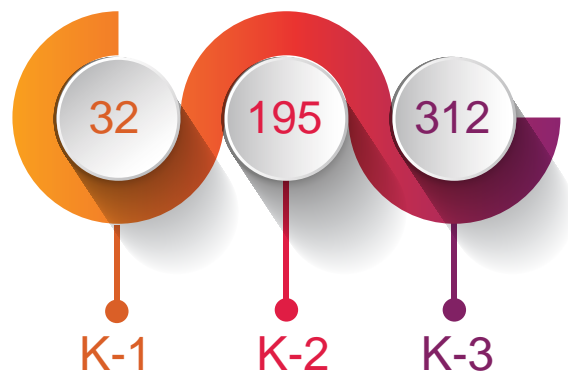


Figure-6: Inspections Performed at K-Series NPPs

plant criticality along with documents required under regulations (PAK/913) and the same were reviewed at PNRA. Upon fulfilling all the pre-requisites, criticality permission was granted to C-1 by PNRA.

The operating license of C-2 was valid till December 2021 and further continuation of the plant operation required license revalidation as per regulatory requirements set forth in PNRA regulations PAK/909. In this regard, C-2 submitted license revalidation application along with reports of the first Periodic Safety Review (PSR1). Upon satisfactory completion of the review and assessment of the submissions, the operating license of C-2 was revalidated up to December, 2031.

C-3 remained in smooth operation throughout the reporting year. C-4 was shut down for refueling outage - 3 (RFO-03) on September 07, 2021 to perform refueling activities. Upon satisfactory completion of RFO activities, criticality permission was granted to C-4 by PNRA on October 18, 2021.

PAEC submitted Site Evaluation Report (SER) of C-5 in October 2020 for acquiring authorization of site registration from PNRA in accordance with Regulations for Licensing of Nuclear Installations in Pakistan - PAK/909 (Rev. 1). The review of SER has been completed by PNRA during the reporting period.

During the reporting period, PNRA reviewed a



Figure-7: Review and Assessment of C-Series NPPs Submissions during 2021

number of routine and non-routine submissions received from C-Series NPPs, consisting of refueling outage submissions, programmes, monthly technical reports and licensee event reports, etc. Furthermore, revised Radiation Protection Programme of C-1 was approved. Moreover, the revised quality assurance programmes of C-Series NPPs, CNPGS physical protection programme, CNPGS radioactive waste management programme and CNPGS Onsite-emergency preparedness plan remained under review during the reporting year.

The review and assessment activities conducted by PNRA are reflected in Figure-7.

In addition to that, total 14 design modifications, 41 technical specifications modifications and 34 FSAR modifications were reviewed by PNRA. Out of these, eight design modifications, 27 Technical Specification modifications and 23 FSAR modifications were approved whereas review of remaining modifications is in progress.

In 2021, PNRA carried out total 456 regulatory inspections at C-1, C-2, C-3 and C-4 including planned, announced and reactive inspections as reflected in Figure-8. As a result, several corrective actions were identified by PNRA in its inspection findings.

3.3 Research Reactors

Two research reactors i.e. Pakistan Research Reactor-1 (PARR-1) & Pakistan Research

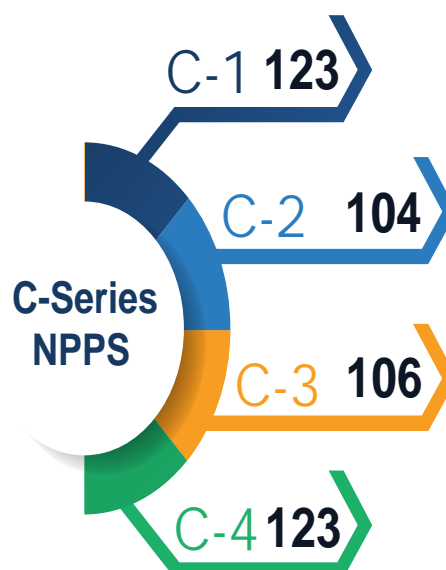


Figure-8: Inspections Performed at C-Series NPPs



Chairman PNRA Awarding Construction License of PARR-3 to Chairman PAEC

Reactor-2 (PARR-2), located at Pakistan Institute of Nuclear Science and Technology (PINSTECH), Nilore, Islamabad, are in operation. The operating licenses of PARR-1 and PARR-2 were valid till December 31, 2021 and December 31, 2024 respectively. PNRA has also issued construction license to third research reactor i.e. Pakistan Research Reactor-3 (PARR-3).

During the year 2021, Periodic Safety Review (PSR) of PARR-1 was carried out and corrective actions were highlighted accordingly. Upon satisfactory resolutions of all regulatory concerns raised during PSR review, the operating license of PARR-1 was revalidated for next period of ten years i.e., up to December, 2031.

PARR-3 request for permission of early concrete pouring in the safety related structure of research reactor was received at PNRA. In this regard, an early specific review of relevant PSAR Chapters was carried out and upon completion of review and assessment process, permission for early concrete pouring was granted to PARR-3 in February 2021. Moreover, upon completion of entire review and assessment process of PARR-3 application, Construction License (CL) was granted by PNRA in May 2021.

In addition to that, review of routine submissions of PARR-1 and PARR-2 (mainly include monthly technical reports and safety performance indicators) has also been performed to ensure operational safety of the reactors.



Award of Revalidation Licenses to C-1 and PARR-1

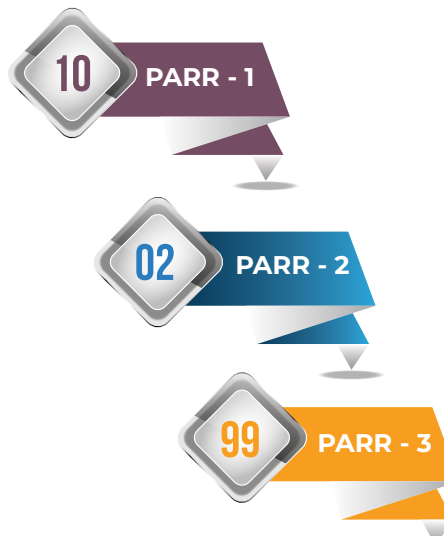


Figure-9: Inspections Performed at Research Reactors

PNRA performed a total of 111 regulatory inspections during the reporting period at PARR-1, PARR-2 & PARR-3 and findings / observations were communicated accordingly. The number of inspections conducted at PARR-1, PARR-2 & PARR-3 are presented in Figure-9.

Furthermore, PNRA also witnessed physical protection exercise held at PINSTECH.

3.4 Molybdenum Production Facilities

Molybdenum Production Facility-1 (MPF-1) is located at PINSTECH, Nilore, Islamabad. The operating license of MPF-1 is valid till December 31, 2022. During the year 2021, MPF-1 remained in operation throughout the year.

During the reporting period, PNRA received an application along with relevant documents

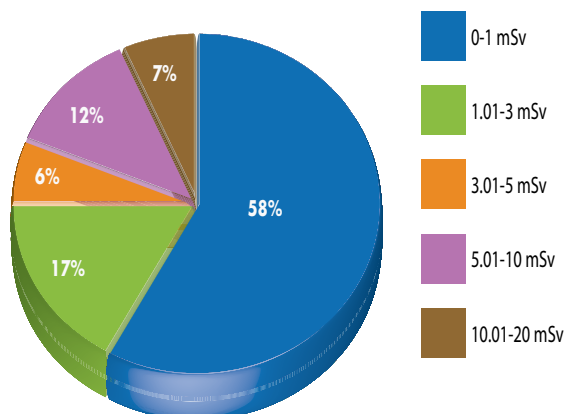


Figure-10: Annual Radiation Doses to K-1 Workers during 2021

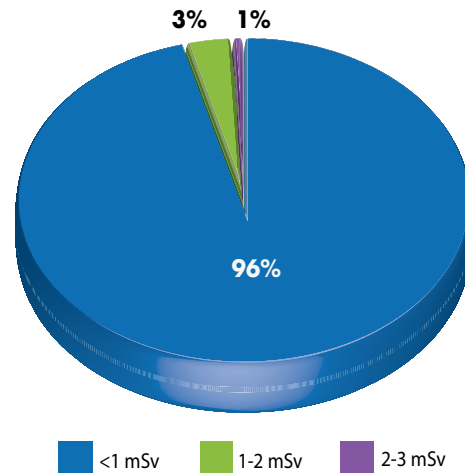


Figure-11: Annual Radiation Doses to C-1 Workers during 2021

for site registration and concrete pouring of another such facility namely Molybdenum Production Facility-2 (MPF-2) to be constructed at PINSTECH. The same were reviewed and after fulfilling all regulatory requirements, the site for construction of MPF-2 was registered by PNRA on November 12, 2021.

PNRA performed two regulatory inspections of MPFs in order to verify compliance of regulatory requirements by the licensee.

3.5 Occupational Exposures of Workers at Nuclear Installations

PNRA monitors dose records of radiation workers submitted by nuclear installations on annual basis. This includes information about number of persons exposed and radiation doses received by each worker.

As per regulatory requirements, the annual radiation dose limit is 20 mSv. However, in special circumstances, radiation dose of up to 50 mSv in a single year may be permitted provided that the average dose over five consecutive years does not exceed 20 mSv / year.

During the reporting period, radiation doses received by the workers during operation and refueling outages at NPPs remained well within the regulatory limits. All the radiation workers at K-2, C-2 and C-3 received radiation dose less than 1 mSv whereas radiation doses received by the workers of K-1, C-1, & C-4 are presented in Figures-10, 11, and 12 respectively.

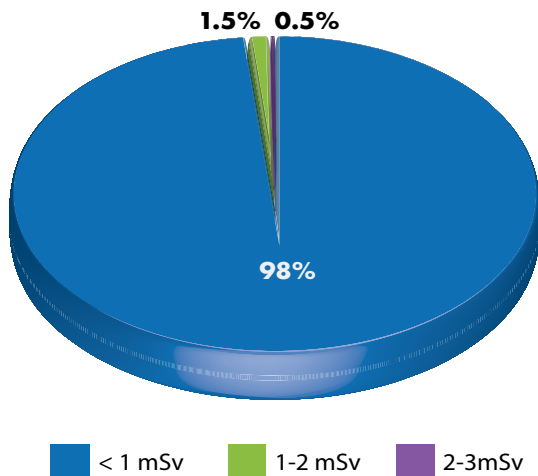


Figure-12: Annual Radiation Doses to C-4 Workers during 2021

Furthermore, dose distribution of workers of research reactors and MPF is shown in Figure-13.

3.6 Radioactive Waste Generation and Effluent Releases at Nuclear Installations

PNRA keeps strict oversight on generation of radioactive waste at nuclear installations.

The nuclear power plants generate solid, liquid and gaseous wastes containing radioactivity. These wastes are properly handled in line with PNRA regulations and waste management programmes of the licensees. PNRA ensures that the generation of solid radioactive waste and discharge of effluents remained within the authorized limits.

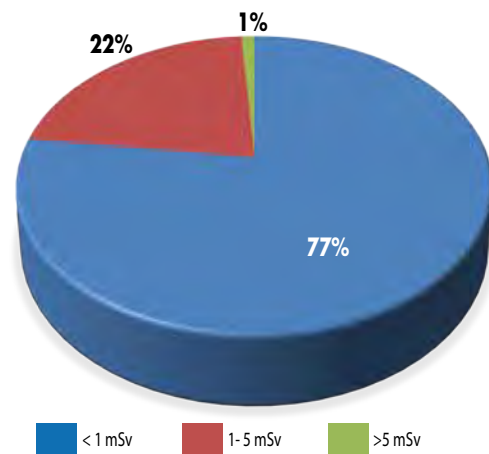


Figure-13: Annual Radiation Doses to Research Reactors and MPF Workers during 2021

During the year 2021, trends of generation of solid radioactive waste (drums) at K-1, C-1, C-2, C-3 and C-4 are shown in Figure-14. The trends of effluent releases from K-1 are reflected in Figure-15 and Figure-16. While effluent releases from K-2 are 5.11 GBq/year (Liquid) and 1.04 GBq/year (Gaseous).

The trends of gaseous and liquid effluent releases from C-Series NPPs are shown in Figure-17 and 18.

3.7 Spent Fuel Storage Facilities

Currently, KANUPP Spent fuel Dry Storage Facility (KSDSF) is in operation at K-1 site, whereas, multiunit dry storage facility for management of spent fuel of Pressurized

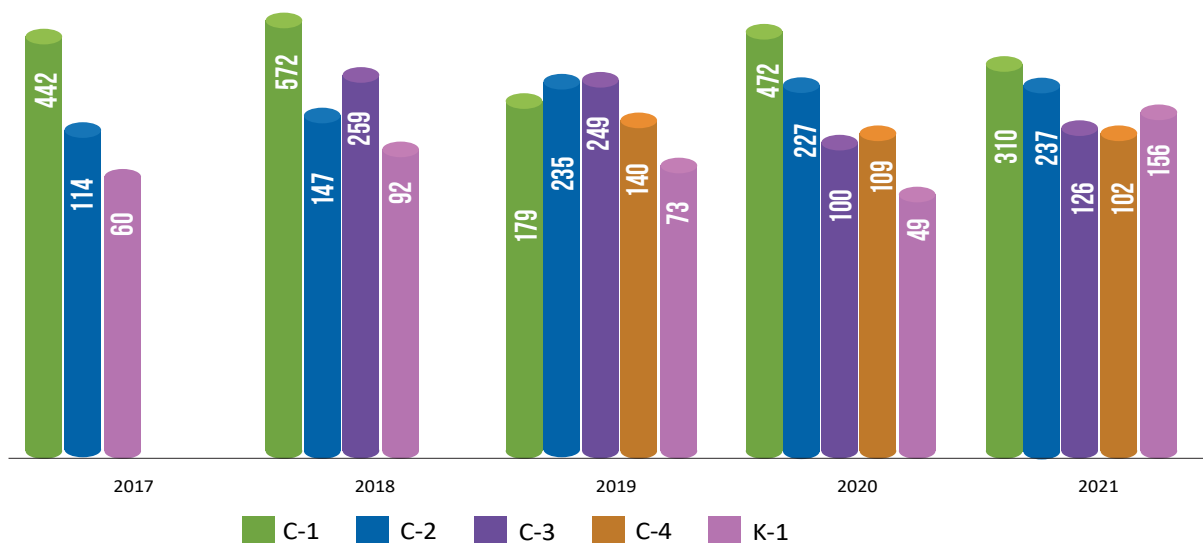


Figure-14: Trends of Generation of Solid Radioactive Waste (Drums) at K-1, C-1, C-2, C-3 and C-4

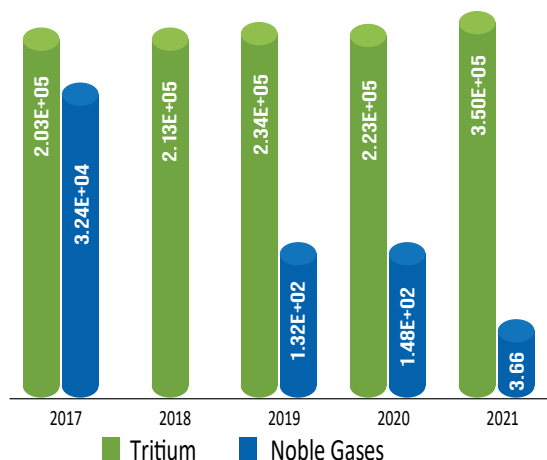


Figure-15: Trends of Gaseous Effluents from K-1 (GBq)
Water Reactors (PWRs) is under construction at Chashma Nuclear Power Generating Station (CNPGS) site.

Regulatory inspections of these facilities were carried out by PNRA to ensure that licensee is complying with the regulatory requirements. As per construction license condition of PWR dry Storage Facility (PDS), construction progress report was submitted by CNPGS which was reviewed and found acceptable.

3.8 Disposal Facilities

During the reporting period, Pakistan Atomic Energy Commission (PAEC) submitted its intention to establish Regional Repository South

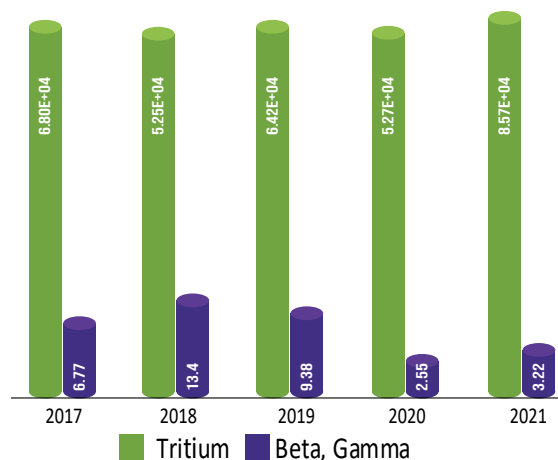


Figure-16: Trends of Liquid Effluents from K-1 (GBq)
(RRS) in Karachi. The RRS is a near surface disposal facility for management of low level and intermediate level waste generated in the southern region of Pakistan.

3.9 Licensing of Plant Operating Personnel

Availability of qualified and trained operating personnel is a fundamental requirement for sustainable and safe operation of nuclear power plants and research reactors. Accordingly, PNRA has set criteria for the qualification and experience of the operating personnel and issues licenses to these personnel after conducting licensing examination of operating personnel for the positions of Shift Supervisors



Figure-17: Trends of Gaseous Effluents from C-Series (Bq)

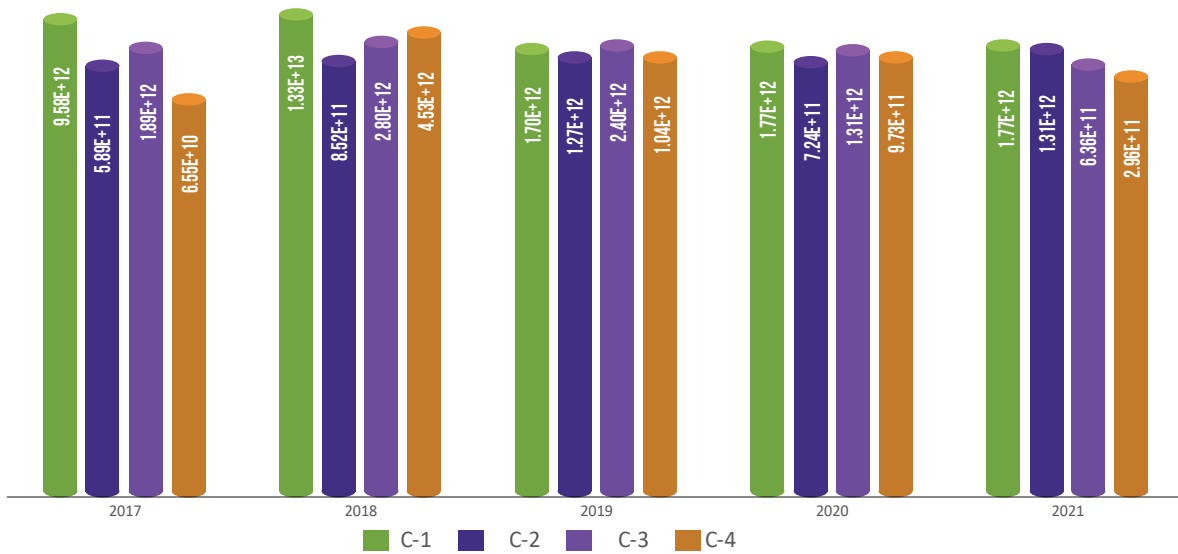


Figure-18: Trends of Liquid Effluents from C-Series (Bq)

(SSs) and Shift Engineers (SEs). The operating licenses are renewed annually based on verification of their technical and professional competences, fulfillment of the condition of minimum required time in shift operation, re-training and medical fitness requirements of PNRA. During the reporting period, licensing

examination of operating personnel of nuclear power plants (i.e. both K-series & C-Series) and research reactors (i.e. PARR-1 and PARR-2) was conducted by PNRA licensing committee. Statistics of issuance and renewal of licenses of operating personnel for nuclear installations are depicted in Figure-19.

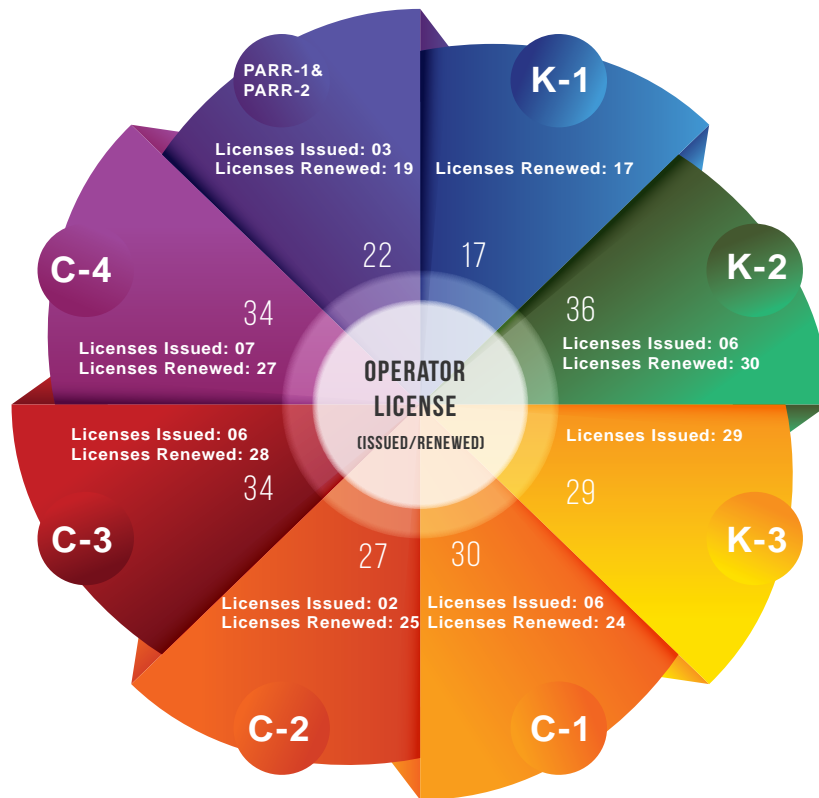


Figure-19: Statistics of Issuance / Renewal of Licenses of Operating Personnel for Nuclear Installations

REGULATING RADIATION FACILITIES

6405 Number of
Radiation Facilities

1695 Inspections
Performed

2325 Enforcement
Actions Taken

1897 NOCs and
Permits Issued

14591 Number of
Radiation Workers



Radiation sources are widely used in Pakistan in diagnostic radiology centres; radiotherapy centres; nuclear medicine centres; industrial radiography facilities; blood, food and material irradiators; well logging units; nuclear gauges, agriculture, research institutes, etc. Since radiation sources are hazardous in nature, these sources can be harmful to workers, public and the environment, if used without following proper safety measures. Therefore, there is a need for a stringent regulatory oversight over radiation facilities and associated activities to protect human beings and the environment from the harmful effects of ionizing radiation.

PNRA is responsible to regulate all radiation facilities and associated activities to ensure that safety requirements are strictly followed during the application of radiation sources and that the workers, public and the environment are protected from radiation risks. The regulatory oversight processes of PNRA include licensing, authorization, review and assessment, inspection and enforcement for ensuring the safe use of radiation sources. In carrying out its regulatory functions, PNRA applies graded approach based upon safety significance and radiological hazards associated with the facilities and activities.

4.1 Medical Radiation Facilities

Radiation sources are extensively used for diagnostic and therapeutic purposes in medical radiation facilities. A medical radiation facility can be a hospital that has facilities for diagnostic radiology, image guided interventional procedures, nuclear medicine and radiation therapy or it can be a standalone facility of radiotherapy, nuclear medicine or cardiology, etc. Majority of the medical radiation facilities

are the diagnostic radiology centres being licensed by PNRA.

By the end of 2021, more than 5700 medical radiation facilities were in the licensing net of PNRA including the addition of 527 new medical radiation facilities. Figure-20 shows the number of various types of medical radiation facilities.

The licensing and authorization process undergo a thorough review and assessment process of the licensing submissions provided by the applicant such as Safety Analysis Report (SAR), Radiation Protection Programme (RPP), Radiation Emergency Plan (REP), Physical Protection Plan (PPP), Quality Assurance Programme (QAP), Initial Decommissioning Plan (IDP) and shielding reports.

The submission requirements are described in "Regulations for the Licensing of Radiation Facility(ies) other than Nuclear Installation(s)- (PAK/908) (Rev.1). In addition, the licensees are also required to submit various documents (routine and non-routine) like dose record of radiation workers, event reports, etc. During the year 2021, PNRA reviewed more than 100 documents of medical radiation facilities and comments were shared accordingly.

PNRA conducts regulatory inspections to verify that the licensees comply with the regulatory requirements and license conditions. Regulatory inspections are conducted in accordance with PNRA Inspection Programme for radiation facilities. Inspections are performed as per frequency defined in Inspection Programme which is based on graded approach. During the year 2021, PNRA conducted 1467 inspections of medical radiation facilities throughout Pakistan. Follow up inspections were also carried out to ensure implementation of required corrective

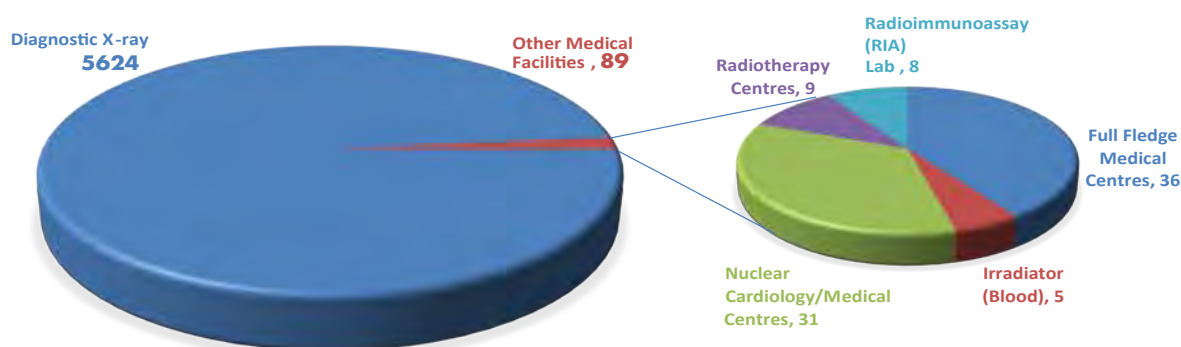


Figure-20: Spectrum of Licensed Medical Radiation Facilities

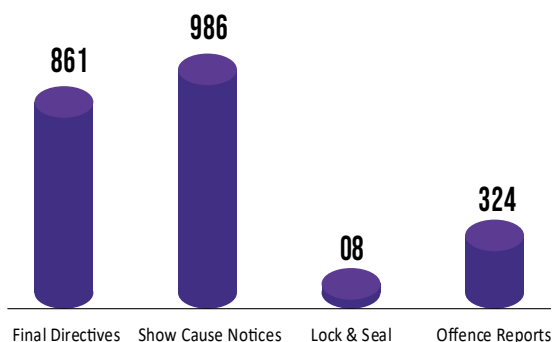


Figure-21: Enforcement Actions against Medical Radiation Facilities

actions. However, the inspection activities were affected by Covid-19 pandemic during the reporting period. Keeping this in view, PNRA shared self assessment sheet with the Diagnostic X-ray Facilities and directed them to submit it to PNRA for ensuring safety.

PNRA takes enforcement actions in case of non compliance of regulatory requirements. Enforcement actions include issuance of show cause notices, offence reports, directives, suspension or revocation of license and lock and seal of the facility. The enforcement process may also lead to prosecution and imposition of penalty through court of law in case the violator does not take the required corrective action. Figure-21 shows the enforcement actions being taken.

PNRA also witnesses the emergency exercises and drills conducted by the licensees to verify effectiveness of the approved emergency plans. During the year 2021, due to Covid-19, the frequency of emergency exercises and drills remained low. A total of eight emergency exercises and drills at medical radiation facilities were witnessed by PNRA.

4.2 Industrial Radiation Facilities

Radiation sources are used in industries for different applications including industrial radiography, well logging, food and equipment irradiations, nuclear gauges, etc. PNRA ensures that these sources are under strict regulatory control during use, storage and transport through regulatory processes.

By the end of 2021, 10 new industrial radiation facilities were added to PNRA licensing net which resulted in a total number of 230 industrial radiation facilities. Number of various types

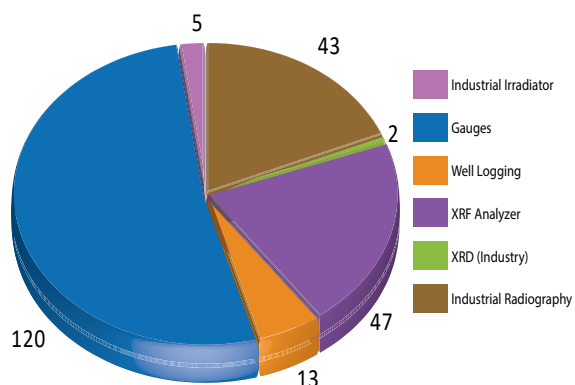


Figure-22: Status of Industrial Radiation Facilities

of industrial radiation facilities are depicted in Figure-22. PNRA reviewed 77 documents including Safety Analysis Reports (SARs), Radiation Protection Programmes (RPPs), Radiological Emergency Programmes (REPs), Physical Protection Programmes (PPPs) and Quality Assurance Programmes (QAPs) as a part of licensing process or periodic submissions.

PNRA performed 110 inspections to ensure compliance of regulatory requirements during the year 2021. Enforcement actions taken against violators of industrial radiation facilities are shown in Figure-23. Furthermore, PNRA witnessed 10 emergency exercises and drills for improvement in weak areas.

4.3 Research and Educational Institutions

Radiation sources are used in universities and other academic and scientific institutions for laboratory demonstrations and experiments such as calibration of radiation measurement instruments. PNRA authorizes these facilities by issuing licenses.

By 2021, PNRA has a total number of 74 research and educational institutions in its

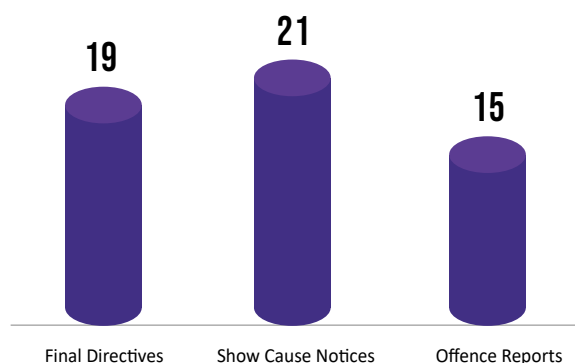
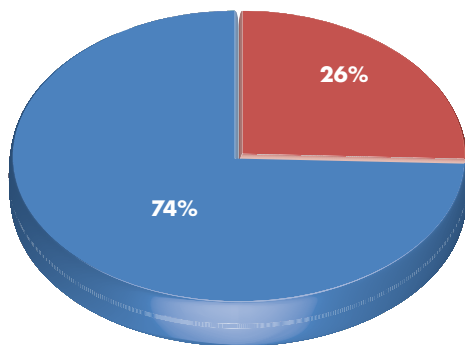


Figure-23: Enforcement Action against Industrial Facilities



Education Research

Figure-24: Research and Educational Institutes in Licensing Net

licensing net including four new facilities, as reflected in Figure-24. Furthermore, PNRA reviewed a number of submissions of research and educational radiation facilities. In addition, PNRA also performed 34 inspections during the year 2021 to ensure compliance of regulatory requirements.

4.4 Other Applications (import, export, scanners, etc.)

Scanners (cargo or vehicle or baggage) either having radiation sources or X-ray based, are used for scanning of large-scale cargo, loaded vehicles, containers, and baggage. Similarly, importers, exporters, traders of radiation sources and non medical human imaging are also licensed by PNRA. By the end of year 2021, 388 radiation facilities belonging to this category were in the licensing net of PNRA including the addition of 51 new facilities. The distribution of scanners, importers and exporters of radiation sources and similar facilities is shown in Figure-25. PNRA reviewed 21 documents submitted by the licensees. PNRA conducted 84 inspections to ensure compliance of regulatory requirements. PNRA has taken enforcement actions against

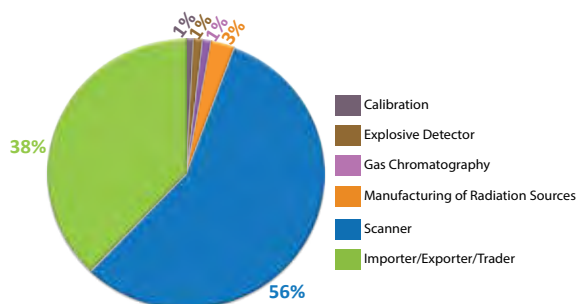


Figure-25: License Issued to Scanners, Importers and Exporters of Radiation Sources

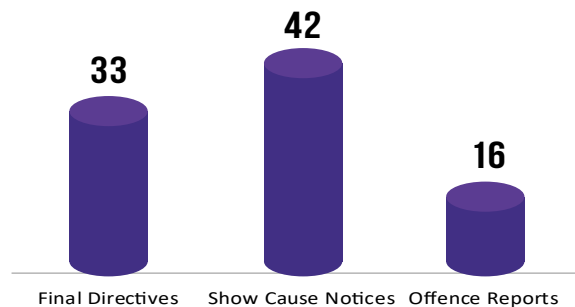


Figure-26: Enforcement Actions Taken against Others (Scanners, Importers, Exporters, Traders)

licensees as shown in Figure-26 to improve or enhance radiation protection and safety.

4.5 Permits and NOCs

Any import or export of radiation sources or radiation generator requires an authorization from PNRA. Accordingly, liaison has been established with the Federal Board of Revenue (FBR) to ensure effective control and prevent entry or exit of any consignment containing radiation sources or radiation generator unless the consigner obtains a "No Objection Certificate (NOC)" from PNRA. Only a valid license holder is authorized for such import or export. The NOC is issued after verification of the intended end use and the technical specifications of the radiation source or radiation generator being imported or exported. During the year 2021, PNRA issued 1740 NOCs for the import and export of radiation sources and radiation generators. In some cases of import, the originating country requires a special permit from PNRA prior to procurement of a radiation source. PNRA issues such permit to facilitate the process of procurement. In 2021, PNRA issued 157 permits for procurement of radiation sources. Figure-27 reflects NOCs issued by PNRA during the 2021.

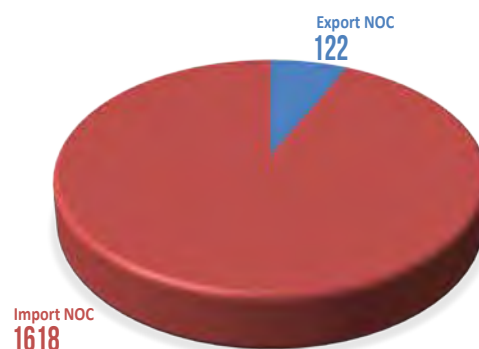


Figure-27: NOCs Issued by PNRA in 2021

4.6 Radioactive Waste and Disused Radiation Sources

The application of radioactive materials in medical, industrial and other sectors generates radioactive waste. PNRA ensures that radioactive waste generated from these facilities is managed by the licensee as per applicable regulatory requirements.

Nuclear Medical Centres (NMCs) produce short lived radioactive waste which can be in solid, liquid or gaseous form. The solid radioactive waste is stored until its activity falls below exemption levels and is then disposed off as ordinary waste. Similarly, liquid radioactive waste is released into the environment after proper dilution or decay when its activity is less than the regulatory limits. The gaseous waste generated at these centres is mainly due to application of Iodine-131, which is trapped into filters at fume hoods. Later, these filters are managed as solid radioactive waste.

PNRA requires the NMCs to submit their radioactive waste management programmes (RWMPs) for review and approval as part of the licensing document. In order to verify the compliance of NMCs with the regulatory requirements, PNRA regularly conducts regulatory inspections of NMCs. The recommendations made during these inspections have improved the management of radioactive waste.

Sealed radioactive sources used in various sectors become radioactive waste after completion of their useful life. These are

termed as Disused Sealed Radioactive Sources (DSRS). According to regulatory requirements, DSRS, having a remaining half life of more than one year and initial activity greater than 100 GBq, are required to be returned to suppliers. Other DSRS are stored at designated storage facilities in the country. There are two designated radioactive waste storage sites in the country namely Radioactive Waste Storage Area (RAWSA), Karachi and PINSTECH Predisposal Radioactive Waste Management Facility (PPRWMF), Islamabad. RAWSA stores DSRS from the southern part of country; while PPRWMF stores DSRS from the northern part of the country.

PNRA maintains inventory of DSRS stored in designated sites and those returned to suppliers. The status of DSRS stored in the country and those returned to the suppliers is reflected in Figure-28.

4.7 Occupational Exposures

Maintaining occupational exposure records are necessary for ensuring safety of the workers. It also provides an insight of the safety culture at the facility. PNRA is maintaining a database of occupational exposure records at national level. Radiation facilities are required to submit radiation exposure records of workers involved in activities associated with applications of radiation sources.

Furthermore, PNRA obtains such records separately from dosimetry service providers. The dose record is directly linked with the CNIC of the workers which enables PNRA to identify

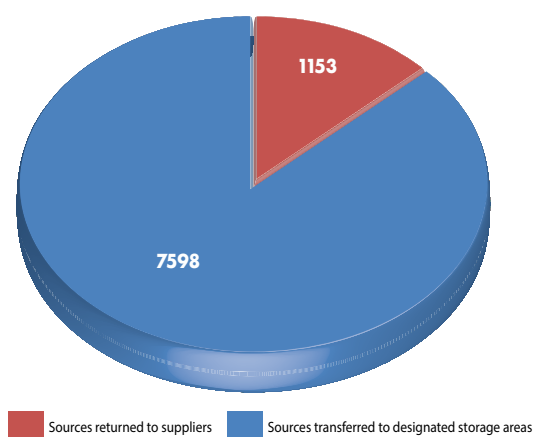


Figure-28: Status of DSRS

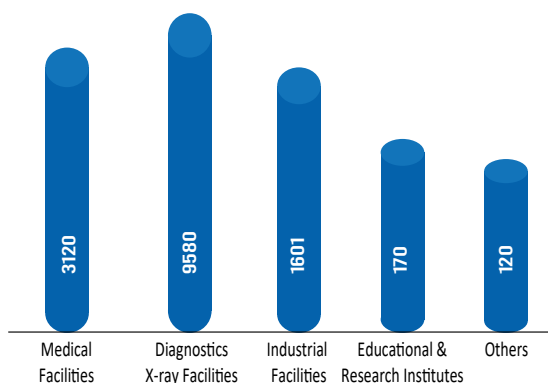


Figure-29: Distribution of Radiation Workers in Radiation Facilities

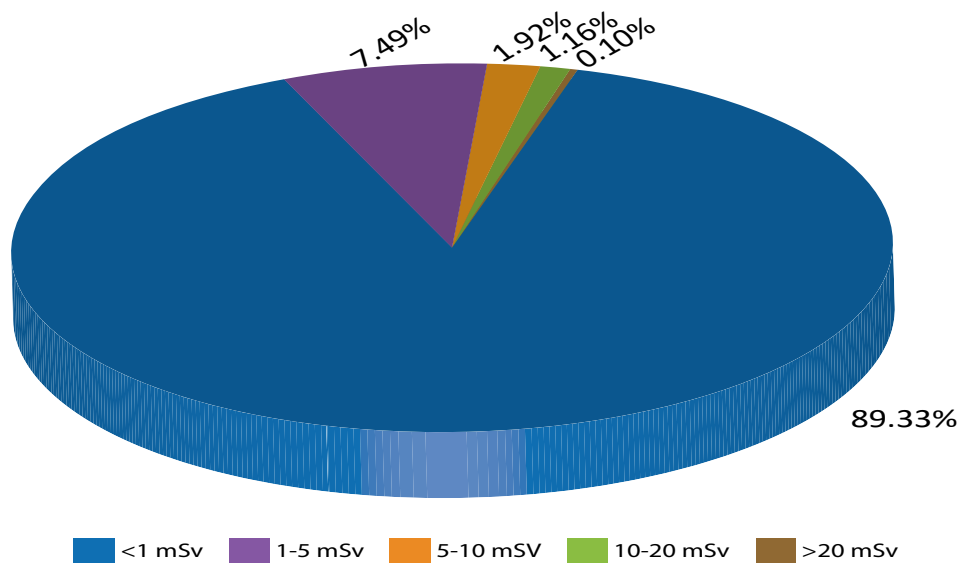


Figure-30: Occupational Exposure of Radiation Workers in Different Dose Ranges

the itinerant workers and smooth retrieval of their dose records.

PNRA evaluates the dose records of the workers to monitor exposures and adherence to regulatory dose limits. At present, the database includes dose records of more than 14500 radiation workers. The distribution of radiation workers in various categories of radiation facilities is shown in Figure-29.

As per this database, to date, doses to more than 96.80% of radiation workers remained less than 5 mSv in a year while more than 3% of the workers received doses between 5-20 mSv

in a year. A small fraction 0.10% of the workers received doses above 20 mSv in a year. The reason for such higher doses was thoroughly investigated and it was ensured that whenever such exposures are reported, the five year average annual dose of such workers is kept within the prescribed regulatory dose limits.

During the reporting period, 10 investigation reports of occupational overexposure cases were reviewed and the licensees were advised to take corrective actions accordingly. Figure-30 reflects the overall occupational exposure of all radiation workers in different dose ranges.

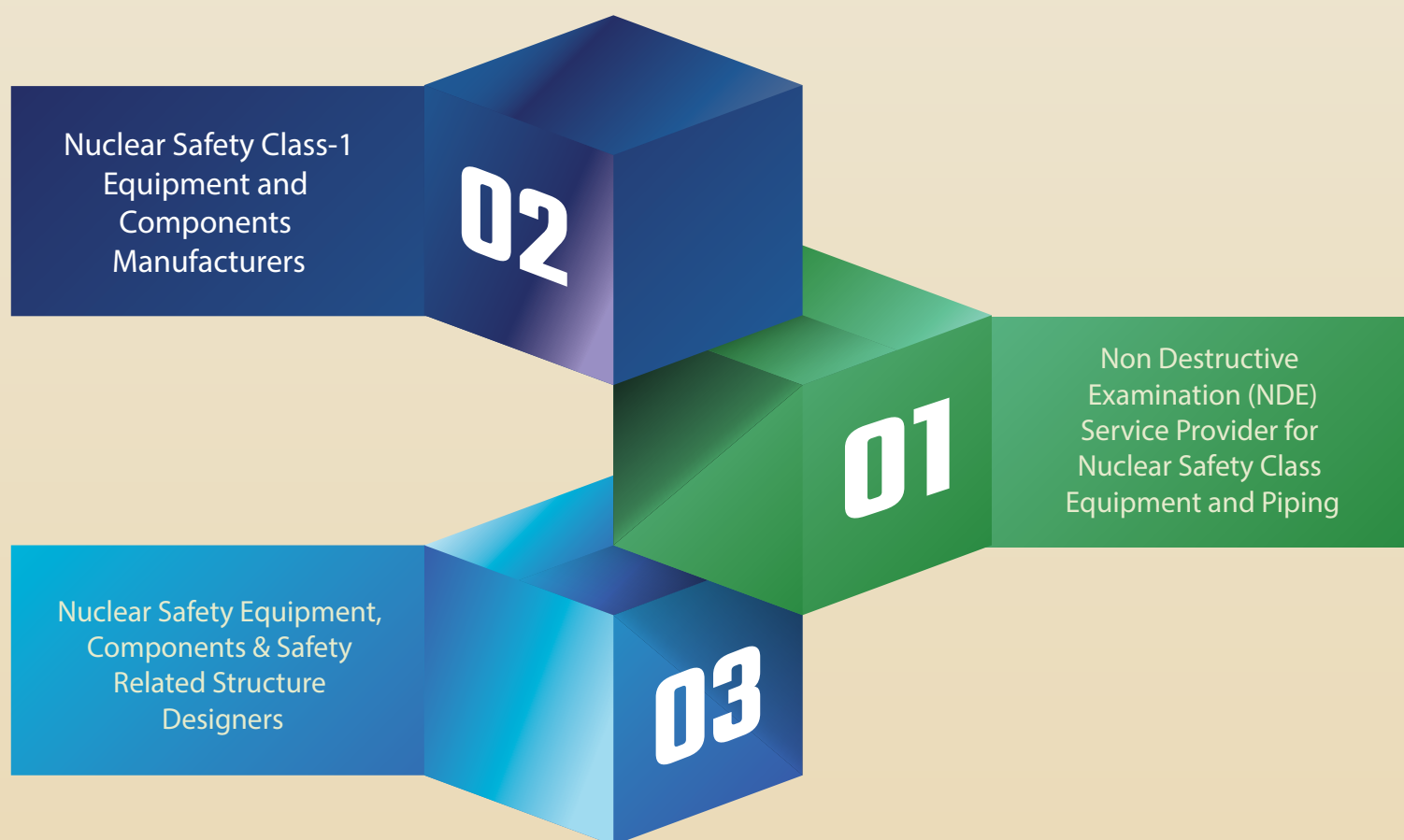


Conduct of Hearing at PNRA HQ's



PNRA Inspectors Conducting Radiation Survey at Nuclear Gauge Facility, Gujranwala

REGULATING MANUFACTURERS, DESIGNERS AND SERVICE PROVIDERS



Design and manufacturing of nuclear safety related structures, systems and components are very important for the safe operation of a nuclear installation.

Accordingly, these areas are regulated by PNRA and licenses are awarded to the organizations involved in design and manufacturing of nuclear safety related structures, systems and components (SSCs).

PNRA also grants authorizations to various service providers performing important activities like non-destructive examination (NDE) of nuclear safety class SSCs.

The licenses and authorizations are issued on the basis of rigorous review and assessment of applicant's submissions, demonstration of its capability to perform the activities on mock-ups and evaluation of results of activities performed in this context.

In addition, PNRA performs regulatory inspections of its licensees including service providers, designers and manufacturers of nuclear safety related SSCs to verify compliance with regulatory requirements, conditions of license / authorization and applicable codes

and standards.

5.1 Designers of Safety Related Structures and Equipment

During the reporting period, PNRA awarded licenses to Heavy Mechanical Complex-3 (HMC-3) for the design of Nuclear Safety Class-3 (NSC-3) mechanical equipment and to Works & Services Organization (WASO) for design of nuclear safety related structures. The design licenses of both HMC-3 and WASO are valid till December, 2025.

Further, after satisfactory demonstration of safety during mock-up inspections, licensing of Instrumentation Control & Computer Complex (ICCC) as designer of nuclear safety class instrumentation and control (I&C) systems was completed and license was issued to ICCC as a designer of analog I&C systems.

5.2 Manufacturers of Safety Class Equipment

Presently, Heavy Mechanical Complex-3 (HMC-3) and Novel Engineering Works-2 (NEW-2), located at Taxila and Karachi respectively,



Ceremony for Grant of Licenses to HMC-3 and WASO

are manufacturing Nuclear Safety Class-1 (NSC-1) equipment. PNRA has granted the manufacturing licenses to HMC-3 and NEW-2 which are valid till June, 2022 and December, 2022 respectively.

Licensing of ICCC as Class 1E equipment manufacturer is in progress. It is currently at mock-up development stage and ICCC has submitted "Technical Document for Development of Mock-up" for acquiring class 1E equipment manufacturer license. The licensing documents are presently under review at PNRA and it is expected that the licensing decision will be made during the first quarter of 2022.

Furthermore, HMC-3 is manufacturing various equipment and components like vessels, tanks and heat exchangers for PARR-3. It has submitted manufacturing related quality assurance plans, technical specifications, drawings and production technologies to PNRA during the year 2021. The licensing documents have been reviewed and found in line with regulatory requirements.

During the reporting period, NEW-2 submissions regarding manufacturing of certain equipment were also reviewed. PNRA comments were

communicated which were resolved before starting the process of manufacturing of these components.

During the year 2021, PNRA conducted seven regulatory inspections at HMC-3 and NEW-2 during equipment manufacturing.

5.3 Service Providers

Currently, National Centre for Non-Destructive Testing (NCNDT) is the only licensed organization which provides non-destructive examination (NDE) services to nuclear industry in Pakistan. The authorization issued to NCNDT is valid till December 31, 2025.

During the reporting period, quality assurance plans (Q-plans) for performing NDE during C-1 RFO-14 and C-4 RFO-3 In-Service Inspection (ISI) activities have been reviewed and accordingly control points were selected for inspection.

During the reporting year, PNRA has conducted total 11 regulatory inspections during NDE activities performed by NCNDT at NPPs and their performance was found satisfactory. Further, QA inspections have also been performed by PNRA during reporting year.



License Award Ceremony of Service Providers



Former Chairman PNRA Granting Design License of HMC-3 to Chairman PAEC



Ceremony for Grant of Licenses to C-1/C-2, PARR-1, K-3 and ICCC by PNRA

EMERGENCY PREPAREDNESS AND RESPONSE

EMERGENCY PREPAREDNESS AND RESPONSE

Participation in
Convention Exercises
(ConvEx)

04

Participation in
Communication Test
Exercises (COMTEX)

02

Events Reported to
Incidents and
Trafficking Database

37

Witnessed Emergency
Exercises of Nuclear
Installations

05

Functional Areas
Registered in Response
and Assistance
Network (RANET)

07

Radiation Monitoring
Teams (RMTs) across
the Country

07

PNRA

Nuclear installations and radiation facilities are designed and operated to the highest safety standards in order to ensure the safety of workers, public and the environment. Nuclear installations are equipped with redundant and diverse safety systems based on multi-layered defense mechanisms to prevent the occurrence of any incident or accident. Similar arrangements are made in radiation facilities according to graded approach to prevent accidents involving radiation sources. In spite of all such safety measures, possibility of occurrence of nuclear or radiological emergencies cannot be completely overlooked.

Therefore, the licensees are required to make arrangements for emergency preparedness and response at nuclear installations and radiation facilities by formulating emergency plans, and conducting exercises at the facilities to cope with such untoward events.

PNRA has established and implemented regulations on emergency preparedness and response based on international standards and experience feedback. PNRA ensures that the emergency response plans at nuclear installations and radiation facilities are in line with these regulations. PNRA is also responsible to notify and advise the government and other stakeholders regarding implementation of necessary safety and protective measures for mitigation of the consequences of nuclear or radiological emergencies. PNRA advises relevant departments, institutions, industries, etc. on matters related to nuclear safety and radiation protection.

Pakistan is also a party to the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency. The Government of Pakistan has designated PNRA as the National Competent Authority and the Point of Contact for these Conventions.

6.1 Emergency Preparedness and Response Functions of PNRA

In order to ensure that the arrangements for emergency preparedness and response are in place at the licensed facilities, PNRA has issued Regulations on Management of a Nuclear or Radiological Emergency - (PAK/914) which give associated requirements, to be fulfilled by the

licensees.

In accordance with the regulatory requirements, installations and facilities having potential for a nuclear or radiological emergency are required to formulate on-site and off-site emergency response plans keeping in view a graded approach. Such plans address the potential emergency situations, provide mechanisms for notifications, describe response actions and explain measures to be taken for mitigation of consequences. These plans also describe arrangements for medical response, measures for preventing ingestion of contaminated food items and mention long-term protective actions.

PNRA also plays a pivotal role in Nuclear Emergency Management System (NEMS) operations. According to NEMS, PNRA is responsible to provide assistance and advice to the government, local and national response organizations in case of an emergency.

Further, PNRA requires the licensees to submit the radiation emergency preparedness and response plans for review and assessment. PNRA thoroughly reviews these plans and verifies compliance with the regulatory requirements and provides recommendations for improvement in these plans. Once PNRA accepts these plans, effective implementation of these plans is ensured through inspections of arrangements, exercises and drills.

During the year 2021, PNRA reviewed three emergency response plans of nuclear installations and 34 Radiation Emergency Plans (REPs) of radiation facilities and activities which included hospitals, industrial units, irradiators, and industrial radiography practices, etc.

PNRA requires its licensees to test the emergency plans periodically through drills and exercises. PNRA witnesses some of these emergency drills and exercises to assess effectiveness and implementation of emergency plans. Accordingly, each nuclear installation is required to conduct emergency exercise annually. The emergency exercise scenarios of nuclear installations are submitted to PNRA for approval.

During the reporting year 2021, a table top off-site emergency exercise at CNPGS; a joint safety / security plant emergency exercise at K-1; Onsite Emergency Exercise at K-3; Facility

Emergency Exercise at PARR-1; and Facility Emergency Exercise at MPF were conducted. PNRA inspectors witnessed the conduct of these exercises and shared observations for further improvement of implementation of emergency plans.

PNRA also participates in international level exercises to test the preparedness and response arrangements. These exercises provide an opportunity to assess the national capacity in relation to emergency preparedness and response under international conventions and keep abreast with the current international practices for further improvement in the relevant areas. Amongst these exercises, IAEA Convention Exercise (ConvEx) is conducted to test the arrangements, identified and maintained under the Early Notification and Assistance Conventions. These arrangements include 24/7 availability of national warning point, activation of national response infrastructure and provision of international assistance under IAEA Response and Assistance Network (RANET). During the year 2021, PNRA participated in four ConvEx exercises.

PNRA conducts various in-house exercises to test its own preparedness and response arrangements during different types of emergency situations. During the year 2021, PNRA conducted two Communication Test Exercises (COMTEX) exercises to test the

availability of dedicated communication channels of PNRA HQ's, regional directorates and inspectorates of PNRA, licensed nuclear installations and other relevant national response organizations.

Radiation Monitoring Teams (RMTs) equipped with necessary radiation detection and personal protection equipment have been established by PNRA to provide technical assistance to local and national response authorities and to perform independent assessment of any situation involving accidental radiation exposures. These RMTs are located at major cities and NPP sites across the country. Recently, PNRA established a radiation monitoring team at Gilgit Baltistan, increasing the number of RMTs to seven. During the reporting period, PNRA radiation monitoring teams were deployed on several occasions of important public events for radiation survey of the venue, monitoring of persons and identification of any presence of a radioactive source.

6.2 National Radiation Emergency Coordination Centre (NRECC)

PNRA maintains National Radiation Emergency Coordination Centre (NRECC) at its headquarters in Islamabad to fulfill the obligations of PNRA Ordinance and International Conventions. The centre is responsible to coordinate and share reliable information and provide assistance to



NRECC Technical Support Team during ConvEx-3 Exercise held in 2021 at PNRA

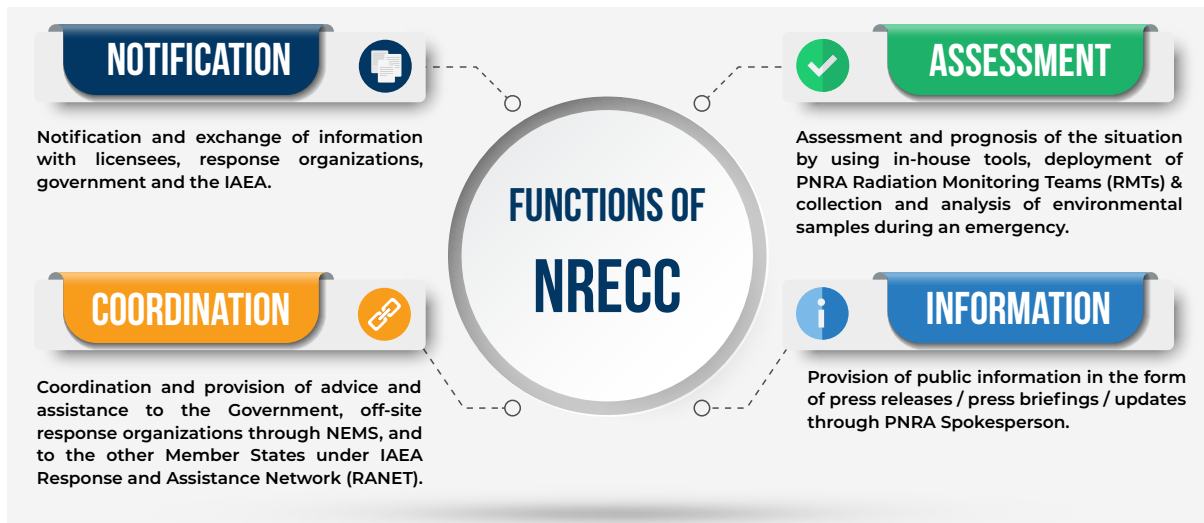


Figure-31: Main Functions of NRECC

response organizations in case of nuclear or radiological emergencies. NRECC serves as Pakistan's designated National warning point under these Conventions. NRECC is authorized to issue and receive radiological emergency related information and notifications, coordinate requests and remains ready round the clock to respond and coordinate in case of a nuclear accident or radiological emergency. Main functions of NRECC during a nuclear or radiological emergency are shown in Figure-31.

During the reporting period, PNRA upgraded its National Radiation Emergency Coordination Centre (NRECC) at its headquarters in

Islamabad. Furthermore, two regional Radiological Emergency Coordination Centres (RECCs) have been established at Karachi and Chashma to support NRECC through monitoring of emergency situation at the nuclear power plant sites. Advance communication facilities such as satellite phones and audio / video communication system are provided at NRECC and Regional RECCs to coordinate with national and international organizations in emergency situation.

NRECC is equipped with means of communication, radiation detection equipment, personal protective equipment, Mobile



Radiation Survey at a Steel Mill

Radiological Monitoring Labs (MRMLs) and technical support team comprising of experts from various directorates of PNRA.

NRECC is activated as per PNRA response plan during emergency situations and exercises. Upon notification of an incident, NRECC functions in one of its three response modes namely Alert, Partial Activation and Full Activation depending upon the level / severity of the emergency. Each event is classified and responded according to the extent of the actual or potential radiological consequences. During the year 2021, NRECC was activated three times in partial activation mode due to declaration of emergencies at plants as a result of off-site power failures.

6.3 Participation in IAEA's Response and Assistance Network

Under the International Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, the IAEA has established Response and Assistance Network (RANET). The aim of this network is to coordinate international assistance to / from its Member States in case of a nuclear or radiological emergency to help in minimizing the radiological consequences. Being the State

Party to the Convention, Pakistan has registered its National Assistance Capabilities (NAC) in seven functional areas in the RANET. During the reporting period, the NACs registered with RANET were tested during the conduct of IAEA ConvEx exercises held in March and October, 2021.

Furthermore, during the year 2021, Pakistan has conducted four national workshops on RANET for testing of mechanisms for the readiness and deployment arrangement of National Assistance Capabilities (NACs).

6.4 Sharing of Information about Events Involving Ionizing Radiation

Under the Convention on Early Notification of a Nuclear Accident, it is mandatory for IAEA Member States to share information of radiation related events among concerned national level organizations and the IAEA. These incidents are reported through international platforms of IAEA which include Nuclear Events Web-based System (NEWS) and Unified System for Information Exchange in Incidents and Emergencies (USIE). NEWS is a publically accessible online communication channel for sharing information about events involving ionizing radiation. USIE is a web portal



Training Course on Medical Response during a Nuclear or Radiological Emergency at GINUM, Gujranwala

for reporting of radiological events under international conventions.

Since, PNRA (NRECC) is the national point of contact, therefore, it shares with IAEA any such events occurred in the country whereas it receives information from Member States through IAEA about nuclear or radiological emergencies occurred in the world and disseminate such information to relevant quarters in the country. Such information is analyzed and lessons learnt are shared with the relevant national stakeholders for improvement of their emergency preparedness and response capabilities.

During the reporting period, information of 37 international events were received and shared with relevant stakeholders in the country. These events were related to overexposure of workers or public, theft or loss of radiation sources, spread of radioactive contamination and malfunction of equipment, etc.

Similarly, events related to nuclear or radiological emergencies in Pakistan are also reported to IAEA on voluntary basis. Reporting of an event is based on its classification on a scale, known as International Nuclear and

Radiological Event Scale (INES) which serves as a tool for communicating the safety significance of nuclear and radiological events. The INES scale is divided into eight levels, ranging from 0 to 7, measuring the events on the basis of their safety significance. During the year 2021, Pakistan reported one event rated at level-0 in the INES of IAEA.

6.5 Reporting of Radioactive Source Movement

Radioactive sources being used for industrial radiography and nuclear medicine are frequently transported to carry out required activities. These sources require robust safety and security measures during transportation to prevent any incident. The regulatory framework, therefore, requires the licensees to report any movement of radioactive sources in the country to NRECC. PNRA shares this information with national authorities and with its regional directorates for conducting inspection during source movement to verify compliance with safety and security requirements as well as for timely response if any incident occurs. During the year 2021, PNRA received 2439 notifications of source movement from licensees which were communicated accordingly.



Demonstration of Emergency Preparedness Measures to Ghana Delegation

ENVIRONMENTAL MONITORING, DOSIMETRY AND CALIBRATION



193

ESTABLISHMENT OF NATIONAL BACKGROUND RADIATION LEVELS

(Analysis of water and soil
samples from GB and AJ&K)

614

EXTERNAL DOSIMETRY

(Radiation dose monitoring of PNRA
inspectors and licensees' workers)

479

INTERNAL DOSIMETRY

(WBC monitoring of RFO workers, IAEA
inspectors, Chinese as well as plant
personnel of CNPGS)

919

EQUIPMENT CALIBRATED

(Calibration of Radiation
Monitoring Equipment)

Nuclear materials and radioactive sources are widely used in electricity generation, industries, R&D activities and in hospitals for treatment & diagnostic purposes for the benefit of mankind. However, the risks for radiation exposures to the workers also exist in such practices. Therefore, monitoring of radiation exposure of radiation workers is very important for taking necessary protective measures to avoid any over exposure. Furthermore, PNRA Ordinance section 39(1) has mandated PNRA to ensure, implement and co-ordinate national programme of environmental surveillance to check any build-up of environmental radioactivity that might affect the public.

In the light of above, PNRA has built its capabilities in the areas of environmental monitoring & personal dosimetry in order to determine the radiation level in the environment and assess the radiation doses received by radiation workers and public and has established various laboratories to serve these purposes. These laboratories are equipped with gamma irradiator, spectrometry systems and personal dose monitoring equipment.

The environmental monitoring labs are utilized in establishing background radiation levels across the country and to conduct environmental radioactivity surveillance around Nuclear Power Plants (NPPs) and Research Reactors (RRs). The details of these activities have been provided in succeeding paragraphs.

7.1 Evaluation of Radioactivity in the Environment

Human beings are continuously exposed to ionizing radiations that stem from several sources natural and man-made sources including cosmic rays, naturally occurring radionuclide and man-made radioactivity from past nuclear accidents, operation of nuclear installations and use of radiation sources and generators in various applications.

In order to evaluate radioactivity in the environment, major activities performed includes establishment of national background radiation levels in soil and water across the country and radiation monitoring by collection of environmental samples in the vicinity of nuclear installations. These activities are further elaborated in the following subsections.

7.1.1 Environmental Monitoring around Nuclear Installations

Nuclear Installations (Nuclear Power Plants (NPPs) and Research Reactors (RRs)) discharge certain amount of radioactivity in the environment in a controlled manner during their operation. These discharges are in the form of liquid and gaseous effluents. PNRA periodically conducts independent environmental monitoring around nuclear installations in order to ensure that operation of NPPs and RRs do not pose any risk to human health and environment. The surveillance involves sampling and analysis of various types of environmental media (soil, water, aerosols, milk, vegetation, etc.). During the reporting period, PNRA collected a total of 266 samples from Chashma Nuclear Power Generating Station (CNPGS), Karachi Nuclear Power Generating Station (KNPGS) and RR. These samples were processed at Environmental Monitoring & Dosimetry (EM&D) laboratories of PNRA for radioactivity analysis.

Moreover, continuous air monitoring, using High Volume Air Samplers (HVAS) installed at Chashma, Karachi and Islamabad, was performed with the objective to detect any radiation abnormality in the environment due to the operation of nuclear installations or any trans-boundary releases. The radiation analysis results revealed that no man-made radionuclide was detected in any air filter sample during the reported period.

7.1.2 Establishment of National Background Radiation Levels

PNRA initiated a country wide study to determine the concentration of naturally occurring radionuclides along with potential man-made radionuclide (Cs-137) in soil and water samples in order to estimate the exposure to the public. In the first phase, samples of soil and water from all four provinces were collected. The samples were then analyzed at Gamma Spectrometry System (GSS) and a baseline data of radionuclide concentration was established.

After successful completion of radioactivity assessment in four provinces, the scope of study was expanded to include the remaining two regions Azad Jammu and Kashmir (AJ&K) and Gilgit-Baltistan (GB). In this regard, AJ&K and GB regions were divided into 27 and 124 grids



Demonstration to COMSTECH Officials about Calibration Process at TSDL, PNRA

respectively. During the year 2021, Radiation survey followed by collection of soil and water samples was performed accordingly. A total of 42 samples from AJ&K and 151 samples from GB were analyzed at Gamma Spectrometry System (GSS) to determine the concentration of gamma emitting radionuclide as reflected in Figure-32. Furthermore, Tritium concentration levels in water samples collected from AJ&K and GB were also determined by using Liquid Scintillation Analyzer (LSA). The analysis results revealed that no significant health hazard is associated with environmental radioactivity to the public.

7.1.3 Analysis of Food and other Samples of Export Items

Pakistan exports various food items to different countries. Some of these countries require

radiation analysis reports for imported food items. The Labs available at PNRA determine the radionuclide contents by analyzing food items received from exporters. During the reporting period, analysis of 26 samples of export items was performed and radiation analysis reports were issued to the exporters.

7.2 Dosimetry and Calibration Services

The external and internal dosimetry laboratories at PNRA are providing assistance in personal dose monitoring of radiation workers, whereas, Tertiary Standards Dosimetry Laboratories (TSDLs) of PNRA are calibrating the radiation monitoring equipment being used at different nuclear and radiation facilities. The details of the activities in these areas are provided below.

7.2.1 External Dosimetry Laboratories

External dosimetry labs are providing dosimetry services to PNRA inspectors as well as radiation workers involved at different licensed radiation facilities on request basis. In the year 2021, dose monitoring of 614 persons was performed and radiation dose of the workers was found within the statutory dose limits. Periodic feedback was also obtained from the licensees to improve the quality of dosimetry services. Furthermore, PNRA is maintaining dedicated batches of TLD dosimeters at Islamabad, Kundian and Karachi to be used by the first responders of any nuclear or radiological emergency situations in the country.

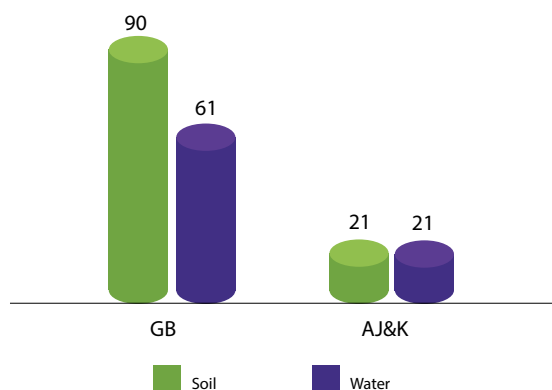


Figure-32: Status of Analyzed Samples for the Establishment of Background Radiation Levels in AJ&K and GB



Briefing about Sample Processing Laboratory at PNRA to COMSTech Officials

7.2.2 Internal Dosimetry Laboratories

The potential risk for internal exposure of radiation workers due to inhalation or ingestion of radioisotopes at their workplaces having airborne radioactivity cannot be ruled out. In such workplaces, reliable estimates of internal doses are essential for ensuring radiation protection of workers. In this regard, three internal dosimetry laboratories are functioning at Islamabad, Kundian and Karachi. The labs are performing Whole Body Counting (WBC) of workers involved in Refueling Outages (RFOs), IAEA safeguard inspectors, Chinese workers involved in maintenance as well as plant personnel of CNPGS and KNP GS on regular basis. During the reporting period, WBC of 479 personnel was conducted and report of each personnel was found satisfactory. Figure-33

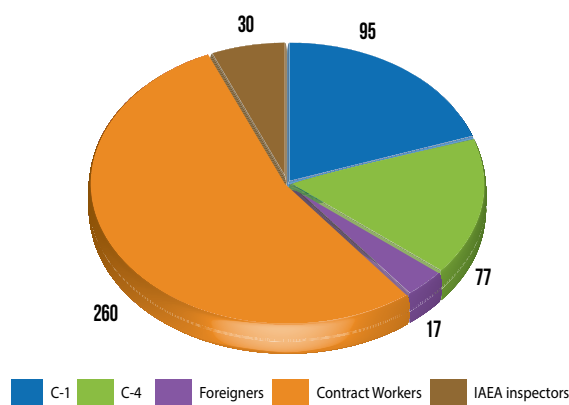


Figure-33: Whole Body Counting of Radiation Workers Performed at EM&D, PNRA

presents the status of WBC of radiation workers performed during the year 2021.

7.2.3 Tertiary Standards Dosimetry Laboratories (TSDLs)

PNRA is operating two Tertiary Standards Dosimetry Laboratories situated at Islamabad & Kundian. These labs are traceable to Primary Standards Dosimetry Lab (PSDL) IAEA through Secondary Standards Dosimetry Laboratory (SSDL PINSTECH), Islamabad. These labs are calibrating Radiation Monitoring Equipment (RMEs) being used at PNRA and also providing calibration services to licensed nuclear and radiation facilities on request basis. During the reported period, 919 radiation monitoring equipment were calibrated and calibration certificates were issued accordingly as reflected in Figure-34.

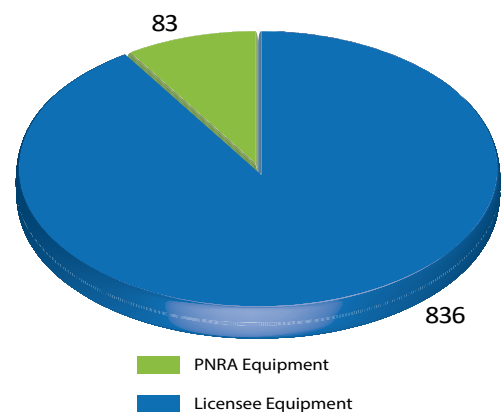


Figure-34: Total Number of Equipment Calibrated at TSDLs in 2021

CAPACITY BUILDING



Competent professionals with in-depth knowledge, experience and skills are essential for any organization in order to perform its functions effectively and efficiently. PNRA always gives highest priority to competence development of its employees with the aim to enhance their knowledge, skills and abilities in all relevant disciplines so as to keep them abreast with the modern developments and emerging technologies. Providing opportunities for higher education and training are part of PNRA policy for capacity building of its workforce.

Since its inception in 2001, PNRA has adopted a three-pronged strategy for competence development including in-house trainings through its own resources, trainings arranged at national level and availing international training opportunities. PNRA also encourages its employees to improve their educational qualifications at national and international universities.

PNRA is implementing a sustainable competence building programme under which new professionals with appropriate academic qualifications and knowledge are inducted. The competence level of the regulatory staff is enhanced through adopting different strategies stated above. In addition, PNRA has effectively utilized the funds received from the Government under its Public Sector Development Programme (PSDP) for enhancing the organizational infrastructure and technical capabilities of its manpower.

This chapter describes organizational efforts being performed for the capacity building during the reporting period.

8.1 Competence Development through In-House Resources

Since nuclear regulatory specific professional training opportunities were not available at any national training institute or university, PNRA established its in-house training institute namely National Institute of Safety and Security (NISAS) for training of PNRA staff as well as its stakeholders. This institute is equipped with necessary training aids including class rooms, laboratories containing scaled down models of NPP equipment, radiation detection and physical protection laboratories for hands on

training. Moreover, a soft panel nuclear power plant training simulator is available for training of PNRA inspectors for knowledge of plant systems and study of plant behavior during normal operation, transients and accidents.

NISAS is responsible to plan and execute in-house competence development and training courses for professionals of the regulatory body and stakeholders. Further, NISAS is an ISO 9001:2015 certified training institute.

The institute has a well qualified and professional faculty capable of providing trainings in all regulatory domains like nuclear, radiation, waste and transport safety; and nuclear security. In addition, experts from different PNRA departments are also invited to support and contribute towards the competence development programme. Some of the major training facilities available at NISAS are shown in Figure-35.

Every year, NISAS seeks input on training needs from all PNRA departments. Annual training calendar is finalized in the Board of Directors meeting in accordance with the need and priority of different organizational units and relevant stakeholders.

During the reporting period, NISAS has arranged 15 training courses. A total of 379 professionals have attended these courses including 172 from PNRA and 207 from other organizations. It is pertinent to mention here that the Covid-19 Pandemic affected training activities conducted at NISAS during the year



Figure-35: Major Training Facilities Available at NISAS

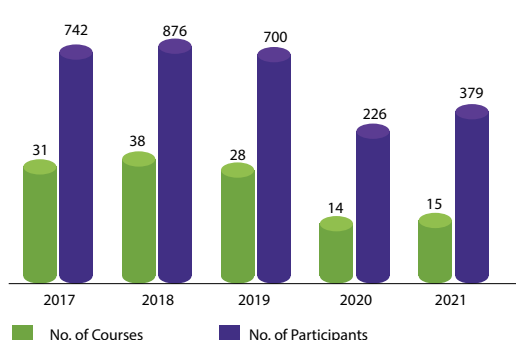


Figure-36: In-house Training Courses Conducted at PNRA

2021. Figure-36 presents the number of training courses conducted at NISAS and the number of participants during the last five years.

8.2 Competence Development through National Organizations

PNRA encourages and facilitates its employees to improve their academic qualification and professional knowledge at reputed national universities and institutes in different specialized areas.

Furthermore, PNRA nominates its officials to participate in education and training activities for improving their qualification, knowledge and skills.

Competence building at national level is described in the following subsections.

a) Higher Education at National Organizations

PNRA follows two approaches for improving academic qualification through higher studies. In the first case, PNRA has signed MoU with Pakistan Institute of Engineering and Applied Sciences (PIEAS) and Karachi Institute of Power Engineering (KINPOE) for fellowship scheme. These institutes provide master degree programmes to young university graduates in nuclear engineering, power engineering, mechanical engineering, systems engineering and medical physics. The candidates pass through a stringent selection process and are sponsored for two year study programme in these institutes. After completion of Master studies, the fellows are offered to join PNRA.

Currently, six fellows are engaged in master studies at PIEAS under the said fellowship scheme. Four out of them are expected to join PNRA by the end of 2022 while two graduates

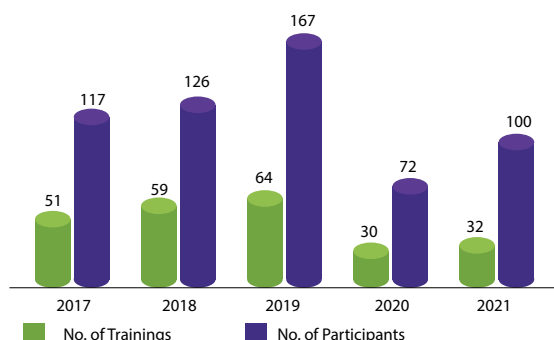


Figure-37: Training Courses at National Institutes

will join PNRA in 2023.

In the second approach, employees are also encouraged and facilitated to pursue higher studies at other national institutes / universities on self finance basis. Currently, eight PNRA employees are pursuing their postgraduate and doctoral degree programmes in various national universities in technical as well as management disciplines.

b) Training at National Organizations

There are several training institutes in the country which arrange training courses, workshops and seminars in various technical disciplines and other areas such as office management, time management and communication skills. The most important among these organizations include Pakistan Welding Institute (PWI); National Centre for Non-Destructive Testing (NCNDT); Pakistan Manpower Institute (PMI); and Secretariat Training Institute (STI). These institutes conduct trainings in welding techniques, technical skills in non-destructive examinations, managerial and interpersonal skills. PNRA officials participate in trainings in these institutions.

During the reporting period, almost 100 PNRA officials have participated in 32 training events at these national institutions. Figure-37 reflects participation of PNRA employees in various training courses arranged at national institutions during the last five years.

8.3 Competence Development through International Organizations

PNRA gives due consideration to the advancements in the emerging nuclear technology in the world. In this regard, PNRA benefits from the training opportunities offered by International Atomic Energy Agency (IAEA).

1st Mid Tier Management Course (MTMC) at PNRA HQ's

Furthermore, PNRA utilizes bilateral cooperation and educational opportunities at international universities for the capacity building of PNRA.

The succeeding sections briefly describe PNRA's competence development through this arrangement.

a) Competence Development through IAEA

IAEA organizes various events for the capacity building of professionals from Member States under its technical cooperation programme.

These events include training courses, workshops, fellowships and scientific visits in the areas of nuclear safety, radiation protection, waste safety, transport safety, emergency preparedness & response, physical protection, nuclear security, etc. PNRA nominates officers in such training opportunities offered by the IAEA. In addition, the IAEA arranges training courses and workshops at PNRA HQ's.

During the reporting period, 82 PNRA officers attended 43 international workshops / training courses in the areas of nuclear safety and



Seminar on Security of Nuclear and Radioactive Material at PNRA

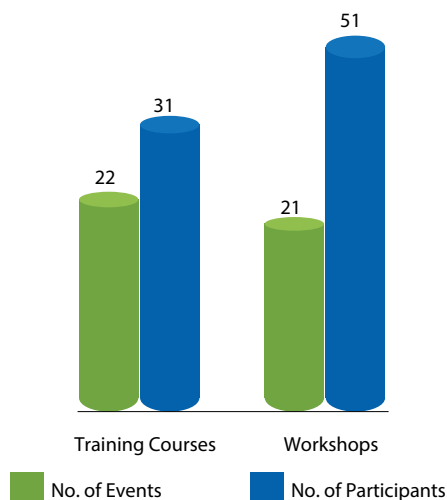


Figure-38: Training of PNRA Officials in International Events

radiation protection as shown in Figure-38. Most of the competence development activities arranged by IAEA took place virtually due to Covid-19 Pandemic situation.

b) Competence Development under Bilateral Cooperation

PNRA has established bilateral agreements of cooperation with National Nuclear Safety Administration (NNSA), Nuclear Safety Centre (NSC) and China Nuclear Power Operation Technology Corporation, Ltd. (CNPO) of the People's Republic of China for scientific and technical cooperation. This bilateral cooperation has played a significant role in the enhancement of capacity building of PNRA.

These organizations provide training opportunities such as workshops and attachments for PNRA employees in specific technical areas.

During the year 2021, due to Covid-19 Pandemic, a virtual meeting was held between PNRA and NNSA in which future course of action was discussed for the capacity building of PNRA employees. Accordingly, it was agreed that two virtual workshops will be conducted to share the experience in the areas of review and licensing. It was further decided that assistance in the area of digital I&C and cyber security would be provided virtually by China. Further, PNRA officials would visit relevant Chinese organizations after relaxation in Covid-19 Pandemic travel restrictions.

c) Competence Development through International Universities

PNRA encourages its officials by allowing them to undertake higher education from international universities to enhance their qualification.

Currently, five PNRA officials are studying abroad for their PhD degrees in various fields such as nuclear engineering, mechanical engineering and electrical engineering at different international universities of China, South Korea and USA.

8.4 Capacity Building through Public Sector Development Programme (PSDP) Projects

PNRA recognized the need for enhancing its technical expertise in different regulatory disciplines to be at par with international standards. Since, capabilities for improvement of competence in these areas were not readily available within the country, therefore, it was imperative for PNRA to develop an in-house technical competence to perform regulatory functions effectively and timely.

Keeping this in view, PNRA initiated several projects under the Public Sector Development Programme (PSDP) of the Government of Pakistan under which technical infrastructure of PNRA was significantly improved in above areas.

Since its inception, PNRA has successfully executed eight PSDP projects while implementation of two more PSDP projects is in progress. The highlights of PSDP projects during the year 2021 are given below:

a) Upgradation of National Radiological Emergency Coordination Centre (NRECC)

Considering the increasing use of nuclear technology in the country and lessons learnt from Fukushima nuclear accident, PNRA initiated a PSDP project to enhance its capabilities for assessment and coordination in case of a nuclear or radiological emergency. The project commenced in 2015 and was successfully completed in June 2021. Under this project, National Radiation Emergency Coordination Centre (NRECC) was up-graded at PNRA HQ's. Furthermore, two regional Radiological Emergency Coordination Centres

(RECCs) have been established at Karachi and Chashma to support NRECC through monitoring of emergency situation at the nuclear power plant sites.

Major facilities established under this project include infrastructure consisting of emergency operation centre, 24/7 communication room and equipment testing / maintenance laboratory. In addition, advance communication facilities such as satellite phones and audio / video communication system have been provided at NRECC and regional RECCs to coordinate with national and international organizations in emergency situation.

Moreover, technical tools such as environmental radiation monitoring detectors, plant parameter display system and radiological consequence assessment software have been arranged. For radiological consequence assessment, PNRA has established collaboration with Pakistan Meteorological Department (PMD) to acquire on-line meteorological data which is used as one of the inputs of the tools. In addition, three mobile labs have also been established to perform radiological monitoring at the incident site; advising the government authorities and response organizations; and assisting licensees. These labs are equipped with portable radiation detectors, vehicular based radiological survey and environmental sampling equipment.

b) Regulatory Oversight against Vulnerabilities of Digital Controls and Cyber Threats

Digital instrumentation and control systems at nuclear installations are replacing analog systems for operations, control, safety and security functions all over the world. Although, these systems have numerous benefits like significant reduction in cost, ease of use / re-use and maintenance, however, this technology inherits some peculiar vulnerabilities which may hamper safe operation of any facility. In order to enhance competence of regulatory professionals in this important area, PNRA initiated a PSDP project on "Reinforcement of PNRA's Capacity and Regulatory Oversight against Vulnerabilities of Digital Controls and Cyber Threats". The objective of this project is to establish relevant infrastructure, develop competence and enhance expertise of its professionals in regulating digital I&C system for ensuring safety and cyber security.

During the year 2021, the progress of activities performed under this project, is as under:

- i. The work on establishment of PNRA's Lab on Digital Safety and Cyber Security for training of PNRA officials in digital safety and cyber security is in progress. The lab is expected to be fully operational by February, 2023;
- ii. Procurement of equipment for PNRA's offices to strengthen against cyber threats is almost completed;
- iii. Development of DPP for "Regulations for the Licensing of Digital Software Based Safety Systems of Nuclear Installations" is in progress; and
- iv. Development of Cyber Security Policy of PNRA remained in progress.

c) Strengthening Regional Regulatory Oversight of PNRA

Within the last few decades, the use of radioactive material has increased many folds in the country which resulted in consequent increase in regulatory responsibilities of PNRA. Accordingly, the resulting workload necessitated country wide expansion of PNRA offices in order to regulate the radiation facilities more effectively.

It is worth mentioning that a significant number of licensed radiation facilities are in operation in Punjab particularly in Lahore, Gujranwala, Faisalabad and Sahiwal Divisions. Moreover, radioactive sources are frequently transported from the licensed premises to the operating sites for field application. Similarly, import and export of goods through Wagah border and Lahore and Sialkot dry-ports need to be vigilantly monitored in collaboration with Pakistan Customs to identify and control any shipment of unauthorized nuclear or radioactive materials or contaminated goods.

Therefore, it was imperative for PNRA to ensure its continuous presence in the region for keeping stringent and effective regulatory control. Accordingly, PNRA initiated a PSDP project for "Establishment of Regional Nuclear Safety Inspectorate" at Lahore". During the reporting period, PNRA has purchased land for construction of its regional office.

RESEARCH AND DEVELOPMENT



The application of nuclear technology is continuously increasing day by day across the world. New designs and advanced technology is evolving with time which extends significant challenges for the regulatory bodies. In order to cope with the challenges, necessary research and development is conducted to improve regulatory effectiveness and facilitate regulatory decision making.

PNRA has been mandated to perform Research and Development (R&D) in various technical areas of regulatory interest. PNRA has initiated research and development projects and also collaborating with relevant institutions for conducting research in nuclear safety and radiation protection. This chapter elaborates PNRA efforts and progress made in the research and development areas during the reporting period.

9.1 Regulatory Research Activities

This section describes the regulatory research activities carried out by PNRA during the year 2021.

9.1.1 Use of Computer Codes for Regulatory Assessment

PNRA has acquired various computer codes for safety analysis and research activities. The research being performed with these codes is described below.

9.1.1.1 Development of PSA Regulator Models

PNRA has been using Risk Spectrum computer code for Probabilistic Safety Assessment (PSA). This code has been used for safety evaluation of design modifications and conduct of regulatory inspections in nuclear power plants.

During the reporting period, PNRA has analyzed five severe accident scenarios for calculation of time windows of Reactor Pressure Vessel (RPV) lower head failure under different configurations of safety systems. The results of these analyses will be utilized for the development of Level-2 PSA regulatory model.

PNRA has also developed an initial version of Regulator Full Power Level-1 PSA model of K-2 / K-3 1000 MWe NPPs in 2021. This model will be utilized in performing regulatory functions such as prioritization of regulatory inspections, review of design modification and risk informed

decision making.

9.1.1.2 Structural Analysis of Fuel Basket Cover of K-1 Dry Storage Cask

PNRA performed structural analysis of fuel basket cover of KANUPP spent fuel dry storage cask using DIANA software to evaluate mechanical strength of basket. This analysis provided PNRA a better position to take regulatory decision on whether the fuel basket can handle spent fuel safely.

9.1.1.3 Analysis of DC System to Evaluate Batteries Performance

The DC system model was analyzed using ETAP software to assess the performance of batteries at K-2 / K-3 units up to 72 hours with conservative motor horse power (30% extra power) input. The results showed that batteries can perform their intended functions for required time.

9.1.1.4 Radiation Protection and Radioactive Waste Management

i. Radiological Environmental Impact due to Radioactive Discharges

Radioactive effluents are generated at the operating nuclear power plants which can pose risk to the people and environment. Therefore, it is essential to determine the expected doses and its consequence. Thus, PNRA analyzed the maximum individual doses to any age group of the public at the restricted area boundary due to K-2 / K-3 liquid and gaseous radioactive effluents using LADTAP-II and GSAPAR-II computer codes. The analyses results verified the compliance of dose criteria of PNRA regulations PAK/904 and international standards.

ii. Source Term Assessment of K-2 / K-3 Radioactive Effluents

The source terms of liquid and gaseous radioactive effluents of K-2 / K-3 were estimated using mathematical models considering realistic and conservative conditions for radionuclides of significant discharges. The results indicated that concentration of radionuclides in liquid and gaseous radioactive effluents at the unrestricted area boundary are within acceptance criteria.

9.1.1.5 Combined Source Model-based PSHA

An in-depth combined source model-based Probabilistic Seismic Hazard Analysis (PSHA) is



Chairman PNRA Addressing in a Seminar on Current R&D Potential, Future Needs and Ambitions of PNRA

being performed to validate the peak ground acceleration for PARR-3 site using EZ-FRISK and HAZ-45 software.

During the study, the earthquake catalogue and seismic tectonic were modeled. Calculation of earthquake recurrence parameters and maximum postulated magnitude from potential faults are in progress. This study will provide an in-depth picture of the seismic response of the site while incorporating site response analysis.

9.1.1.6 Tsunami Hazard Assessment for K-2 / K-3 site from Murray Ridge

Tsunami hazard assessment for K-2 / K-3 site was performed to calculate tsunami height and its time of arrival at site using Murray Ridge as a source. During the assessment, three different cases were considered for Murray Ridge using different rupture parameters. The results revealed that the plant site is safe against tsunami as the maximum tsunami height calculated at K-2 is less than the site elevation. This R&D area has strengthened site evaluation process of PNRA.

9.1.1.7 Structural Analysis of CVTR of PDS Facility using ETABS

ETABS computer code was used for structural analysis of Container Vessel Transfer Room (CVTR) of PWR Dry Storage (PDS) facility using the response spectrum method. The results

revealed that integrity of CVTR is maintained against design seismic loading.

9.1.1.8 Need Assessment of Internal Dosimetry

PNRA has initiated a project for the assessment of internal dosimetry of nuclear medicine practitioners and technologists. In this project, urine samples of practitioners and technologists are being collected fortnightly and analyzed on gamma spectrometry system.

The assessment of reasonable number of samples will provide the basis for necessity of internal dosimetry of nuclear medicine practitioners and technologists on routine basis.

9.1.1.9 Evacuation Time Estimation for K-2 / K-3 Emergency Plan

PNRA has initiated a study for calculation of Evacuation Time Estimate (ETE) within Emergency Planning Zone (EPZ) of K-2 / K-3 NPP to effectively implement nuclear / radiological emergency plans during a general emergency. This analysis is based on assumptions, scenarios and criteria presented in international standards.

9.1.2 Development of Computer Codes

PNRA has indigenously developed some computer codes for performing analysis. Code development activities of the year 2021 are described in the below sections.

9.1.2.1 Development of RCAT

PNRA has developed Root Cause Analysis Tool (RCAT) with the support of IAEA to perform root cause analysis of an undesired event at nuclear installations. RCAT can be used for capacity building as well as review and audit calculations of the licensee submissions.

9.1.2.2 Development of AIRBORNE Computer Code to Assess Airborne Activity

PNRA has indigenously developed AIRBORNE computer code to estimate the airborne activity of K-2 / K-3 buildings (reactor, auxiliary, spent fuel pool and turbine buildings) at full power operation. The results verified the compliance of acceptance criteria.

9.2 IAEA Coordinated Research Project

PNRA, in collaboration with IAEA, is conducting a Coordinated Research Project (CRP) "Maintenance, Repair, and Calibration of Radiation Detection Equipment" to improve the effectiveness of hand-held and fixed installed radiation detection equipment being used for nuclear security.

During the year 2021, the project proposal was approved and PNRA prepared a three years detailed action plan to reduce the cost of maintenance, repair and calibration of the equipment by using new approaches. PNRA research team will collaborate with IAEA during implementation phases from 2021-2023.

9.3 Research Collaboration with National Institutes

PNRA is collaborating with academic institutions such as PIEAS, Quaid-i-Azam University, NCP and KINPOE to conduct R&D in various disciplines. PNRA also shares its expertise with national institutes and as a part of such cooperation. PNRA officials prepare and supervise research projects of students of MS Nuclear Engineering at PIEAS using facilities, laboratories, computer codes, etc. of national institutes. Some of the projects are enlisted below:

- CFD analysis of ACP-1000 pressurizer surge line to investigate thermal stratification;
- Stress and fatigue analysis of ACP-1000 steam generator;
- Intrusion Detection System of Industrial Network using Machine Learning technique; and
- Sensitivity analysis of smart grids impact over advanced NPPs.

9.4 Publications

PNRA encourages its officials to publish outcome of R&D work in the form of internal technical reports, conference papers and international journal papers. The conference and journal papers of the year 2021 are shown in Figure-39.

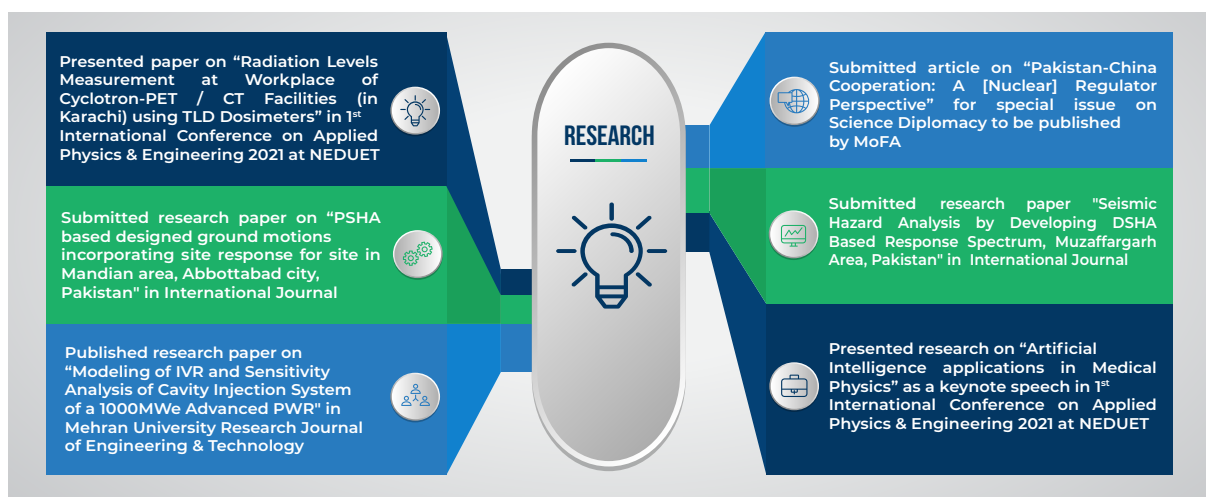


Figure-39: Highlights of Research and Development Activities at PNRA during 2021

NATIONAL AND INTERNATIONAL COOPERATION



COORDINATION MEETINGS

99

Nuclear Installations
and Radiation Facilities

SEMINARS CONDUCTED

18

More than 1650 individuals
participated in these seminars

PNRA EXPERTS IN IAEA EVENTS

187

PNRA experts represented
Pakistan in 123 virtual IAEA
events

IAEA COMMITTEES ETC.

15

PNRA is a member of IAEA
Committees, Forums and
Working Groups



PNRA recognizes that establishing and maintaining close collaboration and relationship with relevant national and international organizations is of prime importance for discharging regulatory responsibilities in an effective and efficient manner. In this regard, PNRA maintains strong working relationship for dissemination of information, knowledge and experience; providing experience feedback; education and training; and research and development in regulatory perspective. This cooperation leads to strengthening the nuclear safety and radiation protection regimes both at the national and international levels.

PNRA's endeavours in this regard are described in the forthcoming sections.

10.1 Cooperation and Coordination at National Level

At the national level, PNRA maintains an effective liaison with different stakeholders including governmental organizations, licensees, general public and educational institutes.

10.1.1 Interaction with Government Organizations

PNRA maintains interaction with relevant Government organizations on matters related to administration, finance, legal, policy and regulatory affairs. These organizations include Strategic Plans Division (SPD), Ministry of Foreign Affairs (MoFA), Planning Commission, Ministry of Finance (MoF), Federal Board of Revenue (FBR), Law Enforcement Agencies, Pakistan Customs, Civil Defense, National Logistic Cell (NLC), etc. This coordination aims to strengthen safety and security regimes and to enhance confidence of the public, government and other stakeholders in PNRA activities.

PNRA also provides technical support to national stakeholders in physical protection and nuclear security areas. During the reporting period, PNRA provided handheld radiation detection equipment to first responders at Qasim International Container Terminal (QICT) Karachi for monitoring cargo trafficking for presence of any nuclear or other radioactive material. In addition, PNRA provided technical support / assistance to national stakeholders including Pakistan Customs, Civil Defense, National Logistic Cell and Pakistan Institute of

Engineering and applied Sciences (PIEAS).

Furthermore, PNRA is responsible to provide technical assistance and advice to the Federal and Provincial Governments and technical assistance to relevant stakeholders in case of nuclear or radiological emergencies. During the reporting period, PNRA provided technical support to SPD in the following activities:

- i. Conduct of trainings in the field of emergency preparedness and response as well as physical protection;
- ii. Development of mobile labs to perform radiological monitoring;
- iii. Conduct of security survey of areas for major public events; and
- iv. Installation of radiation detection equipment at Chaman and Taftan borders for radiological monitoring and to provide training to custom officials.

PNRA coordinated with Pakistan Customs and FBR for participation of PNRA in Pakistan Single Window (PSW) Programme. PNRA hosted the visit of officials from Programme Management Office (PMO) for PSW, Pakistan Customs, and shared relevant documents and procedures with the visiting team for inclusion in Trade Information Portal of Pakistan (TIPP) under PSW Programme.

PNRA coordinated with Ministry of Commerce (MoC) and proposed to amend Import and Export Policy Orders (IPO and EPO) in order to reflect PNRA regulatory requirements applicable in case of cross-border trade.

PNRA also provided its input to MoC in preparation of national response to the "Questionnaire on the Import Licensing Procedures" under the World Trade Organization (WTO) "Agreement on Import Licensing Procedures".

PNRA provided its support to National Disaster Management Authority (NDMA) by participating in the working group discussion session arranged jointly by NDMA and Japan International Cooperation Agency (JICA). Moreover, PNRA has increased collaboration with public administration and Law Enforcement Agencies on matters related to improving the

effectiveness of enforcement measures such as lock & seal of radiation facilities. PNRA has developed liaison with Federal Home Secretary, Home Secretary Punjab & IG Police Balochistan, Punjab, KPK for enforcement of PNRA regulatory requirements.

Furthermore, upon request of importers / users of Sealed Radioactive Sources (SRS), PNRA arranged meetings with MoFA, SPD and relevant stakeholders and accordingly resolved the issue of import of all types of gamma radiography equipment including SRS and gamma cameras to Pakistan.

PNRA is a member of Oversight Board (OSB) of SECDIV on implementation of strategic export controls in Pakistan. As a major support to SECDIV, PNRA regularly deputes its technical officers in SECDIV to serve in its licensing and regulations directorates. Besides, PNRA interacts with SECDIV for issuance of NOCs/ authorization of items stipulated under the jurisdiction of both organizations.

PNRA held meetings with National Electric Power Regulatory Authority (NEPRA) in order to strengthen mutual regulatory regimes in power sector. NEPRA arranged a webinar on national occupations and health safety awareness for power sector. Member (Executive), PNRA delivered a key note address on industrial safety & PNRA's regulatory regime in nuclear power industry during the webinar.

10.1.2 Interaction with Licensees

PNRA periodically holds meetings with its major licensees to discuss safety and security issues at nuclear installations and radiation facilities.

During the reporting period, PNRA held 11 coordination meetings with the management of operating and under construction nuclear installations, equipment manufacturers and service providers regarding licensing, construction, operation and training matters. In addition, PNRA arranged 88 coordination meetings with radiation facilities and discussed safety design requirements of Radiology Department and NOCs issuance requirements for the import of radiation generators, registration/licensing and inventory of their newly imported radiation generators, improvements of radiation safety and physical protection measures.

10.1.3 Interaction with Public

PNRA established a public awareness programme to inform the general public across the country about the application of ionizing radiation in everyday life, associated hazards to human health as a result of overexposure and basic radiation protection principles.

During the reporting period, PNRA conducted 18 seminars in various educational institutions. More than 1650 individuals participated in these seminars. Figure-40 shows an overview of public awareness seminars and number of participants attended these sessions over the past five years. Relatively less number of public awareness sessions in last two years is due to Covid-19 pandemic.

10.2 Cooperation and Coordination at International Level

PNRA maintains close cooperation with International Atomic Energy Agency (IAEA) and bilateral cooperation with People's Republic of China. Furthermore, PNRA represents Pakistan in the activities of United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

10.2.1 Collaboration with IAEA

PNRA maintains close cooperation with IAEA for capacity building of staff, fulfillment of Pakistan's obligations under conventions assisting IAEA by providing experts from PNRA in various IAEA activities and providing technical assistance to other Member States under the auspices of IAEA.

Overview of participation in other IAEA activities

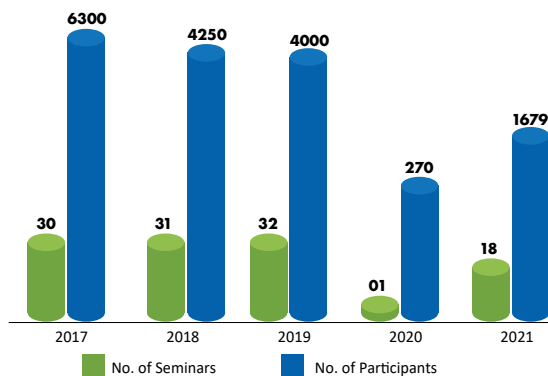


Figure-40: Statistics of Public Awareness Seminars



PNRA Officials Conducting Public Awareness Seminar at INOR, Abbotabad

during the reporting period is given in the subsequent sections.

a) International Conventions

PNRA, acts as a national contact point for the implementation of obligations arising from Convention on Early Notification of a Nuclear Accident; Convention on Assistance in the case of a Nuclear Accident or Radiological Emergency; Convention on Nuclear Safety; and Convention on Physical Protection of Nuclear Materials. PNRA also assists the Government of Pakistan on implementation of the commitments under the Code of Conduct on Safety and Security of Radioactive Sources.

During the reporting period, PNRA participated virtually in the 9th Organizational Meeting of the Convention on Nuclear Safety. Further, preparation of Pakistan's National Report for joint 8th and 9th review meeting remained in progress in consultation with national stakeholders.

During the year 2021, PNRA initiated a proposal for national preparation related to the Review Conference (RevCon) of State Parties of CPPNM, The RevCon is planned to be held in 2022. Accordingly, a Steering Committee was constituted which finalized the proposal for effective participation in the RevCon including preparation of national statement. In addition, PNRA officials participated in IAEA regional

meeting held for preparation of the RevCon during the year 2021.

b) IAEA Missions, Consultancies and Technical Meetings

IAEA invites experts for its Member States for contributing in peer review missions, technical meetings and consultancies to support Member States in their efforts for enhancing nuclear safety and security worldwide. Experts from PNRA are also invited as part of IAEA team in conducting such activities.

During the reporting period, 187 PNRA experts represented Pakistan in 123 IAEA events, as highlighted in Figure-41. In addition, one PNRA official participated in two Integrated Regulatory Review Service (IRRS) Missions to Switzerland and Belarus from 17 – 29 October, 2021 and from 05 – 13 December, 2021 respectively.

c) IAEA Technical Cooperation Programme and Projects

IAEA provides support to its Member States for the capacity building and strengthening of its nuclear and radiation safety infrastructure through different technical cooperation projects, regional projects and coordinated research activities. PNRA has been regularly benefiting from such activities over time.

PNRA is also part of IAEA Coordinated Research

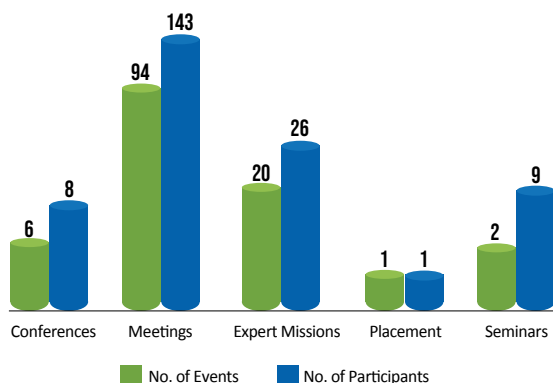


Figure-41: Participation of PNRA Experts in International Events

Project (CRP) on “Maintenance, Repair and Calibration of Radiation Detection Equipment” to improve the effectiveness of handheld and fixed installed radiation detection equipment.

d) IAEA Committees, Forums and Working Groups

IAEA has constituted several safety standard committees comprising senior representatives from Member States to provide guidance and recommendations in the development of international safety standards. In this regard, PNRA has designated its technical officers in five safety standards committees namely, Nuclear Safety Standards Committee (NUSSC), Radiation Safety Standards Committee (RASSC), Transport Safety Standards Committee (TRANSSC), Waste Safety Standards Committee (WASSC) and Emergency Preparedness and Response Standards Committee (EPRsC).

PNRA experts regularly participate and contribute in the proceedings of these committees.

Furthermore, IAEA has established a number of international forums. PNRA officials participate in these forums and share experiences amongst the participants of Member States. During the year 2021, PNRA officials participated in International Reporting System for Operating Experience (IRS); Incident and Trafficking Database (ITDB); International Nuclear and Radiological Event Scale (INES); Meetings of the Commission on Safety Standards (CSS); Regulatory Cooperation Forum (RCF); Technical Support Organization (TSO) Forum; Global Nuclear Safety and Security Network (GNSSN); International Generic Ageing Lessons Learned (IGALL); International Nuclear Security Education

Network (INSEN); and International Network for Nuclear Security Training and Support Centres (NSSCs).

e) IAEA-Pakistan Nuclear Security Cooperation Programme

Under this programme, PNRA is the designated focal point and is responsible for coordination with all national stakeholders for effective implementation of the programme. During the year 2021, the design documents for enhancement of Physical Protection Exterior Lab (PPEL) have been reviewed and approved by PNRA and IAEA. The contractor has initiated implementation of pre-handover maintenance schedule for repair and maintenance of physical protection system.

During the reporting year, PNRA submitted the project proposals to IAEA for refurbishment, procurement and up-gradation of radiation detection equipment. The proposal was approved by IAEA and implementation initiated.

During the year 2021, the project for physical protection upgrades of three Irradiation Facilities and one Nuclear Medicine Centre (NMC) of PAEC was agreed with IAEA under the cooperation programme. PNRA reviewed Project Initiation Documents (PIDs) and the Statement of Work (SoW) prepared by PAEC for this project and shared the final documents with the IAEA.

Under the IAEA-Pakistan Nuclear Security Cooperation Programme, IAEA assisted Pakistan for the implementation of land and sea based physical protection upgrades at KANUPP. Final Site Acceptance Testing (SAT) of the upgrades is expected to be completed in first quarter of 2022.

f) Technical Cooperation with Nuclear Regulatory Bodies

PNRA provides technical and scientific support to regulatory bodies of the embarking countries under the auspices of the IAEA. During the reporting year, a seven member delegation of Nuclear Regulatory Authority (NRA), Ghana visited PNRA from 13-17 December 2021 on IAEA scientific visit. The delegation was led by Director General (NRA). During the visit, a Memorandum of Understanding (MoU) was signed between PNRA and NRA for cooperation

in the field of nuclear safety and radiation protection for capacity building of regulatory staff of NRA.

Furthermore, during the reporting year, PNRA coordinated with Nuclear Regulatory Authority (NRA) of the Republic of Turkey; the Department for Nuclear and Radiation Safety of the Ministry for Emergency Situations of the Republic of Belarus; for the capacity building and conduct of activities for exchange and collaboration in the field of nuclear safety and radiation protection.

g) IAEA General Conference

PNRA participated in the proceedings of the 65th Regular Session of the IAEA General Conference as part of Pakistan's delegation, comprising members from PNRA, PAEC, MoFA and SPD. PNRA participated in various sideline meetings with delegates of other Member States during the General Conference and discussed matters of mutual interest.

10.2.2 Bilateral Cooperation with People's Republic of China

PNRA has established bilateral cooperation agreements for exchange of information and regulatory experience with three organizations

of China. These include National Nuclear Safety Administration (NNSA), Nuclear Safety and Radiation Protection Centre (NSC) and China Nuclear Power Operations Technology Cooperation Ltd. (CNPO).

During the year 2021, PNRA and NNSA have agreed to extend the cooperation in areas of nuclear safety regulation. Due to Covid-19 pandemic situation, no physical visit was organized. Both parties signed and shared copies electronically with each other through email. A coordination meeting was held virtually on 29 March, 2021 with NNSA / NSC to discuss the future collaboration in nuclear safety and other areas of regulatory interest.

10.2.3 United Nations Scientific Committee on Effects of Atomic Radiation

Since 2011, Pakistan is a permanent member of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). PNRA represents Pakistan in UNSCEAR and participates in proceedings of the annual sessions. During the reporting period, PNRA participated in the virtual proceedings of Annual Session of UNSCEAR and contributed in finalization of a number of documents.



Delegation of NRA Ghana Meeting with Chairman PNRA

PERFORMANCE REVIEW



■ Satisfactory

□ Minimally acceptable

■ Needs improvement

■ Unsatisfactory

■ Not acceptable

Regular assessment of performance of an organization is of prime importance for ensuring that the organization is working effectively and efficiently in line with the assigned obligations and tasks. Particularly for public sector organizations involved in ensuring public health and safety, the importance of performance assessment is even more valuable. Such assessment enables an organization to identify deficiencies in its processes and provide opportunities to take appropriate measures for further improvement.

PNRA, being a progressive organization, has documented its management system and subsequently developed several mechanisms for monitoring and assessment of regulatory performance. The detail of monitoring and assessment mechanisms in place at PNRA is presented in the following sections.

11.1 Management System

PNRA has established and implemented an Integrated Management System which enables PNRA to perform its tasks and functions in a systematic, effective and efficient manner in order to achieve its Vision, Mission and Goals.

PNRA Management System integrates all the elements of management including Vision, Mission and Core Values; Organizational Structure; Tasks and Functions; Policies, Goals, Strategies and Plans; Core and Support Processes; and approach towards Monitoring, Assessment and Improvement; etc. During 2021, PNRA initiated the revision of its Management System Manual (MSM) based on experience feedback of the implementation of the existing manual and developments in international

standards.

Furthermore, PNRA conducts Management Review to evaluate opportunities for improvement in its processes. The Directors' Meeting is one of the activities of Management system review. In this regard, during the year 2021, 7th Directors' Meeting was conducted at PNRA HQ's. The objective of Directors' Meeting was to discuss the progress of activities, achievements, learning from each other experiences, issues and challenges faced by the departments and discussion on further improvement in the effectiveness and efficiency of the organization.

In order to further enhance the effectiveness of PNRA working and to improve various reporting channels, changes were introduced in the organizational structure of PNRA during the year 2021.

11.2 Performance Monitoring

PNRA has developed a comprehensive mechanism to monitor and record the performance of its departments on quarterly basis.

During the reporting period, PNRA monitored the performance of PNRA departments against annual work plans and PNRA strategic plan 2019 - 2023 on quarterly basis and issued reports highlighting areas requiring further improvement.

11.3 Self Assessments

Self assessment is a process in which an organization analyzes its own performance to identify the areas for further improvement.



Group Photo of the 7th Directors' Meeting held at PNRA HQs, Islamabad

In this regard, PNRA performs periodic self-assessments at departmental level and at organizational level. Accordingly, self-assessment reports are prepared and corrective action plans are developed and implemented for further improvement in the identified areas.

At department level, self-assessments are conducted biennially as required under PNRA Management System Manual and necessary corrective actions are initiated for further improvement.

During the reporting period, PNRA conducted its performance assessment at organizational level against Strategic Performance Indicators (SPIs) which is presented in Section 5 of this Chapter. In addition, PNRA initiated the process to conduct 2nd organizational level self assessment based on IAEA Self Assessment of Regulatory Infrastructure for Safety (SARIS) tool. The response and review phases of the assessment were completed as per plan during 2021. The assessment is planned to be completed by the end of 2022. Furthermore, PNRA assessed its regulatory performance by acquiring feedback from its licensees of diagnostic X-rays facilities during the year 2021. Accordingly, PNRA evaluated the feedback received from around 900 radiation facilities and issued report highlighting areas for further improvement in PNRA regulatory processes.

11.4 Independent Assessments

PNRA conducts independent assessments through organizing peer reviews by international organizations. International Regulatory Review Service (IRRS) is a peer review process of the International Atomic Energy Agency. IRRS mission to PNRA was conducted in 2014 and the follow-up of this mission is planned in 2022. PNRA is making necessary preparations for the follow-up mission.

During 2021, PNRA regularly monitored the progress and status of the corrective action plan on the findings of the IAEA IRRS Mission. As part of advance reference material for the follow-up mission, PNRA prepared a Self Assessment Report reflecting progress on actions taken by PNRA to fulfill the intent of recommendations and suggestion of the initial IRRS Mission. The government also constituted a committee to regularly monitor the progress on the corrective action plan and accordingly report the progress

to the government.

11.5 Performance Indicators-2021

PNRA conducts its performance assessment annually on the basis of 12 SPIs and subsequent performance elements. The performance is rated on a five level rating scale i.e. satisfactory, minimally acceptable, needs improvement, unsatisfactory and not acceptable. The performance assessment made against each indicator for the year 2021 is described below.

Performance Indicator 1 - "Ensures that acceptable level of safety is being maintained by licensees"

The performance elements relevant to this indicator include the review and assessment of licensees submissions; inspection and enforcement and reporting of events.

During the year 2021, PNRA reviewed a number of licensees' submissions of nuclear installations that mainly included PSAR of PARR-3, SER of C-5, refueling outage submissions of C-1 & C-4, licensee event reports, monthly technical reports, radioactive waste management reports, emergency preparedness and response plans, quality assurance programmes, radiation protection programmes, etc. In addition, various submissions for design licensing of HMC-3, WASO and ICCC were also reviewed at PNRA.

Based on these review and assessment activities, PNRA granted licenses to HMC-3 for design of nuclear safety class (NSC-3) equipment; to WASO for design of nuclear safety related civil structures and to ICCC as designer of analog safety I&C systems of research reactors. PNRA also granted permissions to K-2 for initial criticality and power operation; and criticality permissions to C-1 and C-4 after successful completion of refueling outages. In addition, construction license was granted to PARR-3 upon satisfactory resolution of all major safety issues.

Besides, PNRA also reviewed licensees' submissions of radiation facilities. These included safety analysis reports, radiation protection programmes, radiation emergency plans, physical protection plans, quality assurance programmes, initial decommissioning plans and shielding reports, etc.

Based on the review and assessment of these



submissions, PNRA granted 492 new licenses to radiation facilities and renewed 3700 licenses. PNRA also issued 1740 NOCs for the import / export of radiation sources and 157 permits for procurement of radiation sources.

PNRA conducted a number of regulatory inspections of nuclear installations, radiation facilities, equipment manufacturers and service providers to ensure compliance with regulatory requirements. In addition, PNRA witnessed and evaluated a number of emergency drills conducted by the licensed facilities. The findings / directives were communicated to the licensees and corrective actions for implementation which were followed-up accordingly.

In addition, PNRA ensured that all reportable events were timely reported by the licensees and assessed accordingly. Further details of these activities are presented in Chapters 3, 4, 5 and 6 of this report.

While assessing against Indicator # 1, it was concluded that all the major activities related to review & assessment, inspection and enforcement were carried out effectively and accordingly safety improvements were made by the licensees. The efforts made by PNRA contributed in ensuring that an acceptable level of safety was maintained by the licensees. Keeping this in view, PNRA performance against this indicator is rated as **"Satisfactory"** for the year 2021.

Performance Indicator 2 - "Ensures that regulations and guides are in position and understood by licensees"

PNRA's performance against this indicator is assessed on the basis of availability of regulations and guides and licensees' perception and understanding of regulations.

During the year 2021, PNRA promulgated the Regulations on Radiation Protection - (PAK/904) (Rev.1) and the Regulations on the Safety of Nuclear Power Plants Operation - PAK/913 (Rev.2). In addition, development of five new regulations remained in progress and five regulations remained under revision. Furthermore, two regulatory guides were also issued during the reported year. Besides these, six new regulatory guides remained in the process of development during 2021.

PNRA also ensured the involvement of its

licensees during the development process of regulations and regulatory guides. The draft regulations and regulatory guides were shared and uploaded on PNRA website for seeking input from the licensees. Their feedback was evaluated and considered before finalization of the regulations and regulatory guides to ensure transparency and uphold their confidence.

During the reporting period, PNRA organized several lectures for developing and enhancing the understanding of its stakeholders regarding PNRA regulatory framework.

Chapter 2 of this report presents further detail of these activities.

Keeping in view the progress made during the year 2021, the performance of PNRA against this indicator is rated as **"Satisfactory"**.

Performance Indicator 3 - "Strives for continuous improvement of its performance"

The performance elements for this indicator are based on different mechanisms of monitoring and assessment such as implementation of plans, self-assessments, regulatory audits, international peer reviews and feedback received from national / international stakeholders.

During the year 2021, PNRA monitored the implementation of PNRA strategic plan 2019-23 and accordingly issued three progress reports. PNRA also performed quarterly performance evaluation of all departments and issued four reports reflecting the implementation progress of annual work plans.

During the year 2021, a number of PNRA departments performed self-assessment as per defined frequency. In addition, PNRA initiated the process to conduct organizational level self-assessment using IAEA "SARIS" tool during 2021. As per management system of PNRA, conduct of 5th regulatory audit of PNRA departments was also planned during 2021. However, due to Covid-19 constraints, it was postponed.

Further, progress on implementation of IRRS mission recommendations and suggestions was periodically monitored. PNRA also initiated internal preparations for upcoming IRRS follow-up Mission to Pakistan in 2022. In this

regard, a preparatory meeting was conducted to finalize the formalities for the mission. In addition, self-assessment report reflecting the progress of IRRS Mission recommendations and suggestions was prepared.

Keeping in view the fact that PNRA is continuously monitoring and assessing its activities and performance and initiating necessary actions for further improvement, the performance of PNRA against this indicator is rated as **"Satisfactory"** for the year 2021.

Performance Indicator 4 - "Takes appropriate actions to prevent degradation of safety and to promote safety improvements"

The assessment against this indicator is made on the basis of activities related to conduct of periodic safety assessment of licensees; implementation of necessary design modifications and international experience feedback.

During the year 2021, PNRA performed a comprehensive review of C-2 first periodic safety review reports for revalidation of operating license. A total of 220 PSR reports were reviewed and licensee was required to prepare corrective action plan for resolution of queries raised by PNRA. In addition, periodic safety review of PARR-1 was also carried out and corrective actions were highlighted accordingly for revalidation of operating license of PARR-1.

During 2021, PNRA also reviewed safety analysis report of PARR-3. Accordingly, PNRA issued preliminary safety evaluation report upon compliance of regulatory requirements and awarded construction license. In addition, PNRA performed operational safety trend assessment of C-Series NPPs and issued report accordingly.

Furthermore, PNRA approved 59 technical specification modifications of K-2/K-3; and 14 design modifications, 41 technical specification modifications and 34 FSAR modifications of C-Series NPPs during the reported period.

During the year-2021, PNRA also evaluated operating experience feedback and prepared report which was shared with licensees and within PNRA for taking necessary actions.

PNRA also performed safety assessment of a number of industrial and medical radiation facilities to verify compliance of regulatory requirements. The assessment revealed that the overall safety performance of the radiation facilities is satisfactory. However, some radiation facilities need improvement and relevant Regional Directorates are taking necessary measures to ensure improvement in the identified areas of radiation facilities.

Further details of these activities are presented in Chapters 3 and 4 of this report.

Taking into account the above activities, performance of PNRA against this indicator is rated as **"Satisfactory"** for the year 2021.

Performance Indicator 5 - "Takes appropriate steps for human resource development and has competent and certified regulatory staff"

This indicator is evaluated on the basis of activities related to human resource development, training need assessments and subsequent competence development of regulatory officials.

During 2021, PNRA completed the task to assess competence needs of professionals working in various departments and identified their competence development areas. These will now be transformed into specific training activities.

Based on needs of its departments, 172 officials of PNRA were trained in various regulatory domains through in-house training arrangements while 100 employees participated in various training courses arranged at different national training institutions. Due to Covid-19 pandemic restrictions, most of the competence development activities at international level took place virtually. A number of PNRA officials participated in these virtual events organized by IAEA and other international organizations.

Furthermore, a number of PNRA employees are pursuing their postgraduate and doctoral degree programmes in various national / international universities in technical as well as management disciplines. However, it was noted that certain training activities could not be materialized as per plan due to Covid-19 pandemic situation.

Further details of these activities are presented in Chapters 08 and 10 of this report.

Keeping in view the training activities which could not be performed as per plan mainly due to pandemic related restrictions, performance of PNRA against this indicator is rated as **"Minimally Acceptable"** for the year 2021.

Performance Indicator 6 - "Ensures legal actions are taken in case of violations of regulatory requirements"

The performance elements related to this indicator include availability of enforcement mechanism, issuance of notices to ensure compliance with regulatory requirements and actions taken against violators.

At present, all the nuclear installations and almost all the radiation facilities are under the licensing net of PNRA.

During the year 2021, PNRA identified a number of non-compliances of regulatory requirements made by licensees. Accordingly, PNRA issued 914 final directives, 1056 show cause notices and conducted 355 hearing against the violators.

Further, hearing proceedings of five radiation facilities of lock & seal were conducted at PNRA HQ's Islamabad, which were resolved accordingly. Whereas, three complaints were filed in the court of law against the violators of radiation facilities.

However, by the end of 2021, around 30 % of radiation facilities are still defaulters. PNRA is making efforts that these defaulters comply with regulatory requirements.

Moreover, for effective implementation of PNRA enforcement process against defaulter radiation facilities, PNRA has increased collaboration with Law Enforcement Agencies for implementation of the enforcement action of Lock & Seal. For this purpose, PNRA has developed liaison with provincial and district management as well as Police force.

Foregoing in view and recognizing that a significant number of radiation facilities are still defaulters, PNRA's performance against this indicator is rated as **"Needs Improvement"** for the year 2021.

Performance Indicator 7 - "Performs its functions in a timely and cost-effective manner"

This indicator is evaluated by considering the performance against predefined targets and schedules, execution of activities according to plans and optimization of available resources.

Despite Covid-19 constraints in 2021, PNRA completed most of the planned activities regarding oversight of licensees activities, review & assessment and licensing in accordance with set plans. Furthermore, efforts were made to complete the development of regulatory and management system documents; monitoring and evaluation of regulatory processes; and implementation of PSDP projects in time and within the estimated budgets.

However, it was noted that some of the activities were not executed as planned and postponed till next year. Most significant ones include, conduct of 5th regulatory audit of PNRA departments and revision of Strategic Performance Indicators (SPIs). In addition, a number of trainings and public awareness activities were also not conducted. Delays were also noted in the development process of some regulations. Further detail of these activities is presented in Chapters 2, 8 and 10 of this report.

Considering the delays or postponement noted in execution of some planned activities mainly due to pandemic related restrictions, PNRA's performance against this indicator is rated as **"Minimally Acceptable"** for the year 2021.

Performance Indicator 8 - "Ensures that a well established quality management system exists"

This indicator is evaluated on the basis of existence of updated management system; its understanding and implementation.

During 2021, PNRA monitored the implementation of requirements of Management System through various monitoring and assessment mechanisms. As per defined frequency, review of management system was also initiated during 2021. In addition, to further enhance the effectiveness of PNRA working, various changes were made in the organizational structure of PNRA. Furthermore, a number of

programmes, procedures and processes were also developed by PNRA departments during the reporting period. PNRA also revised the document on tasks and functions of its various departments which is being finalized.

Considering the activities presented above, the performance of PNRA against this indicator is rated as **"Satisfactory"** for the year 2021.

Performance Indicator 9 - "Ensures that adequate resources are available for performing its functions and technical support centre is available for specialist assistance when required"

PNRA assesses performance against this indicator on the basis of availability of required human and financial resources and in-house technical support centres.

During 2021, PNRA made efforts for ensuring the adequacy of human and financial resources to perform its functions in effective and efficient manner.

Currently, six fellows are engaged in master studies at Pakistan Institute of Engineering and Applied Sciences (PIEAS) under the fellowship scheme while eight PNRA employees are pursuing their postgraduate and doctoral degree programmes in various national universities. Furthermore, five PNRA officials are studying abroad for their PhD degrees in various fields such as nuclear engineering, mechanical engineering and electrical engineering at different international universities.

During the year 2021, efforts were made for approval of necessary budget from Government. However, allocated budget was less than the proposed budget and accordingly PNRA had to optimize the available resources. Nevertheless, PNRA made efforts for timely release of allocated funds and subsequent effective utilization of the released funds for accomplishment of organizational goals and targets. However, some activities were affected due to these constraints. These include several activities of competence development programme and public awareness programme.

The technical support centres of PNRA i.e. Centre for Nuclear Safety (CNS) and Safety Analysis Centre (SAC) effectively supported in carrying out review and assessment; and

audit analysis of various licensees' submissions thus provided adequate technical support in regulatory decision making. Further details of these activities are presented in Chapters 2-10 of this report.

Keeping in view the availability of resources and technical support to PNRA during 2021; while considering the restrained allocation of finances, the performance of PNRA against this indicator is rated as **"Minimally Acceptable"** for the year 2021.

Performance Indicator 10 - "Performs its functions in a manner that ensures confidence of the operating organizations"

This indicator is rated on the basis of participation of licensees in various activities organized by PNRA and acquisition of direct feedback of licensees through a questionnaire.

During 2021, PNRA convened two corporate level meetings and 11 coordination meetings with the management of licensees of nuclear installation and associated activities. In addition, 88 coordination meetings were held with the licensees of radiation facilities. The purpose of these meetings was to discuss and resolve the challenges being faced by licensees regarding licensing, construction, operation, training matters and import / export matters etc. Due consideration was given to the licensees point of views which helped in upholding the confidence of licensees in PNRA.

In addition, PNRA has developed a mechanism to evaluate its regulatory performance by obtaining direct feedback from the licensees. For this purpose, PNRA developed a questionnaire in national language "URDU" and distributed it to more than 5000 diagnostic X-rays facilities. Feedback from around 900 diagnostic X-rays licensees was received. PNRA performed evaluation of feedback received from diagnostic X-rays facilities and accordingly issued report highlighting areas for further improvement. On the basis of licensees feedback evaluation, it was noted that licensees were generally satisfied with regulatory performance of PNRA and the overall performance was rated as satisfactory. However, certain areas such as inspections, communication of information to licensees and training sessions for licensees have been identified which need to be more focused by PNRA for further improvement.

Keeping in view the above efforts made by PNRA to win the trust and confidence of its licensees, the performance of PNRA against this indicator is rated as **"Satisfactory"** for the year 2021.

Performance Indicator 11 - "Performs its functions in a manner that ensures confidence of the general public"

This indicator reflects performance related to public awareness programme, sharing of information with public and their involvement in preparation of regulatory documents.

PNRA has developed a well established public awareness programme in the country to inform the general public about the application of radiation in everyday life, the associated hazards to human health and basic protection principles. PNRA has been conducting such public awareness seminars at the universities / colleges / schools level over the last ten years. However, during the year 2021, this programme remained limited due to Covid-19 Pandemic and PNRA was able to conduct only 18 seminars in various educational institutions. More than 1650 individuals participated in these seminars.

During the reporting period, PNRA ensured involvement of public in development process of regulatory documents. For this purpose, draft regulatory documents were placed at PNRA website (www.pnra.org) for feedback and comments of public. Moreover, information for placing draft regulations on the website for public comments was also shared with the public through print media. The comments received from public were duly considered while finalizing the regulations. In addition, PNRA ensured the communication of regulatory decisions to public through various means i.e. by uploading information on PNRA website and publication of annual report. Further details of these activities are presented in Chapters 2, 8 and 10 of this report.

Considering the efforts made by PNRA during this year, PNRA's performance against this indicator is rated as **"Satisfactory"** for the year 2021.

Performance Indicator 12 - "Performs its functions in a manner that ensures confidence of the Government"

PNRA rates this indicator on the basis of information sharing, reporting and communication of regulatory activities to the Government and providing necessary support to Government for fulfillment of national and international obligations.

PNRA maintains an effective liaison with relevant Government organizations on the matters related to administration, legal, policy and regulatory affairs. PNRA also provides technical support to national stakeholders in areas of physical protection and nuclear security.

During 2021, PNRA provided handheld radiation detection equipment to Qasim International Container Terminal (QICT) Karachi for monitoring cargo trafficking for presence of any nuclear or other radioactive material. Furthermore, PNRA provided technical assistance to national organizations under Nuclear Emergency Management System (NEMS) for various events.

During the reporting period, PNRA coordinated with Ministry of Commerce (MoC) regarding preparation of the proposal to amend Import and Export Policy Orders (IPO and EPO). PNRA also provided its input to MoC in preparation of national response to the "Questionnaire on the Import Licensing Procedures" under the World Trade Organization (WTO) "Agreement on Import Licensing Procedures".

In addition, PNRA extended its support to National Disaster Management Authority (NDMA) by participating in the working group discussion session arranged jointly by NDMA and Japan International Cooperation Agency (JICA).

PNRA also supported the government of Pakistan in meeting Pakistan's national and international obligations under relevant International Conventions and represented the country at relevant international forums. During the year 2021, PNRA officials participated in the proceedings of the 65th regular session of the IAEA General Conference, participation in the 9th Organizational Meeting of the Convention on Nuclear Safety and participation in the virtual proceedings of Annual Session of UNSCEAR.

Keeping in view the above efforts, performance of PNRA against this indicator is rated as **"Satisfactory"** for the year 2021.

PNRA TARGETS FOR 2022

01 Gazette notification of four regulations

03 Issuance of decommissioning license to K-1

05 Site registration of C-5

07 Issuance of construction license to Molybdenum Production Facility-2 (MPF-2) at PINSTECH

09 Design certification of type-AF packages for transport of fresh fuel

11 Licensing of ICCC as manufacturer of class 1E I&C equipment

13 Establishment of laboratories for capacity building of PNRA against vulnerabilities due to digital control and cyber threats

15 Determination of baseline background radiation levels in Gilgit Baltistan

17 Participation in the Review Conference of amended CPPNM

Development of four regulatory guides

02

Issuance of operating license to K-2

04

Revalidation of operating license of Molybdenum Production Facility-1 (MPF-1) at PINSTECH

06

Licensing of CNPGS spent fuel dry storage facility

08

Site registration of national institute for conservation of environment and regional repository south facility

10

Revalidation of manufacturing license of HMC-3 and NEW-2

12

Conduct of IRRS Follow up Mission to Pakistan

14

Evaluation of integrated emergency exercise for Chashma Nuclear Power Generating Station (CNPGS) at Chashma site

16

Submission of Pakistan's National Report for joint 8th & 9th review meeting under Convention on Nuclear Safety to IAEA

18

19 Establishment of regional nuclear safety inspectorate in AJ&K



PNRA HEADQUARTERS

Mauve Area G-8/1
Islamabad, 44000 Pakistan

Tel: +92 (51) 926 3001-6
Fax: +92 (51) 926 3007

www.pnra.org