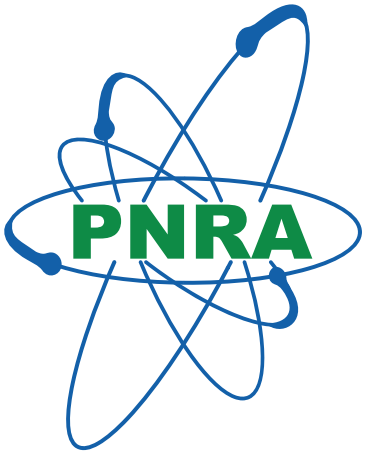
20 YEARS OF PNRA

PNRA

PAKISTAN NUCLEAR REGULATORY AUTHORITY

2001 - 2020

Ensuring Protection from Ionizing Radiation



CHAIRMAN'S MESSAGE

Zaheer Ayub Baig, HI

I am delighted that Pakistan Nuclear Regulatory Authority has completed its 20 years journey since its creation as an independent regulatory authority. At the time of inception, PNRA confronted countless challenges including lack of infrastructure, inadequate regulatory framework, meager financial resources and acute shortage of competent manpower for licensing and regulating a large number of facilities and activities.

It is worth mentioning that with the foremost endeavors of every PNRA individual, these challenges were transformed into remarkable achievements. Establishment of elegant office space with conducive working environment for employees, strengthening of regulatory framework, availability of sufficient trained manpower and creation of opportunities for competence development are the most prominent examples.

Similarly, establishment of ISO certified training facility with necessary training aids and internal technical support organization having expertise in specific technical areas; laboratories for environmental radioactivity monitoring, calibration and cross verification of exposure of radiation workers; restructuring of National Radiological Emergency Coordination Centre and efforts for strengthening regulatory oversight against cyber threats are other notable initiatives for emerging as a vibrant, dynamic and competent organization.

I am happy that the licensing network has been expanded due to dedication and teamwork of my PNRA colleagues and now we are regulating several nuclear installations; manufacturers of safety class equipment; service providers; radioactive waste management facilities and around 6000 radiation facilities across the country in an effective and efficient manner and at par with international standards.

During these two decades, PNRA has also earned a respectable name at international level by contributing in various international activities specially for providing assistance to embarking countries in strengthening their regulatory infrastructure. These services have been acknowledged at the international frontiers.

I must say that we have achieved a lot during these twenty years, however, there are still many challenges ahead of us. We should remain cognizant of our growing responsibilities in coming years. We should be futuristic, innovative and proactive while planning our functions. We should make efforts to further improve and share technical knowledge; explore new ideas; perform as a team for achieving our goals; enhance communication skills to deliver clear, accurate and understandable message; promote sense of ownership; be transparent and enthusiastic while performing regulatory responsibilities. We should also search for and adopt the best regulatory practices around the globe to further improve our regulatory oversight. We must also ensure that the regulatory decisions are made without any interference and influence from external sources and that safety is never compromised while making such decisions.

In the end, I would like to thank all PNRA colleagues that whatever we have achieved, so far, would not have been possible without your untiring efforts, paramount dedication and utmost commitment. I wish PNRA may further flourish, continue its prosperous journey and be successful in fulfillment of its national obligation of protecting individuals and environment from the hazards of ionizing radiation.

PNRA ACHIEVEMENTS 2001 – 2020

2001-2005

- Issued operating license to Chashma Nuclear Power Plant Unit-1 (C-1)
- Re-licensed Karachi Nuclear Power Plant Unit-1 (K-1)
- Established Centre for Nuclear Safety as Technical Support Centre

2006

- Issued construction license to Chashma Nuclear Power Plant Unit-2 (C-2)
- Hosted Peer Review Mission from China for PNRA's Technical Support Centre
- Established School for Nuclear and Radiation Safety
- Established Nuclear Security Action Plan

2007

- Established Nuclear Security Training Centre and Nuclear Security Emergency Coordination Centre at Islamabad

2008

- Established National Dosimetry and Protection Level Calibration Laboratory and National Environmental Radioactivity Surveillance Program
- Established regional offices at Peshawar and Quetta

2009

- Equipped eight entry/exit points i.e. Torkham, Chamman, Sost, Taftan, Wagah, Gawadar, Karachi and Bin Qasim with radiation detection equipment
- Established network of six incident response mobile laboratories

2010

- Renewed operating license of C-1 after satisfactory conduct of periodic safety review
- Issued fuel load permit to C-2
- Approved first PNRA Management System Manual

2011

- Issued construction licenses to Chashma Nuclear Power Plant Unit-3 and Unit-4 (C-3 & C-4)
- Completed periodic safety review of Pakistan Research Reactor-1 (PARR-1)

2012

- Issued operating license to C-2
- Extended operating license of K-1
- Issued license to HMC-3 to manufacture nuclear safety class-1 equipment
- Developed first strategic plan of PNRA

2013

- Conducted self-assessment of PNRA using IAEA SARIS tool
- Registered site for Karachi Nuclear Power Plant Unit-2 (K-2)
- Hosted IAEA Education and Training Appraisal (EduTA) Mission and IAEA Education and Training Review Services (ETRES) Mission

PNRA ACHIEVEMENTS 2001 – 2020

2014

- Issued operating licenses to PARR-1 and PARR-2
- Hosted IAEA Integrated Regulatory Review Services (IRRS) Mission
- Developed PNRA strategic plan 2015-2018

2015

- Issued construction licenses to Karachi Nuclear Power Plant Unit-2 and Unit-3 (K-2 & K-3)
- Granted authorizations for commissioning to C-3 and C-4
- Issued license to Molybdenum Production Facility (MPF) as a nuclear installation
- Completed Safety Culture Self Assessment (SCSA) of PNRA

2016

- Issued fuel load permit to C-3
- Issued license to PINSTECH pre-disposal radioactive waste management facility
- Issued design approval certificate to PINSTECH for type B(U) transport container
- Issued authorization to NCNDT to perform non-destructive examination of nuclear safety class components and systems of NPPs

2017

- Extended operating license of K-1
- Issued fuel load permit to C-4
- Revalidated manufacturing license of HMC-3 for manufacturing nuclear safety class-1 equipment

2018

- Issued national policy on safe management of radioactive waste, decommissioning and spent nuclear fuel
- Issued operating licenses to C-3 and C-4
- Issued manufacturing license to NEW-2 for manufacturing nuclear safety class-1 equipment

2019

- Granted permissions for commissioning of K-2 and K-3
- Granted design approval certificate of spent nuclear fuel dry storage cask for K-1 site
- Issued construction license to Chashma Nuclear Power Generating Station PWR Dry Storage Facility
- Established background radioactivity level across the country due to natural as well as man-made sources
- Developed PNRA strategic plan 2019-23

2020

- Issued fuel load permit to K-2
- Re-validated operating license of C-1
- Granted design approval certificate of spent fuel dry storage cask for C-series NPPs
- Established PNRA inspectorate in Gilgit-Baltistan
- Revalidated authorization of NCNDT

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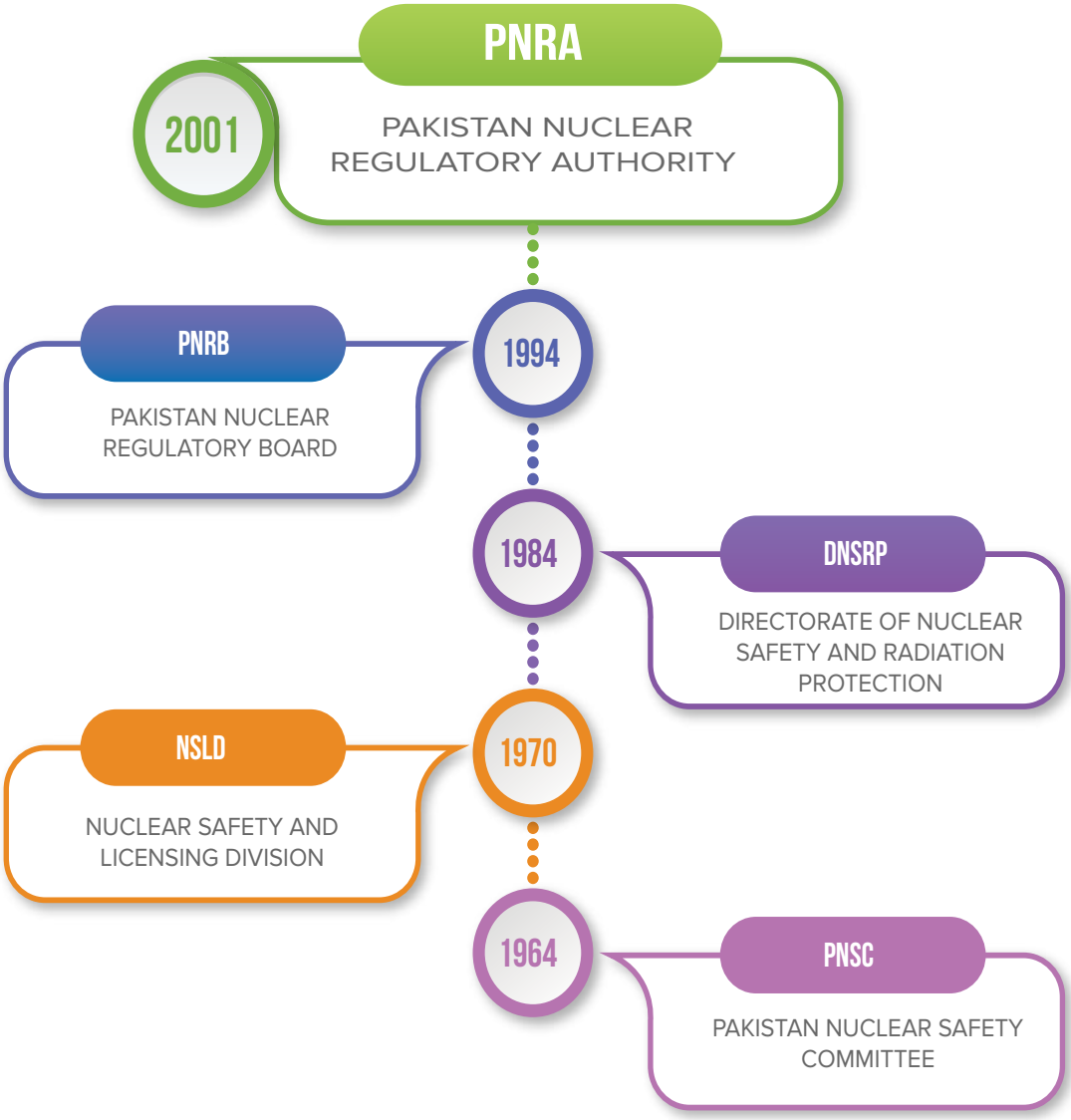
1 INTRODUCTION



The use of ionizing radiation plays an important role in the life of mankind through its utilization in a variety of fields such as medicine, research, industry, agriculture and electricity generation.

However, the use of ionizing radiation carries hazards to human health, if not handled carefully. In the absence of appropriate safety measures, such use carries a potential of harming the user itself as well as the general public and the environment.

Keeping in view the hazards associated with the use of ionizing radiation, strict regulatory control is essential to harness the use of ionizing radiation for the benefit of mankind. The existence of a well established and effective legislative and regulatory framework is imperative to ensure safe use of sources and material emitting ionizing radiation.

Pakistan has long been utilizing the ionizing radiation in various fields and practices. The nuclear and radiation safety has been of prime importance since its utilization in Pakistan.

1.1 Nuclear Safety Regime in Pakistan

Pakistan Atomic Energy Commission (PAEC) was the first institution established in Pakistan in 1956 to promote the peaceful uses of atomic energy in the country. PAEC was also responsible to maintain safety in its applications of ionizing radiation. However, first formal regulatory setup was created several years later in 1964 with the creation of Pakistan Nuclear Safety Committee (PNSC) within PAEC. This setup was assigned with the responsibility of overseeing the safety matters related to the first research reactor of the country - Pakistan Research Reactor-1 (PARR-1).

Later, Pakistan decided to install its first nuclear power plant for electricity generation at Karachi, namely Karachi Nuclear Power Plant (KANUPP). In order to oversee the safety matters of KANUPP, the existing setup and scope of PNSC was expanded and it was transformed into a division called Nuclear Safety and Licensing Division (NSLD) in 1970. Since, the use of radioactive sources in private sector in the country was out of regulatory control, therefore, the Government of Pakistan promulgated the Pakistan Nuclear Safety and Radiation Protection Ordinance in 1984 to bring use of such radioactive sources under the regulatory net. Under this Ordinance, NSLD was upgraded into a directorate namely Directorate of Nuclear Safety and Radiation Protection (DNSRP). This setup was still within the administrative control of PAEC. Through this legislation, PAEC was simultaneously made responsible for the promotion of atomic energy as well as regulation of matters related to nuclear safety and radiation protection in the country.

In 1994, Pakistan signed the Convention on Nuclear Safety of the International Atomic Energy Agency (IAEA). This Convention obliged the contracting parties to maintain a high level of nuclear safety in the country. One of the obligations of this Convention was to establish a regulatory body and providing it with adequate authority, competence and resources. The aim of this obligation was to ensure effective separation between the functions of regulatory body and the organizations concerned with the promotion or utilization of nuclear energy.

Keeping in view the requirement of this Convention, Pakistan Nuclear Regulatory Board (PNRB) was established in 1994. This was partial fulfillment of the Convention as the Chairman of this Board was still the Chairman of the Pakistan Atomic Energy Commission. However, it also had representation from other stakeholder organizations outside PAEC.

Establishment of PNRA

Pakistan Nuclear Regulatory Authority (PNRA) was established as an independent national regulatory body with the powers to regulate all nuclear installations, radiation facilities and associated activities to ensure nuclear safety and radiation protection in Pakistan.

Finally, in 2001, the Government of Pakistan promulgated the Pakistan Nuclear Regulatory Authority Ordinance, allowing

Members of the Authority at 59th Authority Meeting held at PNRA HQs.

complete separation of promotion of nuclear energy and regulatory functions at national level.

1.2 The Ordinance - Powers and Responsibilities

The Ordinance mandated PNRA to control, regulate and supervise all matters related to nuclear safety and radiation protection measures in Pakistan.

The Ordinance empowered PNRA to establish and enforce a regulatory framework for nuclear safety and radiation protection in the country.

The Ordinance also empowered PNRA to grant authorizations and licenses to all nuclear installations, radiation facilities and associated activities. Furthermore, it authorized PNRA to conduct inspections to verify compliance with the regulatory requirements and take appropriate enforcement actions in case of any non-compliance.

The installations, facilities and associated activities regulated by PNRA are presented in Figure-1.

An important function of PNRA is to ensure that arrangements to mitigate the consequences of a potential nuclear or

Figure-1: What We Regulate

Chairman PNRA Presenting Souvenir to Director General IAEA

radiological emergency are appropriately maintained by the licensees. Apart from that, PNRA is also empowered to regulate the transport of radioactive material and physical protection measures at nuclear installations and radiation facilities. The Ordinance also entrusts PNRA to fix the extent of civil liability for nuclear damage in case of any nuclear incident.

Regulatory functions and domains of PNRA are reflected in Figure-2.

Keeping in view its mandate, PNRA has established and documented its Vision, Mission, and Core Values under its Management System so that organizational efforts are effectively channeled and resources are constructively utilized. Figure-3 presents Vision, Mission and Core Values of PNRA.

The Ordinance delineates the composition of the Authority which comprises a Chairman, two full-time Members and seven part-time Members. The part-time Members include representatives of the Ministry of Health, Pakistan Environmental Protection Agency, Pakistan Atomic Energy Commission, Strategic Plans Division of the Joint Staff Headquarters and eminent professionals from the science, engineering and medical sectors.

The headquarter of the Authority is located in Islamabad while eight regional offices are strategically located throughout the country in order to exercise regulatory functions in an effective and efficient manner. The presence of PNRA offices across the country is shown in Figure-4 and organizational structure of PNRA is presented in Figure-5.

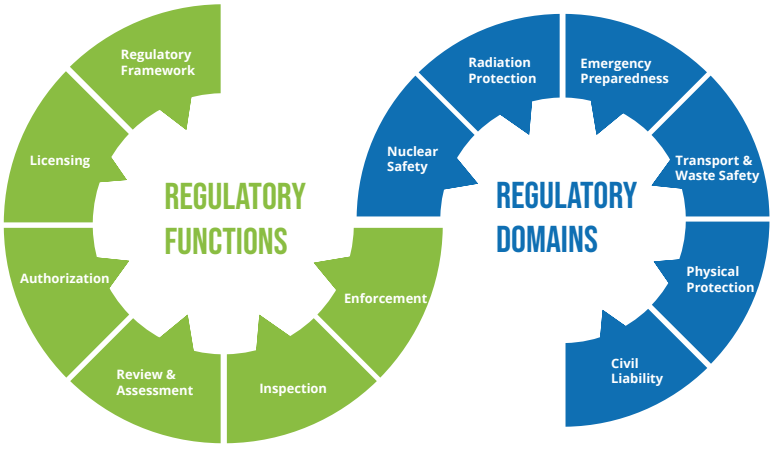


Figure-2: Regulatory Functions and Domains of PNRA

Figure-3: Vision, Mission and Core Values of PNRA

PNRA's Presence Across the Country

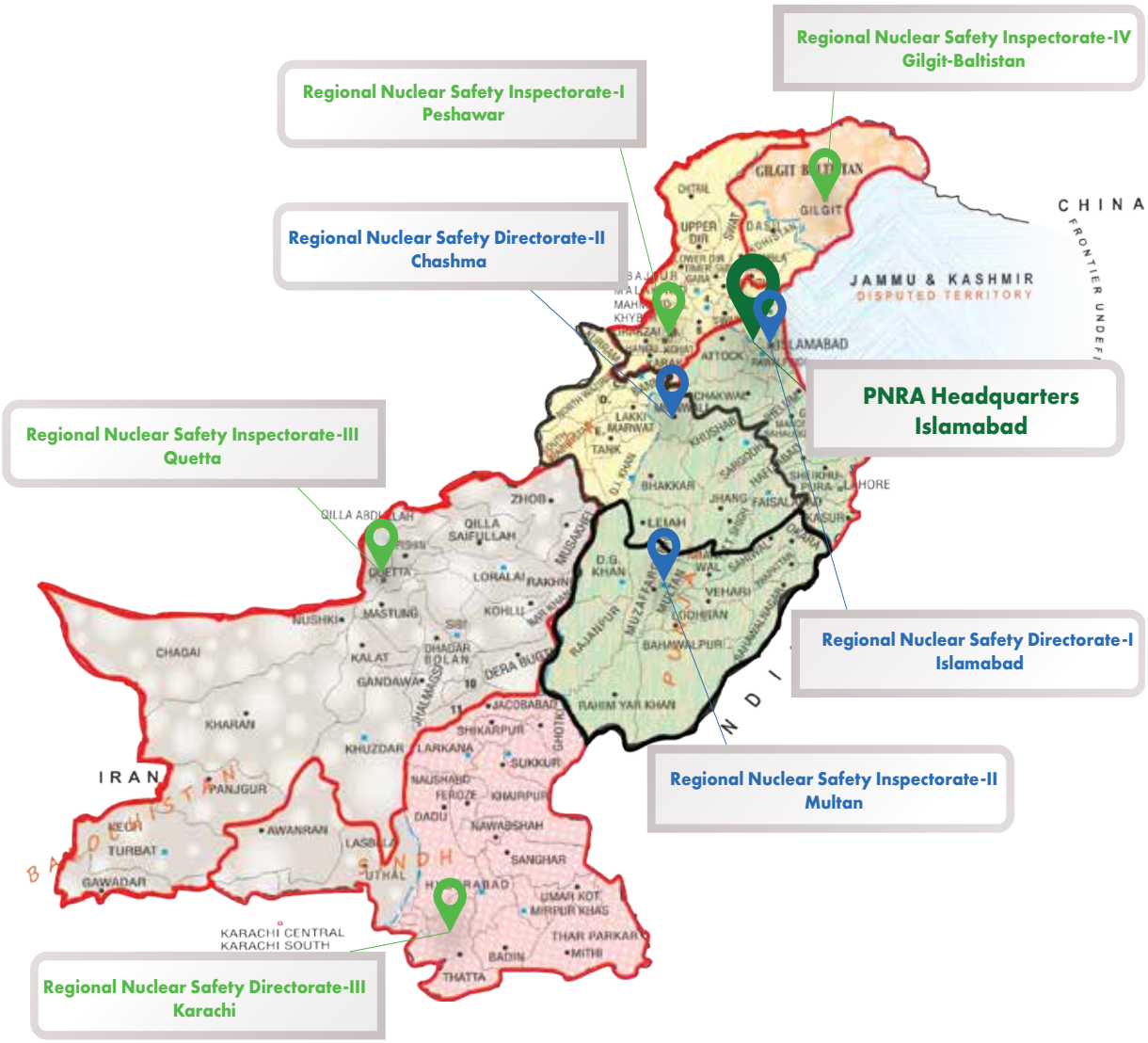


Figure-4: PNRA Offices Across the Country

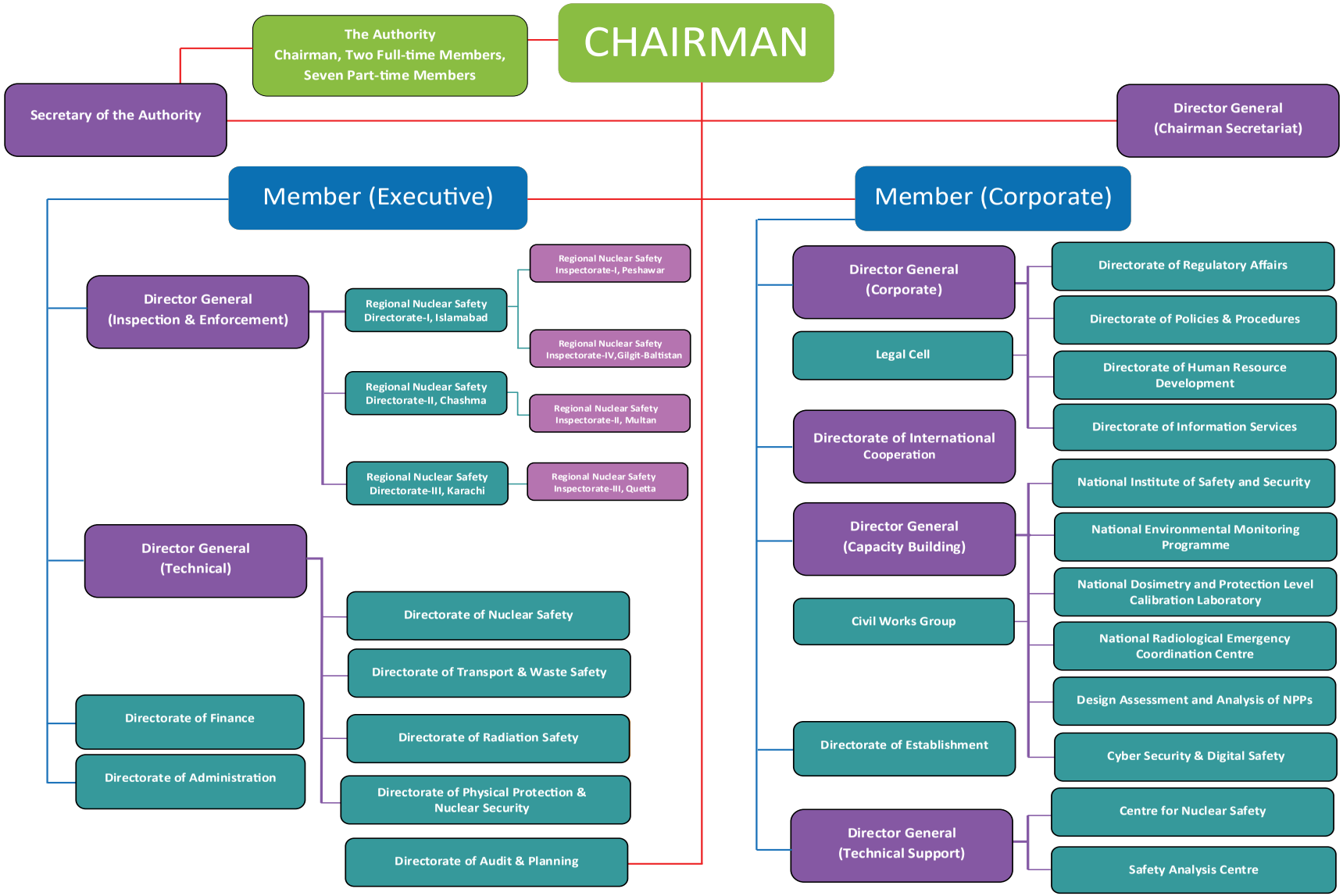


Figure-5: Organizational Structure of PNRA

National Independence Day Celebration at PNRA HQs.

Chairman PNRA Addressing Employees on PNRA Day

CHAIRMEN OF PNRA

Zaheer Ayub Baig, HI
2017 - Present

M. Anwar Habib, HI
2009 - 2017

Jamshed Azim Hashmi
2001 - 2009

FULL TIME MEMBERS OF PNRA

M. Saleem Zafar
2017 - Present

Faizan Mansoor
2016 - Present

Zaheer Ayub Baig, HI
2016 - 2017

Mahboob Ali, SI
2011 - 2016

Mohammad Iqbal
2012 - 2015

Dr. Shahid Mallick
2009 - 2011

M. Shakilur Rahman
2005 - 2011

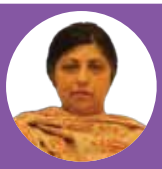
M. Anwar Habib, HI
2007 - 2009

Syed Badshah Husain
2003 - 2007

Jawad Azim Hashimi
2001 - 2005

SECRETARIES OF PNRA

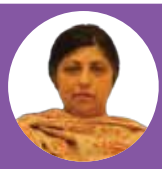
Dr. Mohammad Sadiq
2019 - 2020



Fauzia Ansari
2016 - 2019

Abdul Mannan
2006 - 2016

M. Shakilur Rahman
2005 - 2006



Fauzia Ansari
2002-2005

PART TIME MEMBERS OF PNRA

Dr. Anisa Qamar
2020 - Present

Lt. Gen. Nadeem Zaki Manj, HI(M)
2019 - Present

Dr. Rana M. Safdar
2019 - Present

Dr. M. Aslam
2018 - Present

Saeed-ur-Rehman
2018 - Present

Dr. Tariq Mahmood
2016 - Present

Farzana Altaf
2016 - Present

Lt. Gen. Sarfraz Sattar, HI (M)
2017 - 2019

Syed Yusuf Raza
2014 - 2018

Hussain Ahmad Siddiqui
2010 - 2018

Dr. M. Nuruddin Qazi
2010 - 2018

Dr. Huma Qureshi
2017

Lt. Gen. Mazhar Jamil, HI (M)
2015 - 2017

Lt. Gen. Zubair Mahmood, HI (M)
2014 - 2015

Dr. M. Khurshid
2014 - 2015

Dr. Mustafa Kamal
2011 - 2015

Saeed Alam Siddiqi
2011 - 2014

Lt. Gen. Khalid Ahmed Kidwai, HI (M)
2002 - 2014

Asif Shuja Khan
2002 - 2014

Dr. Qazi A. Saboor
2002 - 2014

Zia-ul-Hasan Siddiqui
2006 - 2011

Dr. Inayat Shah
2006 - 2010

Dr. Inam-ur- Rahman
2002 - 2010

Prof. Dr. M. Ali Maud
2002 - 2010

Dr. M. Younus Sheikh
2002 - 2006

Anwar Ali
2002 - 2006

2 FRAMEWORK FOR REGULATORY ACTIVITIES

After creation of PNRA in 2001, significant progress has been made in the development of regulatory framework for fulfilling the national obligations under the PNRA Ordinance. This chapter provides the hierarchy of the nuclear regulatory documents and presents an overview of progress made in development of regulatory framework during the last 20 years. Based on strategic plan, 20 years time period is distributed in four eras to facilitate the readers in understanding the development of the regulatory framework, these being 2001-2005, 2006-2010, 2011-2015 and 2016-2020 respectively.

2.1 Hierarchy of Regulatory Documents

Hierarchy of the nuclear regulatory documents starts with the basic nuclear safety principles defined by the government and includes regulatory requirements and associated guidance being formulated by PNRA upon which safety of nuclear installations and radiation facilities is ensured in Pakistan. The regulatory pyramid comprises three tiers i.e. PNRA Ordinance, PNRA regulations and PNRA regulatory guides. These tiers are shown in Figure-6.

2.2 PNRA Ordinance - Establishment of Regulatory Body and its Mandate

PNRA Ordinance constitutes top tier of the regulatory pyramid, which provides fundamental principles of nuclear and radiation safety, establishment of PNRA; and its mandate. The Ordinance was promulgated on January 22, 2001, which was validated and affirmed by the Parliament under the 17th amendment in the Constitution of the Islamic Republic of Pakistan.

The Ordinance describes the powers, functions and responsibilities of the regulatory body and authorizes PNRA to control and regulate all matters related to nuclear safety and radiation protection in country. It empowers PNRA to devise, adopt, make and enforce rules, regulations, orders or codes of practice in order to protect the life, health and property against the risk of ionizing radiation.

2.3 PNRA Regulations - Mandatory Requirements for Users of Ionizing Radiation

Regulations are at the second tier of the regulatory pyramid, which prescribe mandatory requirements for applicants and licensees of nuclear installations, radiation facilities and associated activities.

The development of PNRA regulations is based upon the obligations of PNRA Ordinance, national circumstances, international standards and practices, experience feedback and input from stakeholders.

PNRA has a comprehensive mechanism

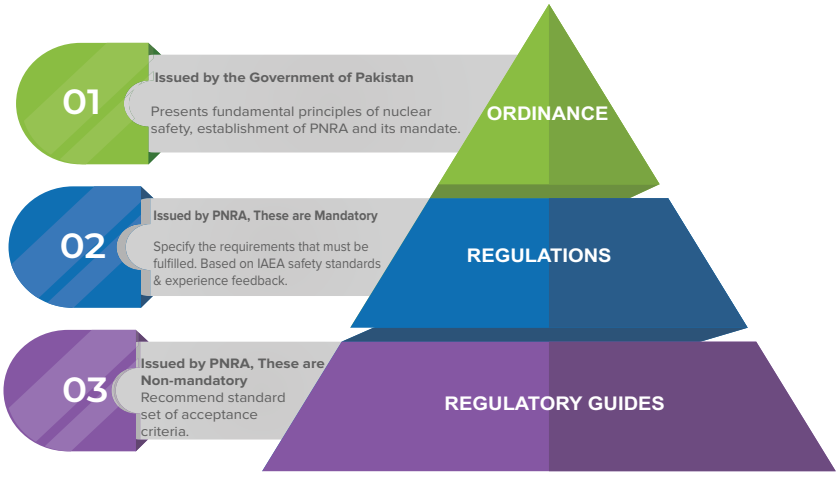


Figure-6: Regulatory Framework of PNRA

Types of Regulations

PNRA issues Administrative and Technical Regulations. The mechanism for performing different regulatory processes such as licensing, enforcement, dispute resolution, etc. are described in Administrative Regulations. The Technical Regulations prescribe specific technical requirements to be followed by the licensees while performing authorized activities in different areas e.g. design, operation, radiation protection, etc.

for the development, adoption, revision, amendment and repeal of regulations. The process involves in-depth internal review at various levels, review by relevant stakeholders and final approval by the Authority. The approved regulations are then notified in the Gazette of Pakistan. The regulations are placed on PNRA website (www.pnra.org) for information of stakeholders including the general public.

PNRA regulations are reviewed after five years in the light of experience feedback, improvement in international standards and stakeholders' input. Accordingly, revision of regulations is initiated, if new or any emergent requirements are identified which need to be addressed.

So far, 20 regulations have been gazette notified containing six administrative and 14 technical. Figure-7 shows an overview of regulations developed over the past twenty years.

Era-1 (2001-2005)

To ensure effective regulatory control over nuclear installations and radiation facilities, PNRA developed essential framework consisting of seven regulations during the period 2001-2005.

Era-1 (2001-2005) - During this era, PNRA focused on establishing the regulatory framework to supervise and regulate safety of nuclear installations, radiation facilities and associated activities. PNRA issued regulations related to radiation protection,

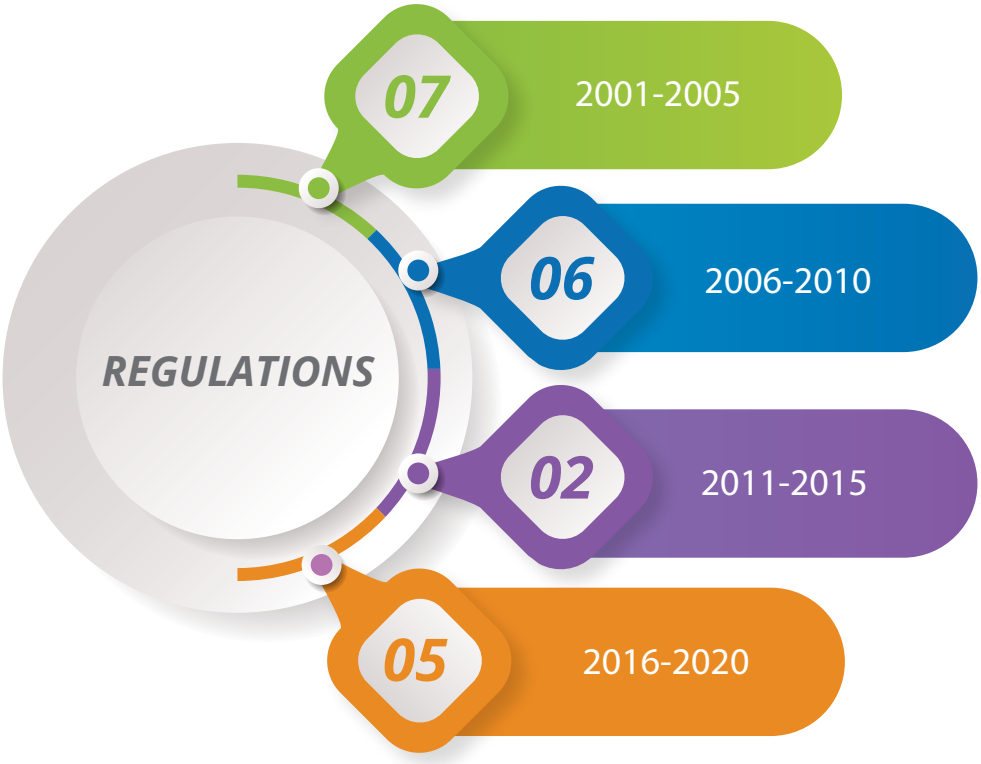


Figure-7: New Regulations Issued by PNRA since 2001

licensing of nuclear installations and radiation facilities, safety of NPP design, operation & quality assurance and radioactive waste management as listed below:

i. Regulations on Radiation Protection - (PAK/904);

ii. Regulations for the Licensing of Radiation Facility(ies) other than Nuclear Installation(s) - (PAK/908);

iii. Regulations for Licensing of Nuclear Installations in Pakistan - (PAK/909);

iv. Regulations on the Safety of Nuclear Power Plant Design - (PAK/911);

v. Regulations on the Safety of Nuclear Power Plants - Quality Assurance - (PAK/912);

vi. Regulations on the Safety of Nuclear Power Plants Operation - (PAK/913); and

vii. Regulations on Radioactive Waste Management - (PAK/915).

Era-2 (2006-2010)

PNRA issued six new regulations during 2006-2010. In addition, one previous regulation was revised and amendment in one regulation was issued.

Era-2 (2006-2010) - During the second era, PNRA focused on further development of regulatory framework and issued a number of new regulations as listed below:

i. Regulations on Licensing Fee by PNRA - (PAK/900);

ii. Regulations on Nuclear Safety Class Equipment and Component Manufacturers - (PAK/907);

iii. Regulations on the Safety of Nuclear Installations - Site Evaluation - (PAK/910);

iv. Regulations on Management of a Nuclear or Radiological Emergency - (PAK/914);

v. Regulations for the Safe Transport of Radioactive Material - (PAK/916); and

vi. PNRA Enforcement Regulations - (PAK/950).

Era-3 (2011-2015)

During 2011-2015, PNRA issued two new regulations and a national policy while seven amendments in different regulations were issued.

Era-3 (2011-2015) - During the third era, a strong earthquake followed by a deadly tsunami shook Japan and in addition to other devastating effects, damaged four nuclear power plants at Fukushima Daiichi, Japan.

PNRA took this accident very serious and advised the licensees to re-assess the safety of all operating power plants and address filling of gaps in safety measures, if any.

PNRA re-assessed its regulatory framework and made several amendments in regulations on power plant design, operation, quality assurance and licensing of nuclear installations. In addition, two new regulations were issued as given below:

i. Regulations on Safety of Research Reactor(s) Operation - (PAK/923); and

ii. Regulations on Transaction of Business of PNRA - (PAK/901).

During this era, PNRA realized the need for the development of a national policy on radioactive waste management. PNRA in collaboration with other relevant national stakeholders formulated "National Policy on Control and Safe Management of Radioactive Waste" which was issued by Government of Pakistan in 2011. Assistance from IAEA was also obtained during its development.

Era-4 (2016-2020)

PNRA issued five new regulations, revised six regulations and amended two regulations during 2016-2020. Furthermore, one national policy was issued while one was revised. In addition a regulatory order was issued during this period.

Era-4 (2016-2020) – Development of regulatory framework remained in progress during this period. Considering the regulatory

needs, experience feedback and internal practices, in addition to amendments and revision of a number of existing regulations, PNRA issued a number of new regulations as listed below:

i. Regulations for the Safe Management of Spent Nuclear Fuel - (PAK/918);

ii. Regulations on Physical Protection of Nuclear Material and Nuclear Installation(s) - (PAK/925);

iii. Regulations on Security of Radioactive Sources - (PAK/926);

iv. Regulations on Decommissioning of Facilities Using Radioactive Material - (PAK/930); and

v. Regulations on Dispute Resolution - (PAK/949).

A large number of 660 Series Gamma Radiographic Projectors were being used for industrial radiography all over the country. In year 2013, these projectors ceased to have a valid design certification of the country of origin. In view of this, PNRA issued a regulatory order in 2018 and prohibited further use of this projector in the country.

As already mentioned, Government of Pakistan had issued a policy on waste management in 2011. Later, it was realized that certain important areas need to be addressed in this policy. The existing policy was thoroughly reviewed in collaboration with relevant stakeholders and areas like decommissioning, spent nuclear fuel, financial arrangements and responsibilities of different stakeholders were added in the policy. Accordingly, "National Policy on Safe Management of Radioactive Waste, Decommissioning and Spent Nuclear Fuel in Islamic Republic of Pakistan - (RWP-01/2018)" was gazette notified in 2018.

Further, PNRA realized the need for establishment of a policy on nuclear safety at national level. PNRA collaborated with relevant national organizations for the development of national level policy. Fundamentals of nuclear safety and radiation protection were incorporated and the "National Safety Policy - (NP-02/2020)" was gazette notified in 2020.

2.4 PNRA Regulatory Guides - Guidance on Acceptable Approaches

Regulatory guides form the third tier of PNRA regulatory pyramid. These are non-mandatory in nature and prescribe acceptable methods to be followed by the licensees to fulfill the regulatory requirements. However, the licensees have the privilege to choose any alternate approach instead of methodology presented in the regulatory guides of PNRA. In such a case, the licensee has to demonstrate

Training Course on PNRA Regulations for Stakeholders

that the adopted approach provides an equivalent or higher level of safety than the approach described in regulatory guides. PNRA issued a total of 17 regulatory guides during the past 20 years.

During the period 2001-2005, PNRA issued one regulatory guide on Registration, Licensing and Issuance of NOC to the Exporter(s) of Radiopharmaceuticals - (PAK/9801) to provide guidance to licensees for the implementation of Regulations (PAK/908).

During the years 2006-2010, PNRA issued following four regulatory guides to provide guidance to licensees for the implementation of relevant regulations:

i. Quality Assurance in Nuclear Medicine (PNRA-RG-904.01);

ii. Probabilistic Safety Assessment of Nuclear Power Plants Level-1 (PNRA-RG-911.01);

iii. Dosage and Distribution of Potassium Iodide Tablets (a Thyroid Blocking Agent) in Radiation Emergencies (PNRA-RG-914.01); and

iv. Transportation of Radioactive Material by Road in Pakistan (PNRA-RG-916.01).

During the period 2011-2015, PNRA continued its efforts and developed following two regulatory guides:

i. Guidance for the Users of Iodine-131 in Nuclear Medicine Centres (PNRA-RG-904.02);

ii. Format and Content of Application for Modifications in Technical Specifications and Operating Policies and Principles of Nuclear Power Plants (PNRA-RG-913.03).

During the period 2016-2020, PNRA issued ten regulatory guides including four in different technical areas and six regulatory guides on the format and contents of documents to streamline and bring uniformity in submissions by the licensees. These are listed below:

i. Radiation Safety in Industrial Radiography (PNRA-RG-904.03);

ii. Protection of Patients in Diagnostic Radiology (PNRA-RG-904.05);

iii. Radiation Protection and Safety in Radiotherapy (RG 904.06);

iv. Format and Contents of Radiation Protection Program (RG 904.07);

v. Format and Contents of Physical Protection Program of Nuclear Installations (PNRA-RG-909.02);

vi. Format and Contents of Environmental Monitoring Program for Nuclear Installations (PNRA-RG-909.03);

Review of PNRA Regulatory Documents

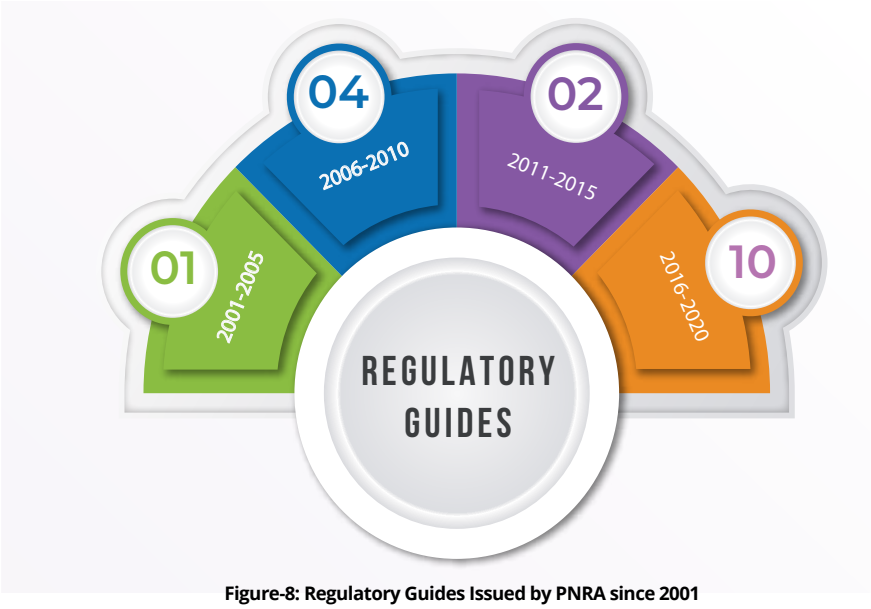


Figure-8: Regulatory Guides Issued by PNRA since 2001

vii. Format and Contents of Application for Modification of Design and Safety Analysis Report in Nuclear Installations PNRA-RG-913.02 (Rev.1);

viii. Preparation of Radiation Emergency Plan for Radiation Facilities and Activities (PNRA-RG-914.02);

ix. Format and Contents of Radioactive Waste Management Program for Nuclear Medical Centres (PNRA-RG-915.01); and

x. Format and Contents of Radioactive Waste Management Program for Nuclear Installations (PNRA-RG-915.02).

Period-wise development of regulatory guides is shown in Figure-8.

Similarly, Figure-9 presents the list of regulatory guides developed against each regulation.

2.5 Management System of PNRA

Management System is a framework of processes, procedures, policies and practices

Figure-9: Regulatory Guides Issued under PNRA Regulations

that enables an organization to perform the assigned tasks in a systematic and efficient manner.

In 2007, PNRA initiated the documentation of its management system based on IAEA GS-R-3 "The Management System for Facilities and Activities". The first version of PNRA Management System Manual - MSM was issued in 2010 as one of the top level documents within the PNRA documentation hierarchy.

In 2016, PNRA MSM was revised on the basis of experience feedback and IAEA GSR Part-2 "Leadership and Management for Safety".

PNRA conducted awareness drives in 2011-2012 and 2017-2018 respectively to develop common understanding about the management system among all PNRA employees.

2.5.1 Management System Documentation

PNRA management system documents comprise three levels namely Level-1, Level-2 and Level-3 documents. The categorization of management system documents of PNRA is reflected in Figure-10.

Major documents of PNRA include internal policies, programs, PNRA level procedures and department level procedures. These documents are developed based on the needs identified during the organizational working. The review and revision of documents is carried out as per frequencies defined in the management system manual. PNRA maintains a central registry of all regulatory and major management system documents.

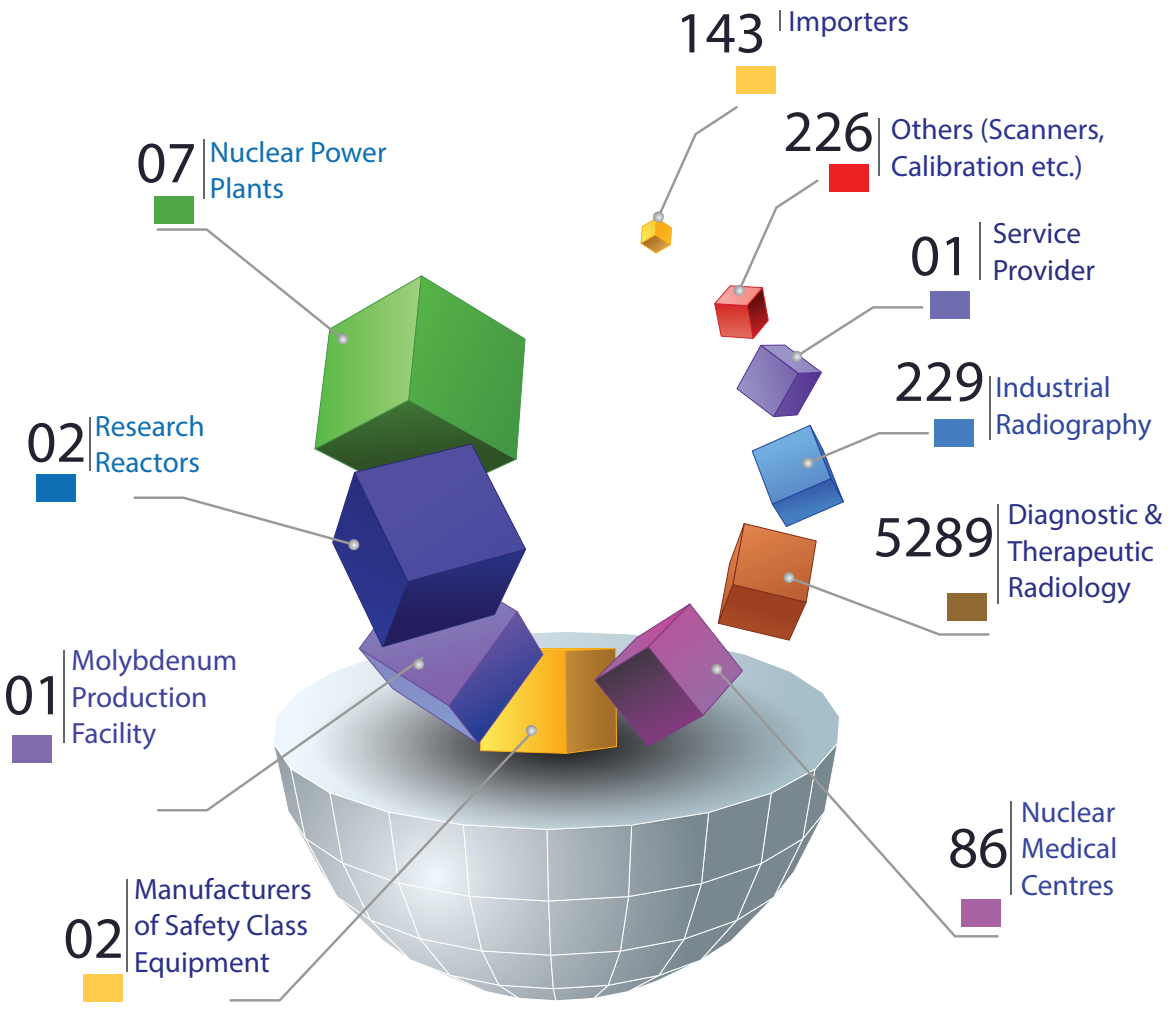
PNRA issues internal policies for its routine working in different areas of regulatory interest. So far, PNRA has issued nine policies.

PNRA level programmes and working procedures reflect the processes and activities in which more than one PNRA departments are involved. Till date, more than 50 PNRA level programs and working procedures have been issued within PNRA.

Department level working procedures delineate the activities where only one department is involved. As of today, more than 390 department level procedures have been developed at PNRA.

Figure-10: Categorization of PNRA Management System Documents

3 REGULATING NUCLEAR INSTALLATIONS, RADIATION FACILITIES AND ACTIVITIES



Regulatory Ambit

PNRA has a mandate to regulate nuclear installations, radiation facilities and associated activities in Pakistan. Three main core functions of PNRA are licensing & authorization, review & assessment of applicant's submissions and inspection & enforcement. In 2001, the facilities regulated by PNRA were limited. As the time passed, the number of regulated facilities increased and new facilities and activities kept accumulating during the journey of two decades.

Increase in energy demand and need to cater for the electricity outages in the country acted as drive for expansion in nuclear power program by Pakistan Atomic Energy Commission (PAEC). Consequently, PAEC started construction of new nuclear power plants and related facilities that lead to increase in volume of work of PNRA as well. In the area of radiation facilities, not only facilities kept increasing but also PNRA made efforts to take-in unregistered facilities into its licensing net.

3.1 Nuclear Power Plants

In 2001, PNRA was regulating two nuclear power plants which were already constructed and in operation i.e. Karachi Nuclear Power Plant Unit-1 (K-1) and Chashma Nuclear Power Plant Unit-1 (C-1). Before the establishment of Pakistan Nuclear Regulatory Authority, regulatory matters were being looked after by Directorate of Nuclear Safety and Radiation Protection (DNSRP) of the Pakistan Atomic Energy Commission. DNSRP conducted licensing process according to IAEA safety standards and through other widely accepted international practices.

During 20 years after its inception, PNRA has achieved major milestones in the field of review and assessment of NPPs starting from re-licensing of K-1 to licensing of K-2 and K-3 as shown in Figure-11.

After its establishment, the first major task performed by PNRA was the re-licensing of K-1 to be operated beyond its design life. K-1 started commercial operation in 1972 and completed its design life of 30 years in 2002. Considering the age of the plant and pertaining safety issues, PNRA adopted the strategy of granting operating licenses for limited time periods instead of whole ten years period in order to exercise enhanced and stringent regulatory oversight.

K-1 remained shut down during 2003 for required safety improvements. In August 2003, K-1 requested to permit plant operation at reduced power to perform commissioning of various plant systems and up gradations. Various joint meetings were held and special study groups were formed to evaluate safety up grades carried out during long outage and to determine a safe power level for interim operation. Accordingly, based on an independent review by PNRA and opinion of international experts, K-1 was conditionally allowed to operate at reduced power. Accordingly, K-1 operated at a reduced power from 2003 to 2007.

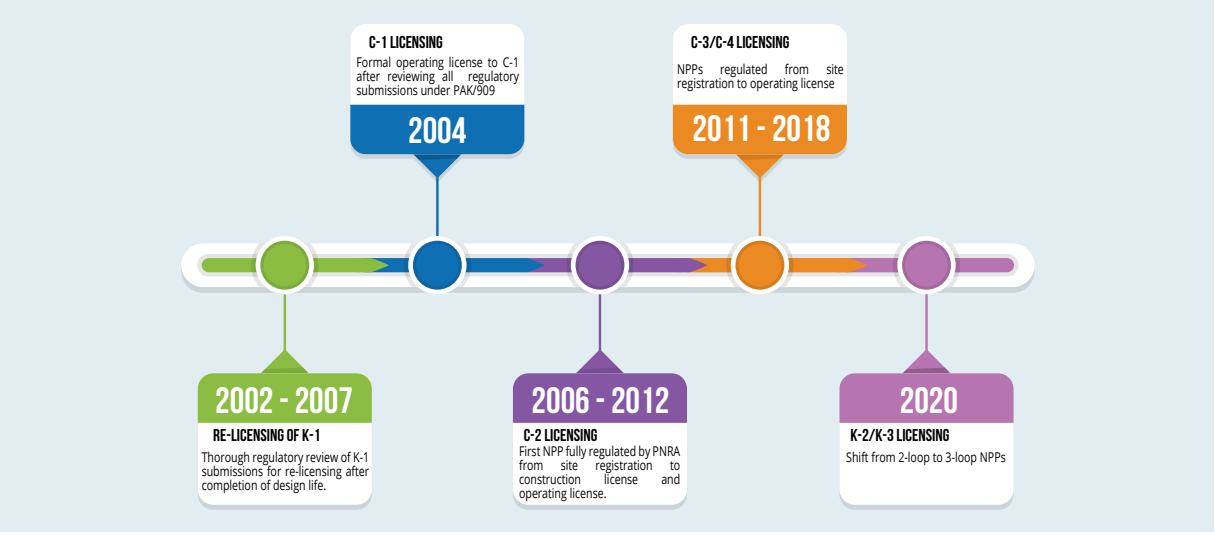


Figure-11: Regulatory Milestones of NPPs Licensing

Meanwhile, a thorough regulatory review of K-1 submissions was completed by PNRA in 2007 and after fulfillment of re-licensing requirements, PNRA granted operating license to K-1 for two years i.e. up to December 2009 with certain license conditions for further extension of operating license. Accordingly, PNRA further extended the operating license to December 2010 subject to fulfillment of certain additional conditions. PNRA continued same approach for K-1 and the latest operating license was granted from October 01, 2020 to December 31, 2020 which has been further extended till July 31, 2021. The plant will be permanently shut down for decommissioning with effect from August 01, 2021.

Chashma Nuclear Power Plant Unit-1 (C-1), which is the first Pressurized Water Reactor (PWR) in the country, was connected to grid on June 13, 2000 and attained full power in September 2000. However, after establishment of PNRA in 2001, a need was felt to pass C-1 through PNRA licensing procedure so as to harmonize it with PNRA processes. Accordingly, a thorough review of C-1 licensing submissions was made and after all regulatory requirements had been met; PNRA formally issued operating license to C-1 in October 2004 valid up to December 2010. As part of ten yearly license renewal requirements, C-1 conducted its first Periodic Safety Review (PSR) and submitted the application for re-validation of its operating license for another 10 years. Based on the review of 193 PSR reports and upon satisfaction that no safety issue has remained unresolved and appropriate corrective actions have been identified, the operating license of C-1 was re-validated up to December 31, 2020. C-1 also conducted its second PSR before expiry of license and, based on satisfactory review, operating license of C-1 was again re-validated up to December 31, 2030.

So far, C-1 has undergone 13 refueling outages (RFOs). It is mentioned that at the end of each RFO, the licensee submits a safety case for operation of the plant in the next cycle along with the documents specified in PNRA Regulations PAK/913. PNRA reviews the safety case and allows continuation of operation or otherwise.

Chashma Nuclear Power Plant Unit-2 (C-2) is the second PWR type NPP at Chashma site. PNRA registered the C-2 site after reviewing and assessing the site evaluation report and confirming that other requirements such as No Objection Certificates (NOCs) from relevant government departments had been fulfilled. The license for the construction of the plant was issued on March 23, 2006 after PNRA had conducted a complete review of the required documentation.

After reviewing the Final Safety Analysis Report (FSAR) and assessment of the documents required under PNRA Regulations PAK/909, successful completion of commissioning tests, demonstration of implementation of emergency preparedness plan in an exercise covering on-site and off-site emergency measures and completion of physical protection measures, fuel load permit was issued to C-2 on December 21, 2010 and first fuel assembly was loaded on December 22, 2010.

Formal operating license was awarded to

C-1 Operating License Award Ceremony

C-2 Operating License Award Ceremony

C-3 and C-4 Operating License Award Ceremony

C-2 on February 25, 2012. So far, C-2 has undergone seven RFOs.

The projects of Chashma Nuclear Power Plant Unit-3 (C-3) and Chashma Nuclear Power Plant Unit-4 (C-4) were started in parallel at Chashma site. After completing the review of documentation, PNRA issued construction license to C-3 on May 28, 2011 and to C-4 on December 14, 2011. PNRA granted permission to load fuel in the reactor core of C-3 on May 17, 2016 and C-4 on February 09, 2017 after satisfactory completion of regulatory process. PNRA granted operating licenses to C-3 and C-4 on May 02, 2018.

After gaining experience of licensing of C-Series NPPs (C-1, C-2, C-3 and C-4) which are two-loop Pressurized Water Reactors (PWRs), PNRA independently undertook licensing of three-loop PWR technology having larger power generating capacity i.e. Karachi Nuclear Power Plant Unit-2 and Unit-3 (K-2 and K-3) at Karachi site. PNRA registered the site for K-2 and K-3 in 2013 and 2014 respectively and issued construction license to both NPPs in 2015. Construction of various structures and installation of equipment of K-2 and K-3 were completed during 2019.

View of K-2 and K-3 NPPs

PNRA granted permission for commissioning of K-2 and K-3 in September 2019 after fulfillment of regulatory requirements. K-2 and K-3 submitted joint application for fuel load permit in February 2019 along with required documents in accordance with PNRA regulations. The fuel load permit has been granted to K-2 in November 2020 while the regulatory process for granting fuel load permit to K-3 remained in progress by the end of 2020.

Furthermore, PAEC has shown its intention to build eighth NPP i.e. Chashma Nuclear Power Plant Unit-5 (C-5) at Chashma site. C-5 submitted site evaluation report for site registration in October 2020 and PNRA has started its review.

As regulatory review & assessment supports the licensing process, so this area requires comprehensive technical expertise.

Initially, PNRA depended heavily on regulatory body of vendor country, i.e. China, for review of safety analysis reports during the licensing phase. PNRA planned to establish a dedicated organizational unit which would provide technical support in its regulatory activities. PNRA proposed to the Government of Pakistan for creating a Centre

Figure-12: Major Licensing Submissions by NPPs

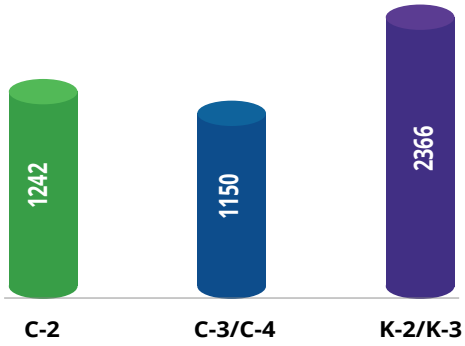


Figure-14: Final Licensing Queries Raised during Review of Final Safety Analysis Reports (FSARs) of NPPs

for Nuclear Safety (CNS) within itself as an internal Technical Support Organization (TSO). PNRA's proposal for this purpose was approved by the government in October 2004 and CNS was formally established in June 2005. Major licensing submissions required from the licensee of nuclear power plants are shown in Figure-12. Major steps for review & assessment of licensing submissions are presented in Figure-13.

Safety Analysis Report (SAR) of NPPs is the most important and lengthy document which PNRA reviews and it becomes the basis for licensing. SAR comprises all the technical and administrative information of a nuclear power plant ranging from siting, design, safety systems, radiation protection, waste management, operation, organization, accident analysis and quality assurance. PNRA has gradually gained expertise in reviewing SARs of different types and sizes of NPPs. PNRA raises queries after review of SAR and after satisfactory settlement of the queries, SAR is approved.

Final licensing queries raised during review of Final Safety Analysis Reports (FSARs) of NPPs are shown in Figure-14

In addition to licensing submissions, routine submissions, such as periodic technical reports, design modifications and event reports are also submitted by the licensee, which are reviewed by PNRA and feedback or approval is provided to the licensees.

Use of Operating Experience Feedback (OEF)

PNRA utilizes OEF available from international and bilateral platforms in review and assessment of submissions of nuclear power plants. These include various country practices, technical reports, event reports, inspection reports, etc.

In order to ensure safety of NPPs as described in licensing submissions, PNRA carries out inspections as per annual inspection plans. The inspections are broadly categorized in two distinct types namely, planned inspections and reactive or special inspections as shown in Figure-15. Either type of inspection may be announced or unannounced; however,

Figure-13: Major Steps of Review & Assessment Process

National Workshop on Level-2 PSA of NPPs

Figure-15: Types of Inspections

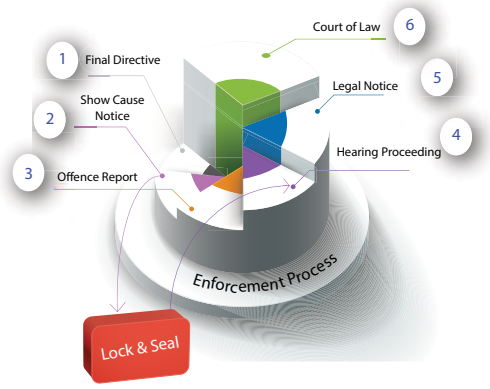


Figure-16: Enforcement Process of PNRA

announced inspections are more common.

PNRA takes enforcement actions in case of violations of PNRA Ordinance, applicable regulations, directives or license conditions. These actions include issuance of directives, violation notices, show cause notices, offence reports, work stop notices, suspension or revocation of license and lock and seal of 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. Enforcement process of PNRA is shown in Figure-16.

During the two decades journey, PNRA inspectors have been performing extensive inspections of nuclear power plants throughout all the stages. During construction and commissioning phase of a NPP, a large number of control points are selected for inspection of activities to verify compliance of regulations and agreed codes and standards. Work plans are developed by regional directorates to perform such inspections. During refueling outages and operation, PNRA chalks out a detailed plan to inspect important activities by selecting control points and through exclusive general surveillances. Figure-17 presents PNRA approach for developing inspection plans.

Fukushima Response Action Plan (FRAP)

After Fukushima accident, PNRA directed its licensees to revisit NPP safety measures against prevention and mitigation of severe accident. Accordingly, post Fukushima assessments of each NPP were conducted by licensee under the Fukushima Response Action Plan (FRAP) and the issues identified during the assessment were addressed in the form of various activities to be undertaken as short, intermediate and long term activities. In this respect, licensees submitted several modifications which were reviewed and approved by PNRA.

Assessment of Safety Culture at NPPs

Keeping in view the importance of safety culture, PNRA conducted the safety culture inspections at C-1 and K-1 in 2005. PNRA followed up the safety culture inspections at K-1 in 2007. These inspections were based on IAEA methodology. During 2019, PNRA updated the safety culture inspection methodology in line with updated standards of IAEA and conducted inspections at C-1 and K-1. Inspection findings were shared with plant management for further improvement in safety culture practices.

3.2 Research Reactors

Pakistan Research Reactor-1 (PARR-1) of 10 MWt and Pakistan Research Reactor-2 (PARR-2) of 30 KWt located at the Pakistan Institute of Nuclear Science and Technology (PINSTECH), Islamabad, started operation in 1965 and 1991 respectively. Initially, PNRA was issuing operating license to research reactors on annual basis till 2014. In January 2014, operating license was issued to PARR-1 for five years which was further extended in January 2018 up to December 2021. PARR-2 operating license was issued up to December 2024. Currently, licensing process for site registration of third research reactor of 10 MWt i.e. PARR-3 is in progress.

Figure-17: PNRA Approach for Developing Inspection Plans

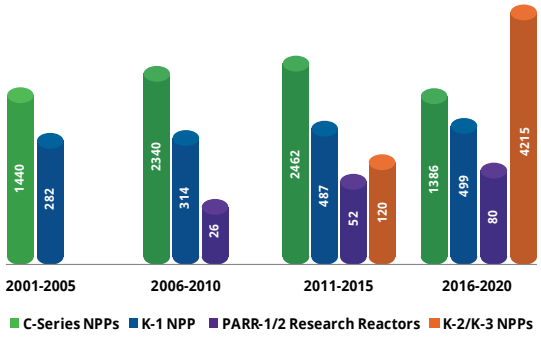


Figure-18: Statistics of Inspections Performed at Nuclear Installations

Finalization of Codes and Standards

A salient feature of PNRA licensing process is the initial requirement for applicant/licensee to establish design and safety criteria (Codes and Standards) in accordance with nuclear safety standards as specified in regulations PAK/909 and submission of the same for approval of PNRA.

Regulatory review & assessment of PARR-1 and PARR-2 submissions under PAK/909 have been conducted by PNRA. Major review tasks include revised SARs for re-licensing and PSR reports for re-validation of operating licenses of PARR-1 and PARR-2. In addition, other licensee submissions (e.g. monthly technical reports, modifications, event reports, etc.) are also being reviewed and evaluated for continuous regulatory control. The review of Site Evaluation Report (SER) of PARR-3 remained in progress till the end of 2020. Inspections of research reactors are also being carried out as per annual inspection plans.

Statistics of inspections performed at nuclear installations by PNRA during the last two decades is presented in Figure-18.

3.3 Molybdenum Production Facility

Molybdenum Production Facility (MPF) is located at PINSTECH, Islamabad to produce Molybdenum-99 (Mo-99) which in turn is used to generate Technetium-99m (Tc-99m) for cancer diagnosis.

A number of licensing submissions made by MPF have been reviewed by PNRA. One of the major documents reviewed during licensing was SAR of the facility submitted in August 2006. A total of 125 queries were raised after review of SAR. MPF has been licensed after review and assessment of its design. Current operating license of MPF is valid till December 2022.

3.4 Licensing of Operating Personnel of Nuclear Installations

Soon after inception of PNRA, importance of qualification and training of operating personnel in ensuring safety at nuclear installations was realized and PNRA ensured that this area receives due attention. PNRA regulations fix the personnel qualification criteria in terms of basic engineering qualifications, training, examination, medical and psychological fitness, etc. PNRA also conducts oral and operating examinations and awards licenses to operating personnel. Operator licenses are awarded for a period of one year and renewed annually. Operator licenses issued by PNRA during the last 20 years are presented in Figure-19.

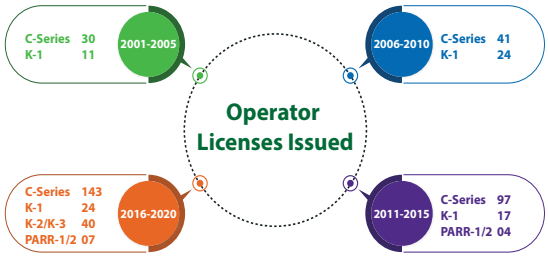


Figure-19: Statistics of Licenses Issued to the Operating Personnel of Nuclear Installations

3.5 Manufacturers of Safety Class Equipment

In the purview of expansion of nuclear energy generation in Pakistan, PNRA received an expression of interest in manufacturing nuclear grade mechanical equipment by the Heavy Mechanical Complex-3 (HMC-3) in 2003. As of that time, formal licensing process and regulatory requirements for nuclear grade equipment manufacturing were not documented. Henceforth, PNRA initiated its efforts for formulating provisional licensing requirements based on well-recognized international licensing and certification practices and procedures. These included practices of American Society for Mechanical Engineers (ASME) and the International Standards Organization (ISO), as well as those adopted by regulatory authorities of other countries. These requirements were communicated to HMC-3 in December 2003 for compliance. In addition, interim processes for licensing; review & assessment and inspection & enforcement for manufacturing of nuclear grade mechanical component were developed and implemented. Meanwhile, PNRA continued to develop formal regulations applicable to such manufacturers.

HMC-3 submitted its license application in January 2004. PNRA conducted a thorough process for review of all technical details and documentation. Further, PNRA evaluated applicant's capability through rigorous inspections and testing for ensuring compliance of thus far established requirements in the light of applicable international standards.

Authorization to HMC-3

After fulfillment of all regulatory requirements, in July 2005, PNRA authorized HMC-3 to manufacture Nuclear Safety Class-2 and below equipment (i.e. pressure vessels, storage tanks & heat exchangers).

PNRA developed "Regulations for Licensing of Nuclear Safety Class Equipment and Components Manufacturers – (PAK/907)". Later on, in October 2012 upon HMC-3 request and after fulfillment of all applicable regulatory requirements and successful demonstration, scope of license was further

Awarding of License to HMC-3 for Manufacturing of Safety Class-1 Equipment

extended to Nuclear Safety Class-1 (highest safety class).

Another organization named Novel Engineering Workshop-2 (NEW-2) showed its interest in manufacturing nuclear grade mechanical equipment. Upon fulfillment of all applicable regulatory requirements, manufacturing license was issued in April 2018 with scope of Nuclear Safety Class-1 equipment through use of precise machining process only.

Moreover, another organization named Instrumentation Control and Computer Complex (ICCC) has shown its expression of interest as manufacturer of Class 1E equipment. The licensing process has been kicked off and case is under process.

PNRA performed many control point inspections of safety class equipment manufacturers during equipment manufacturing. These inspections were conducted to verify compliance with the requirements of PNRA regulations and to assess implementation and effectiveness of Quality Assurance Program (QAP) in compliance with the applicable codes and standards. PNRA also conducted the QA administrative inspections of safety class equipment manufacturers for regulatory oversight in different areas. These included organization and interface, training and qualification, non-conformance control, corrective and preventive actions, procurement control, work control and OEF, design change control, document and record control, calibration control, handling, storage, packaging, preservation, delivery conditions and assessment of safety culture.

3.6 Nuclear Service Providers and Design Organizations

With the expansion of nuclear power generation program in Pakistan, National Centre for Non-Destructive Testing (NCNDT) applied to PNRA for authorization to provide Non-Destructive Examination (NDE) services in nuclear island of NPPs. Being the first of its kind application, PNRA formulated the regulatory requirements taking into account the practices of authorization to NDE service providers in the world. The applicant was asked to submit the details of their facilities, capabilities, infrastructure, experience and others. Upon fulfillment of the regulatory requirements, in December 2015, NCNDT was authorized to perform NDE activities in nuclear island of nuclear power plants.

Furthermore, following three organizations showed their expression of interest as design organizations for which completion of licensing process was in final stages by the end of 2020:

i. HMC-3 as Designer of Nuclear Safety Class Equipment: HMC-3 intended to extend the scope of safety class equipment manufacturing license by including design of Nuclear Safety Equipment (Class-1) in the light of its capabilities and relevant experience;

ii. ICCC as Designer of Safety related Instrumentations: ICCC aimed to achieve Class 1E qualification for production of Radiation Monitoring System (RMS), Nuclear Instrumentation (NI) and Analog Reactor Protection System (ARPS) for NPPs; and

iii. Works and Services Organization (WASO) as Designer of Safety related Civil Structures: The design of safety related civil structures for nuclear installations is also a new area for which license is being sought from PNRA.

In the area of review and assessment for nuclear service providers and design organizations, various submitted documents such as quality assurance programs, quality plans, procedures regarding provision of services related to safety class systems and components during refueling outages and other regulatory submissions were reviewed and approved by PNRA.

Special QA audit, factory inspections and mockup inspections were conducted to verify capabilities and performance of organization to be authorized as NDE service provider.

3.7 Radiation Facilities

By the end of year 2020, a wide spectrum of radiation facilities ranging from simple diagnostic X-ray based units to more sophisticated and state-of-the-art therapeutic modalities like stereotactic radio-surgery, gamma knife, etc. with latest diagnostic and treatment techniques (PET / CT fusion imaging, intensity modulated radiation therapy, image guided radiation therapy, etc.) is in operation in the field of medical care. Similar development is also seen in other areas such as industrial applications and research & education. All such practices are effectively being regulated by PNRA.

During the initial period of regulatory oversight i.e. from 2001 to 2005, PNRA endeavored to strengthen all aspects of regulatory business including continuous increase in licensing net and, as a result of this consistent persuasion, a total of 1351 radiation facilities were registered/ licensed by PNRA. This number was raised up to 2092 registered radiation facilities by the end of first decade i.e. up-to 2010. Presently, after completion of second decade i.e. 2020, PNRA is regulating about 6000 radiation facilities.

Pre-licensing Inspection – A Final Check before Issuance of Operating License to Radiation Facilities

PNRA licensing process for radiation facilities is augmented with pre-licensing inspections as final check before issuance of Operating License. This pre-licensing inspection is conducted to:

i. Verify the commitments made in the approved documents.

ii. Availability of required manpower.

iii. Existence of detailed implementing procedures to execute the approved process.

PNRA licensing process for radiation facilities has been evolved based on graded approach in a manner to encompass a comprehensive set of regulatory requirements so that safety is considered as top priority.

PNRA adopts "cradle to grave" concept to regulate all the activities which include radiation sources. For the import of radiation sources, the originating country, in some cases, requires the applicant to furnish import permit from PNRA prior to procurement of a radiation source. PNRA issues such permit to facilitate the process of procurement. Subsequently, import of radiation sources or radiation generators in Pakistan is authorized through a "No Objection Certificate (NOC)" issued to the licensed facility for customs clearance. NOC is issued after verification of intended end use and radiation safety arrangements. The record of all the radiation sources and generators imported in the country or exported out is maintained at PNRA as shown in Figure-20.

In order to have a strict control on the import of radioactive sources in the country, PNRA has established liaison with Pakistan Customs to control entry and exit of these sources at border check posts. With the increasing demand of radiation sources, the number of authorizations has significantly increased thus demanding more stringent measures for import process. In this regard, an online NOC verification system has been developed with Pakistan Customs for verification of NOCs issued by PNRA.

For the international trade of edible items, some countries demand radiation free certificate issued by the national nuclear regulatory authority of exporting country. On such requests from exporters, PNRA issues radiation free certificates based on the radiometric analysis performed at PNRA laboratories.

For radiation facilities, PNRA performs review and assessment of different documents submitted by the applicant or licensees to ensure that facilities are properly designed for their intended use in the light of relevant applicable PNRA regulations. These documents may include licensing applications, shielding design calculations, commissioning reports, safety analysis reports and plans and programs etc. Regulatory guides have been issued for the licensees to help them out in the development of these radiation safety documents which require approval from PNRA before its implementation at the facility.

For facilities to be licensed, it is also mandatory to comply with all the radiation safety and protection measures in line with applicable regulations. The compliance status of facilities is thereby physically verified and assessed from regulatory submissions. In order to further formalize the assessment, the performance of radiation facilities is also viewed through the frame of criteria defined against certain performance objectives associated with the facilities. Such an assessment under the title "Performance Objectives & Criteria (PO&C)" is based on a

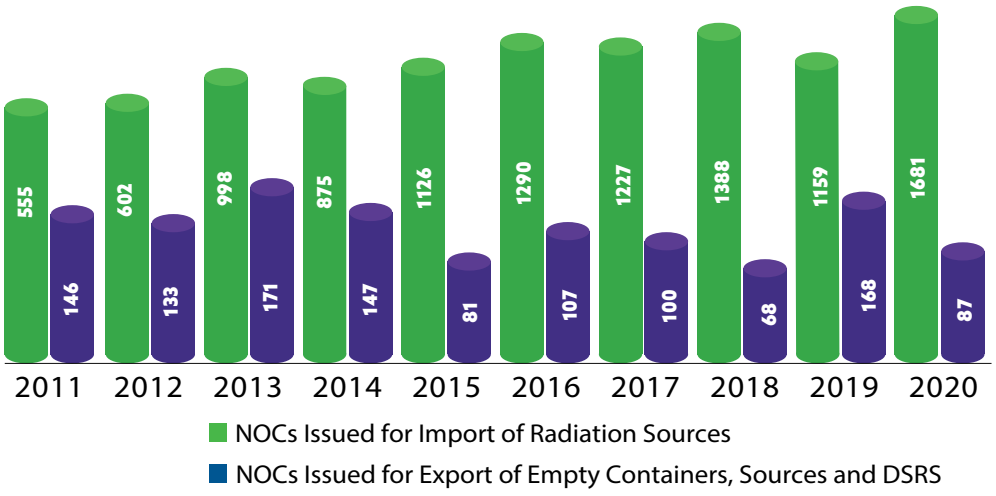


Figure-20: Statistics of NOCs Issued by PNRA

comprehensive list of safety contributing factors and assists for planning and conduct of inspection. The prime objective of safety performance assessment of radiation facilities against PO&Cs is to identify existing weak domains of implementation and to figure out future focus areas for regulatory oversight.

Regulatory inspections are conducted at radiation facilities to verify implementation of regulatory requirements. The inspection frequency for facilities possessing sealed radioactive sources of Cat-I&II is twice a year to verify the implementation of safety measures. These facilities include full fledge medical centres, radiotherapy centres, research irradiators and industrial radiography setups.

Similarly, inspections are being conducted on yearly basis for the facilities having Cat-III sources or diagnostic radiology setup possessing CT scanners, angiography, fluoroscopy machines, etc. For facilities using level measurement gauges and diagnostic X-ray setups, inspection is being performed on biennial basis.

For nuclear medicine centres, regulatory inspections are being performed for different focused areas. These areas include radiation protection, radioactive waste management, radiation emergency, physical protection etc. In addition, inspections are also conducted for the inventory verification of sealed radioactive sources (Cat-I to IV).

Reactive Inspections

In parallel to planned inspections, reactive inspections are also conducted in response of serious radiological events to find out possible deviations from regulatory requirements and fetch experience feedback information in order to control and avoid such events in future.

Detail of the regulatory inspections conducted at radiation facilities during the past 20 years is shown in Figure-21.

In the last few years, transport of radioactive sources has also increased both in medical and industrial setups due to uniqueness of usage and versatility. These frequent

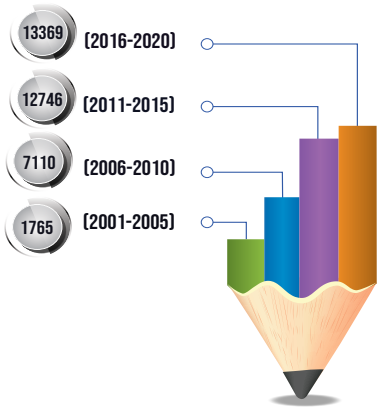


Figure-21: Statistics of Inspections Conducted at Radiation Facilities

movements of Cat-I to Cat-III radioactive sources may have serious radiological and security issues. Considering the importance of this fact, PNRA records each source movement and requires from the licensee to inform PNRA at least 24 hrs before source movement. In this domain, special inspections have been carried out to ensure safety and physical protection of radioactive sources during transportation.

In order to retain all the required information regarding radioactive sources used by the licensed radiation facilities and track-down their movement within the country, PNRA has compiled a comprehensive source-catalog for all the licensed radioactive sources within the country. This catalog preserves the licensing history, usage, location and pictorial information of all the sources in the database. Figure-22 provides the details of radioactive sources within the country under PNRA regulatory control.

Many incidents have been recorded at the international level regarding the presence of orphan radioactive sources at the scrap yards which if remain undetected may cause radiation exposure to the general public and the spread of radioactivity in the environment. Therefore, in parallel to routine inspection program of radiation facilities, PNRA, since its inception, has been carrying out survey of scrap-yards, junk yards etc. located within the country to search for orphan sources that might be imported along with scrap-materials and to educate the workers at these facilities about risk associated with these orphan sources.

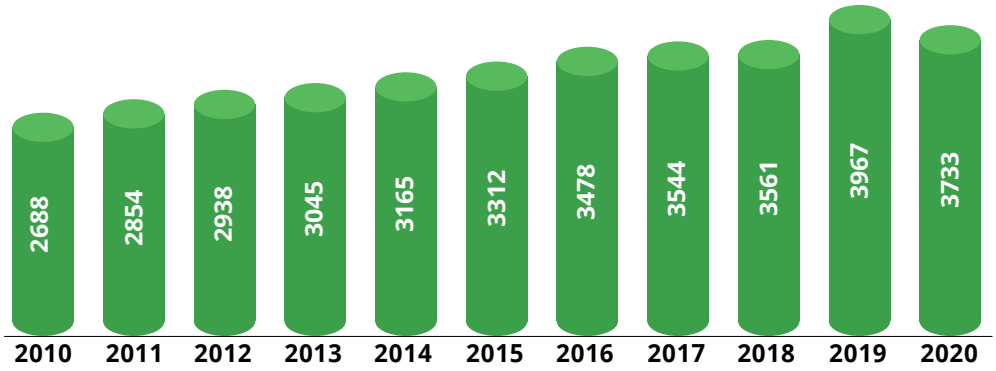


Figure -22: Statistics of Radioactive Sources within Pakistan

These surveys are the integral part of PNRA inspection activities.

PNRA strives to create positive culture among its licensees to ensure compliance of all regulatory requirements during each phase of licensing process. However in some cases when the non-compliance of regulatory requirements may compromise safety, enforcement actions become inevitable. The enforcement process includes issuance of directives, violation notices, show cause notices, etc. If the nature of violation/non-compliance is serious enough and requires urgent enforcement action, then the process of lock and seal is directly executed against the violators. In other cases, offence report is submitted to Legal Cell of PNRA. Summary of enforcement actions taken during the year 2020 is presented as an example in Figure-23.

Legal Cell issues hearing notices to provide the violators a final chance to explain and justify their position with ultimate goal to ensure compliance of needful regulatory requirements.

Despite these opportunities, if the violators neither respond to any notice nor appear in the hearing proceedings then Legal Cell, in consultation with the respective regional directorate decides to proceed against the violators in a court of law for prosecution and imposition of penalty.

In conclusion, it is worth satisfying that PNRA, being a sole national nuclear regulatory body, has not only been able to fulfill its responsibilities against its mandate but also it has matured its processes with the passage of time. After a long learning journey and evolution of two decades, PNRA has successfully established robust processes for licensing & authorization, review & assessment and inspection & enforcement for facilities and activities under PNRA jurisdiction.

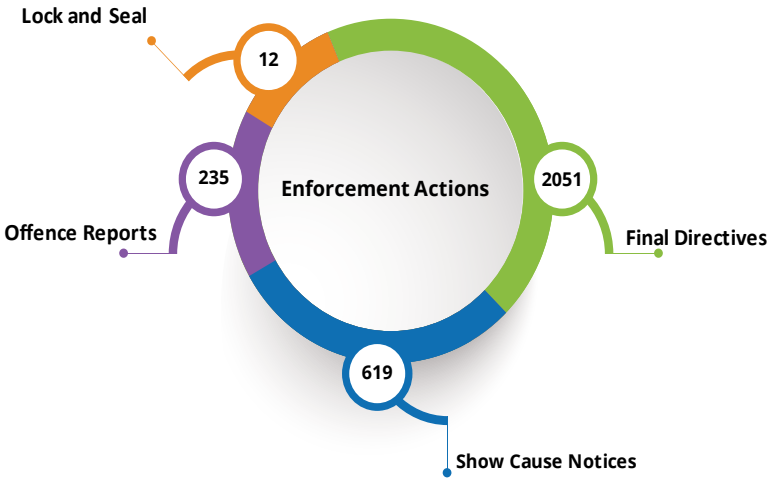


Figure-23: Statistics of Enforcement Actions Taken by PNRA during 2020

4 MONITORING EXPOSURES AND ENVIRONMENT

Radiation workers are vulnerable to exposure to ionizing radiation which may affect their health. Therefore, there is a need for a comprehensive regulatory control over application of ionizing radiation to avoid any untoward situation and improve quality of life. This necessitates regular monitoring of radiation exposure to the workers and radioactive releases into the environment to ensure protection of workers, the general public and the environment from the harmful effects of ionizing radiation.

Radiation dose monitoring of individuals enables to determine whether the exposure received by a radiation worker is within or beyond the authorized limits.

Regulatory Dose Limits

The annual radiation dose limit for the radiation workers in Pakistan is 20 mSv/year. However, under special circumstances, radiation dose 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.

Since its inception, PNRA has been keeping an eye on exposures of radiation workers and the levels of radioactivity in the environment to ensure that these are within regulatory limits. The licensees are required to submit annual radiation exposure record of all their workers. The nuclear installations, capable to release radioactive discharges are also required to submit environmental monitoring results in their vicinity. Meanwhile, PNRA has developed a capability for monitoring any buildup of radioactivity in the environment. This is also useful for cross-verification of environmental radioactivity results submitted by the licensees.

4.1 Trending Exposure of Radiation Workers

According to PNRA regulatory requirements, all licensees are required to regularly monitor the doses of radiation workers and submit dose monitoring reports to PNRA on annual basis. These reports include information about individual dose, number of workers exposed, collective dose of exposed workers as well as maximum and average individual dose.

PNRA maintains a database containing radiation exposure record of all radiation workers in the country. This database is helpful in maintaining dose history of radiation workers and perform trending of occupational radiation exposures.

Based on the data received from licensees, PNRA analyzes the exposure to radiation workers on annual basis to ensure that the doses of individuals are within prescribed limits.

4.1.1 Radiation Workers Exposure at Nuclear Power Plants

In order to ensure safe operation of nuclear power plants, workers have to perform

Training Course on Release of Radioactive Effluents from Nuclear Installations and Dose Calculations held at PNRA HQs.

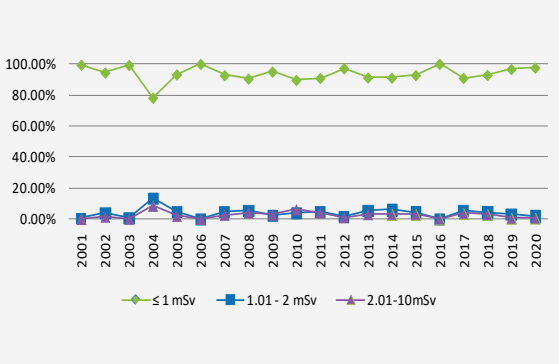


Figure-24: Percentage of C-1 Workers in Different Dose Ranges

various jobs in radiation areas. Moreover, PWR type nuclear power plants normally need refueling after a year of continuous operation. During the Refueling Outage (RFO) period, a number of maintenance surveillance, inspections and test jobs are performed which are otherwise not possible during routine plant operation due to high radiation risks. PNRA through strict regulatory oversight ensures that all activities performed during normal operation as well as during RFOs are safe and exposures to workers remain within the permissible limits.

The nuclear power plants at Chashma site (C-1, C-2, C-3 and C-4) have been reporting minimal radiation exposures to workers during normal plant operation. However, during RFOs, relatively higher exposures have been reported. Nevertheless, radiation exposures at these plants have never exceeded the regulatory dose limit. During normal plant operation, more than 90% of radiation workers are exposed to a radiation dose below 1 mSv/year. Figures 24 to 27 reflect the trend of annual radiation exposure of workers at C-Series NPPs.

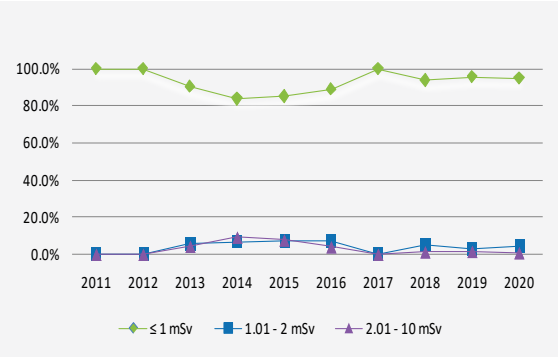


Figure-25: Percentage of C-2 Workers in Different Dose Ranges

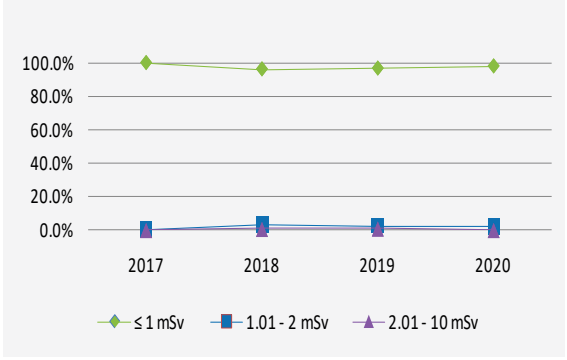


Figure-26: Percentage of C-3 Workers in Different Dose Ranges

PNRA closely monitors the individual doses to radiation workers during RFOs. In this regard, licensees submit the estimated collective doses to workers during RFOs considering the planned activities. Figure-28 shows the trend of collective doses during RFOs at C-Series NPPs.

Karachi Nuclear Power Plant Unit-1 (K-1), is operating beyond its design life since 2002 and requires rigorous regulatory oversight. Radiation exposures to workers were relatively high at this plant owing to its ageing and a number of refurbishment and maintenance activities, carried out to ensure safe operation. Figure-29 shows the trend of annual radiation doses received by the radiation workers at K-1 from 2001 to 2020.

It was observed that, throughout these years, about 65% workers of K-1 received dose below 1 mSv/year. The workers receiving doses from 1-20 mSv were around 25% in any given year. However, there was a small fraction of workers whose annual radiation exposure exceeded 20 mSv in one year. In such cases, PNRA closely monitored the exposures of such workers and ensured that

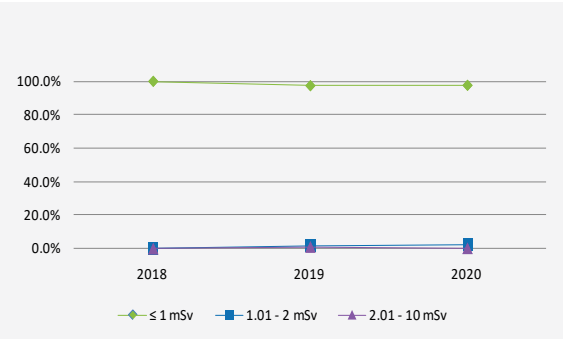


Figure-27: Percentage of C-4 Workers in Different Dose Ranges

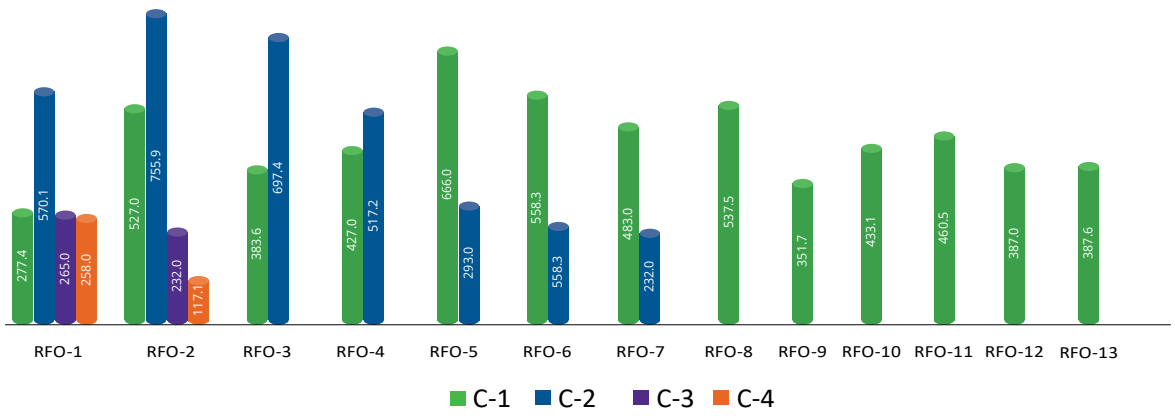


Figure-28: Collective Doses (man-mSv) during RFOs at C-Series NPPs

average radiation dose of these workers over a period of five years remained within the prescribed regulatory dose limit.

4.1.2 Radiation Workers Exposure at Radiation Facilities

All licensed radiation facilities are required to submit the exposure data of their workers to PNRA in order to ensure that the doses received are within the regulatory limits. To ensure correctness in data and facilitate traceability of dose record of workers, PNRA has registered the dose record of workers with their names and Computerized National Identity Card (CNIC) number. Over the years, the number of facilities and workers in this database has grown and currently record of around 6500 radiation workers is available in this database.

PNRA verifies exposure record of workers on annual basis from the data provided by dosimetry service provider. Accordingly, trend of high exposures, if identified, is investigated and directives are issued to relevant facilities for appropriate actions. In general, reported exposures have been within the regulatory limit; however, there were cases where dose of some workers exceeded 20 mSv in some years. These cases were investigated and it was ensured that no such worker receives five year average dose in excess of prescribed dose limit. Over the past five years, 62 investigation reports of overexposure cases were reviewed and directives were issued for taking corrective actions as shown in Figure-30.

4.2 Monitoring Internal Exposures

In 2007, PNRA initiated development of capabilities for independent monitoring and cross verification of radiation exposures of workers. Accordingly, by the end of year 2012, PNRA was able to set-up Whole Body Counting (WBC) facility for monitoring of internal exposures. The whole body counter is capable of measuring radiation doses due

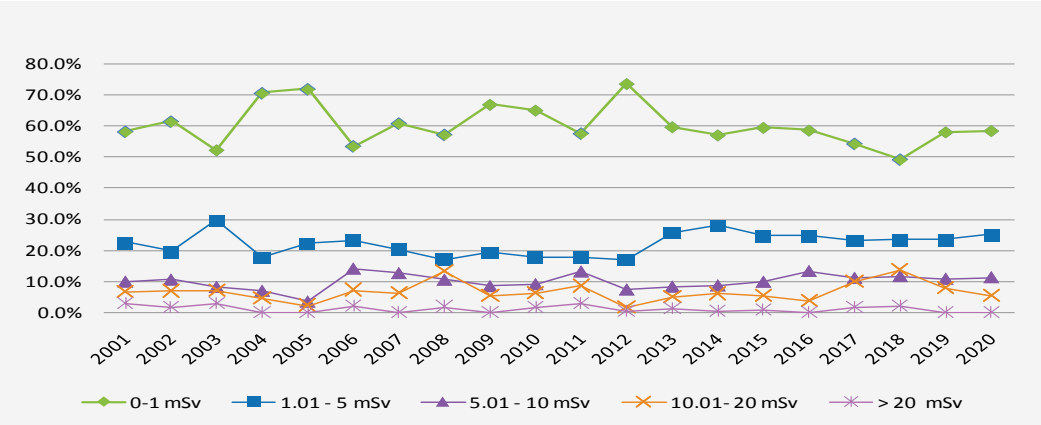


Figure-29: Radiation Doses to K-1 Workers

Figure-30: Statistics of Over Exposure Cases Reviewed

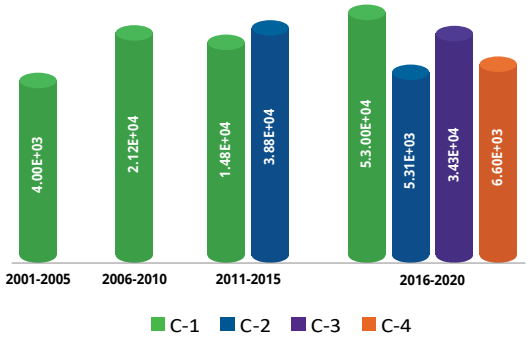


Figure-32: Liquid Effluents (GBq) from C-Series NPPs

to ingested or inhaled radionuclides. PNRA also possesses capability of performing internal dosimetry by employing bio-assay of body fluids (e.g. urine) using alpha, beta and gamma spectroscopy. Figure-31 shows the number of workers monitored by PNRA for internal radiation exposures.

4.3 Radioactive Discharges and Releases

During the normal operation of nuclear power plants, some radionuclides are discharged in liquid or gaseous forms to the environment. PNRA ensures compliance of authorized limits in accordance with ALARA principle so that there is no undue risk to the members of the general public or environment. PNRA keeps strict control on radioactive liquid and gaseous discharges to the environment and has made it mandatory for the licensees of NPPs to keep such discharges below the authorized regulatory limits. Figures 32 and 33 show the releases of liquid and gaseous radioactive effluents from C-Series NPPs respectively while Figure-34 shows such releases from K-1 plant through the years 2001-2020. The discharges and releases always remained well within the permissible limits and there is no instance of any un-authorized release.

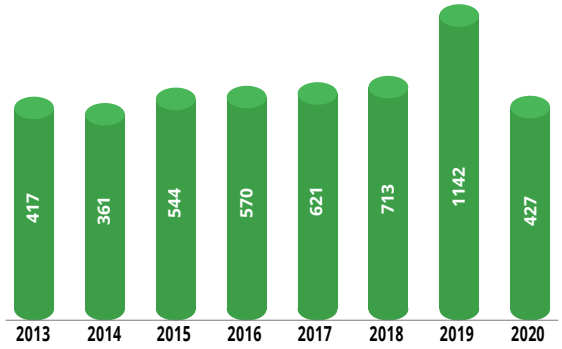


Figure-31: Number of Workers Monitored by PNRA for Internal Radiation Exposures

4.4 Evaluation of Radioactivity in the Environment

PNRA has made it mandatory for nuclear installations to conduct environmental radioactivity monitoring and regularly submit its reports to PNRA. In this regard, PNRA maintains a record of pre-operational radioactive environmental conditions which are used as reference during evaluations of environmental monitoring results submitted by licensees. Over the years, no significant increase in the environmental radioactivity levels reported by nuclear installations has been observed.

Further, PNRA closely monitors the trend of ambient radiation levels in the vicinity of Chashma and KANUPP sites. It is noticed that these levels are mostly of the same order and range throughout the years of

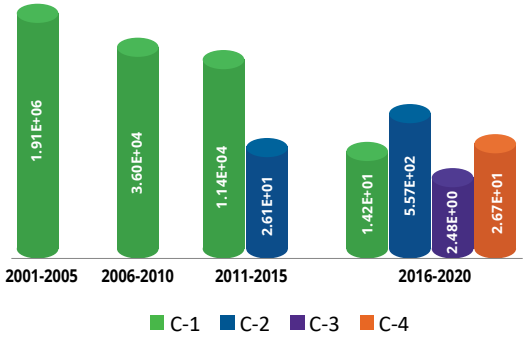


Figure-33: Gaseous Effluents (GBq) from C-Series Plants

their operation. This trend confirms that there is no significant contribution to the natural background radiation levels due to operation of NPPs in the country.

4.5 Establishment of National Background Radiation Level

The Government has empowered PNRA to check any buildup of environmental radioactivity. In 2007, PNRA initiated developing of laboratories for performing independent analysis of environmental samples collected from all over the country. Accordingly, by the end of 2012, PNRA was able to acquire advanced capabilities in the fields of gamma spectrometric analysis, liquid scintillation analysis, alpha spectrometric analysis, gross alpha and beta counting and radon monitoring. These laboratories enabled PNRA to cross verify the results reported by its licensees.

Independent Environmental Monitoring

Since 2013, PNRA has been periodically conducting independent environmental monitoring around nuclear installations and also cross verifies the environmental monitoring results submitted by the NPPs.

PNRA initiated a study to monitor and establish a reference background radiation level across the country in year 2016. The establishment of national background radiation level serves as a baseline radiation level for the whole country so that changes, if any, in environmental radioactivity due to human activities and practices could be noted. For this purpose, the whole country was divided into grids, each having an area of 23 x 24 km^2. Soil and water samples from each district of the country were collected under this program and analyzed.

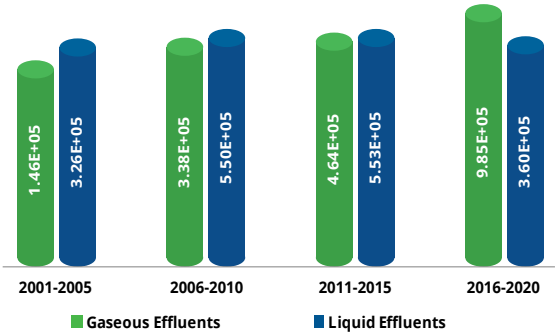


Figure-34: Liquid and Gaseous Effluents (GBq) from K-1

The radioactivity level in soil and water was determined and the resulting background radiation levels across the country were estimated. It was noted that, in general, the average estimated effective dose due to background radiation exposure is less than the world average. Similarly, the estimated annual effective dose by intake of water was also noted to be within the international reference levels. Further, no area in the country was identified with high background radiation level.

After completion of this activity in four provinces of Pakistan, PNRA has planned to extend this study to Gilgit Baltistan and Azad Jammu & Kashmir.

PNRA Team Collecting Environmental Samples from the Vicinity of Research Reactors

5

PROTECTING THE FUTURE GENERATIONS - MANAGING NUCLEAR AND RADIOACTIVE WASTE

Year 2005
Issuance of Regulations on Radioactive Waste Management

Year 2011
Issuance of National Policy on Safe Management of Radioactive Waste

Year 2015
Approval Granted for the Establishment of KANUPP Spent Fuel Dry Storage Facility

Year 2016
Award of Operating License to PINSTECH Predisposal Radioactive Waste Management Facility

Year 2019
Award of Design Approval Certificate for Spent Fuel Dry Storage Cask of K-1

Year 2019
Award of Construction License to PWR Dry Storage Facility of CNPGS

Radioactive waste is generated from a number of activities involving beneficial applications of radioactive material. These activities include operation and decommissioning of installations and facilities; the use of radionuclides in medicine, industry, agriculture, research and education; and the processing of raw material containing naturally occurring radionuclides. The waste contains radioactive material that emits ionizing radiation posing hazards to human health and the environment if not handled safely. In order to protect the people, environment and future generations from such hazards, radioactive waste needs to be managed in a safe manner and subsequently, disposed of at safe and secure premises. Similarly, fuel from nuclear power plants and research reactors after the intended use remains radioactive for a long period of time and needs to be stored safely.

Since its inception, PNRA has been ensuring that the licensees take the requisite measures for safe management of radioactive waste and spent nuclear fuel generated in the country.

Radioactive Waste Management Policy

Realizing the need for the development of a national policy on radioactive waste management, PNRA in collaboration with other relevant national stakeholders formulated a national policy for regulating safe management of radioactive waste which was issued by Government of Pakistan in 2011.

This policy sets out the nationally agreed position and plans for managing radioactive waste. To achieve the objectives, it was felt that a national level strategy for the safe management of radioactive waste needs to be developed. Keeping in view, PNRA coordinated with Pakistan Atomic Energy Commission (PAEC) for the formulation of strategy on safe management of radioactive waste. The strategy was developed on the bases of internationally recognized principles and approaches, available technological options and resources. The strategy reflects a systematic and self-explanatory approach for optimization and harmonization of ongoing radioactive waste management practices.

In order to include the spent nuclear fuel and waste generation from decommissioning of nuclear installations in the national policy, revision of existing policy on radioactive waste was initiated. The policy was revised with coordination and collaboration of PAEC and accordingly, the revised "National Policy on Safe Management of Radioactive Waste, Decommissioning and Spent Nuclear Fuel in Islamic Republic of Pakistan - (RWP-01/2018)" was gazette notified in 2018. This policy is a visible evidence of importance given by the government and the relevant national organizations to ensure that appropriate safety measures are adopted for managing radioactive waste generated as a result of decommissioning of nuclear installations and spent nuclear fuel. In order to implement the intent of the policy, strategies on decommissioning and spent fuel were developed in 2020 and the revision of strategy on radioactive waste management is in progress.

5.1 Radioactive Waste - Regulatory Framework for Radioactive Waste Management

PNRA promulgated regulations for safe management of radioactive waste in 2005 based on the International Atomic Energy Agency (IAEA) standards. These regulations require that the licensee shall have the prime responsibility for the safe management of its entire radioactive waste and ensure that necessary measures are taken to keep the generation of radioactive waste to a minimum. Later on in 2013, the revision of the regulations was initiated to include additional requirements set by IAEA standards and experience feedback. The revised regulations were gazette notified in 2019.

5.1.1 Radioactive Waste of Nuclear Power Plants and Research Reactors

Radioactive waste generated by nuclear power plants and research reactors comprises three types i.e. gaseous, liquid and solid. Radioactive waste in gaseous form is passed through filters and released into the environment after ensuring that the radiation level has fallen below the

prescribed limits. The filters are treated as solid radioactive waste. The liquid radioactive waste is solidified in drums and stored accordingly with other solid waste at the plants site till the decision for final disposal. In order to safely manage radioactive waste, regulations on radioactive waste management require licensees to prepare and submit Radioactive Waste Management Program (RWMP) for review and approval. RWMP is one of the important licensing documents and the licensees are required to manage its radioactive waste according to their respective programs. Over the years, PNRA has reviewed and approved RWMPs of nuclear power plants and research reactors. The regulations also require the licensees to submit other periodic reports such as monthly technical reports, annual radioactive waste generation reports, annual gaseous and liquid release reports, radiological environmental monitoring reports, etc. PNRA reviews these submissions and communicates queries to the licensees for further improvement in their practices.

Inventory Management of Radioactive Waste

PNRA maintains an inventory of radioactive waste generated at nuclear power plants and research reactors. Currently, all generated radioactive waste is kept in storage facilities at site of respective nuclear power plants and research reactors.

PNRA regulatory framework requires the licensees to maintain inventory of radioactive waste and submit details to PNRA on annual basis. Over the past twenty years, no abnormal trend of generation of radioactive waste has been noted. The radioactive waste generated and stored at these installations is reflected in Figure-35.

PNRA regularly conducts inspections with focus on radioactive waste management to verify that the licensee is complying with regulatory requirements.

5.1.2 Radioactive Waste of Nuclear Medicine Centres

The use of radioactive material in Nuclear Medicine Centres (NMCs) may also result in generation of solid, liquid or gaseous radioactive waste. The radioactive waste generated at these centres contains short lived radionuclides which normally decay in a few days and become harmless to human health. PNRA has maintained regulatory oversight to ensure that such radioactive waste is managed safely in conformance with the applicable regulatory requirements.

The solid radioactive waste is stored within the facility for a certain period of time until its radioactivity level falls below the exemption level which is then disposed of as hospital conventional waste. Similarly, liquid radioactive waste is released into the environment after proper dilution or decay until its radioactivity reaches below exemption levels. 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.

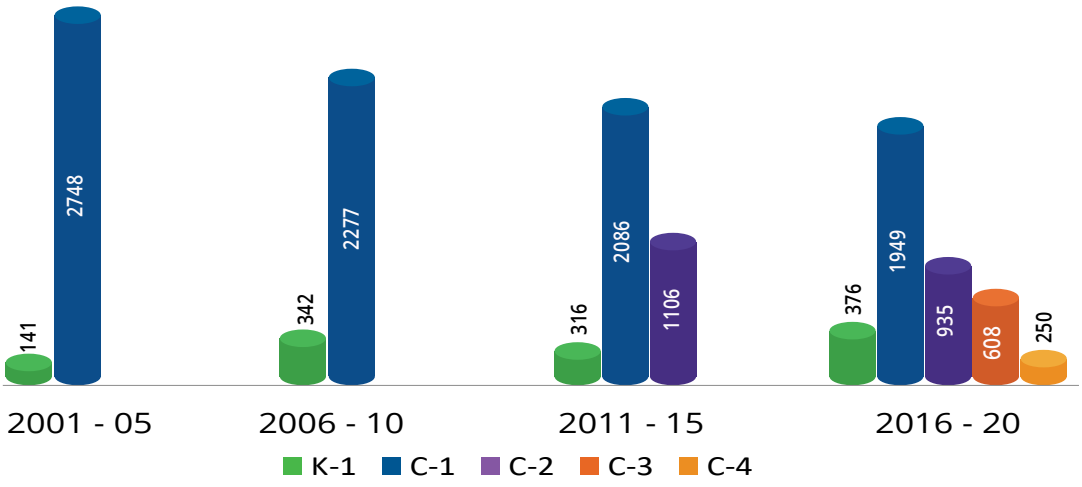


Figure-35: Radioactive Waste Drums Stored at Nuclear Power Plants

PNRA requires the NMCs to submit their RWMPs for review and approval as part of the licensing process. Over the years, a number of RWMPs have been reviewed and approved by PNRA. 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.

5.1.3 Storage Facilities for Radioactive Waste Management

Radioactive waste generated from industry, medical sector, research and other facilities needs to be stored in an interim storage facility until their radiation level falls below the exemption levels or permanently disposed of in a disposal facility. The regulatory framework authorizes PNRA to regulate the pre-disposal and disposal facilities in the country.

Pakistan has two radioactive waste storage or management facilities. These include, PINSTECH Predisposal Radioactive Waste Management Facility (PPRWMF), Islamabad and Radioactive Waste Storage Area (RAWSA) at K-1, Karachi.

Since, radioactive sources are extensively used in other radiation facilities in public and private sectors and become radioactive waste after their useful life. These are termed as Disused Sealed Radioactive Sources (DSRS). A need was realized for proper storing of DSRS in the country. Therefore, the government authorized these storage facilities to manage such radioactive waste generated in respective nearby areas. Detail of these facilities is presented in following sections.

a) PINSTECH Predisposal Radioactive Waste Management Facility (PPRWMF)

PPRWMF is located in Pakistan Institute of Nuclear Science and Technology (PINSTECH) near Islamabad. Initially, this facility was managing radioactive waste generated from research reactors only. Later on, PPRWMF was declared as designated radioactive waste management facility for the private and public sectors in the northern part of the country.

This facility was operating under the license of Pakistan Research Reactor-I (PARR-1). However, PNRA granted a separate license to PPRWMF in 2012 for the receipt and management of low and intermediate level radioactive waste including DSRS from various nuclear/radiation facilities and activities. Subsequently, a number of documents such as safety analysis report, radioactive waste management program, radiation protection program, quality assurance program, etc. were submitted to PNRA by the facility in 2013. Upon satisfactory completion of review, PNRA granted operating license to PPRWMF in January 2016. PNRA has been regularly conducting regulatory inspections of PPRWMF to verify compliance with regulatory requirements.

b) Radioactive Waste Storage Area (RAWSA)

Radioactive Waste Storage Area (RAWSA) is located at Karachi Nuclear Power Plant Unit-1 (K-1) premises. Initially, this facility was managing radioactive waste generated from K-1 only. Later on, RAWSA was declared as designated radioactive waste management facility for private and public sectors in the southern part of the country. This facility is managing low and intermediate level radioactive waste of K-1 and DSRS received from radiation facilities. RAWSA was in operation for a longer period of time, therefore, its capacity for further storage became limited. Thus, the licensee extended the facility and increased the storage

PINSTECH Predisposal Radioactive Waste Management Facility (PPRWMF)

capacity after regulatory review of relevant submissions and approval of PNRA in 2015.

5.2 Regulatory Control over Spent Nuclear Fuel - SNF

The fuel removed from nuclear power plants and research reactors following irradiation that may no longer be used in its present form, is termed as Spent Nuclear Fuel (SNF). This fuel is thermally hot, highly radioactive and potentially harmful, therefore, it needs to be cooled safely in a storage facility.

Initially, when spent fuel is taken out of the reactor, it is placed in specially designed water pools. After ten years storage in the pools, spent fuel can be shifted to a final disposition in a geological repository and handled as radioactive waste.

Spent Nuclear Fuel Storage Methods

There are two acceptable storage methods for SNF i.e. wet storage, where water is used for cooling and dry storage, where natural air circulation dissipates heat.

As per national policy on safe management of radioactive waste, decommissioning and spent nuclear fuel, fate of SNF is not decided yet and NPPs have stored it at their premises in wet storage pools, as an interim arrangement, while dry storage system is also being adopted for long term management of SNF. In Pakistan, dry storage system comprises concrete casks to be placed in spent fuel dry storage facilities. The design of such casks also needs certification from PNRA.

PNRA has developed design certification process for spent fuel dry storage casks. Although, regulatory framework for licensing of spent nuclear storage facilities existed, yet, development of regulations on safe management of spent nuclear fuel and design certification process was needed to include detailed regulatory requirements on management of SNF. PNRA ensures regulatory control over SNF through implementation of its regulatory requirements and conduct of inspections for verification of inventory.

5.2.1 Development of Spent Fuel Dry Storage Facilities

With the passage of time, pools storage capacities became limited, therefore, the power plants management decided to find alternative means for enhancement of storage space. At K-1, the issue regarding storage capacity of spent fuel pool was initially solved through High Density Tray Racking (HDTR) system as a short term solution. For long term management of SNF, development of dry storage system was adopted in the country.

Currently, Pakistan has one spent fuel dry storage facility in operation whereas another facility is under construction. The first spent

Participants of Workshop on Spent Nuclear Fuel Dry Storage Facility held at PNRA HQs.

fuel dry storage facility for SNF of Pressurized Heavy Water Reactor (PHWR) is located at KANUPP, Karachi while the second facility for spent fuel of Pressurized Water Reactors (PWRs) is under construction at Chashma.

a) KANUPP Spent Fuel Dry Storage Facility (KSFDSF)

As K-1 is the oldest NPP in Pakistan, its pool capacity to store spent fuel has reduced, therefore, K-1 requested PNRA in December 2011 for the construction of spent fuel dry storage building at K-1. PNRA conducted a thorough review of a number of submissions supporting the licensee's request, performed safety inspections and held meetings with the licensee for resolution of queries raised by PNRA. After satisfactory conclusion of this regulatory process, PNRA granted approval in 2015 for the establishment of KSFDSF. At present, KSFDSF has come into operation and certified casks are being placed in it under regulatory oversight of PNRA.

b) CHASHMA Spent Fuel Dry Storage Facility

For long term management of spent nuclear fuel generated at Chashma Nuclear Power Generating Station (CNPGS), which is a multiunit site, PAEC submitted its intention for establishment of an independent Spent Fuel Dry Storage Facility (SFDSF) at Chashma site in 2015. PNRA held a number of technical discussions with the applicant for the facility namely PWR Dry Storage (PDS) Facility.

These discussions focused on developing the interface for licensing process, evaluation of design and manufacturing capabilities of applicant and identification of applicable codes and standards for preparation of Safety Analysis Report (SAR).

Site Registration of PDS Facility

PNRA received formal request for site registration of PDS facility in September 2017 along with Site Evaluation Report (SER). PNRA completed regulatory review & assessment process of SER of PDS facility and granted site registration in April 2018.

In January 2019, PNRA received an application for the grant of construction license for PDS facility along with PSAR. PNRA reviewed PSAR in detail and issued construction license to PDS facility in December 2019. PNRA continued regulatory oversight of construction activities of PDS facility which is in progress.

5.2.2 Certification of Spent Fuel Dry Storage Casks

Dry storage casks are properly designed for storing the already cooled spent nuclear fuel. The casks are designed to provide shielding to people and environment from harmful effects of ionizing radiation. Design and manufacturing of casks requires certification from PNRA. In this regard, PNRA issued design approval certificate for spent nuclear fuel cask of Pressurized Heavy Water Reactor (PHWR) while design approval certification

PNRA-IAEA Workshop on Review and Design Assessment of NPP Spent Fuel Dry Storage Facility

for spent nuclear fuel cask of Pressurized Water Reactor (PWR) is under process.

a) Certification of Design for Spent Fuel Dry Storage Cask for K-1

In 2015, PNRA received intention from HMC-3 for certification of design for spent nuclear fuel dry storage cask of K-1. In this regard, PNRA established an interim regulatory process for design certification of spent nuclear fuel dry storage cask during the year 2016. As a part of application for such design certification, PNRA received Safety Analysis Report (SAR) for dry storage cask, which was reviewed on the basis of applicable codes and standards. After satisfactory completion of review, PNRA granted permission for manufacturing of a prototype cask in March 2017.

PNRA conducted inspections during manufacturing and testing of the prototype cask in 2017-18 and upon verifying compliance with all applicable regulatory requirements, design approval certificate for spent fuel dry storage cask was awarded in April 2019.

b) Certification of Design of Spent Fuel Dry Storage Cask for C-Series NPPs

As dimensions and characteristics of PWR fuel are different from those of PHWR fuel, therefore, design of CNPGS cask is different from K-1 cask. In August 2017, PNRA received intention from HMC-3 for design and manufacturing of storage & transfer cask for C-Series NPPs. Regulatory review and assessment of Safety Analysis Report (SAR) and other submissions are in progress. PNRA conducted a meeting with HMC-3 to resolve the regulatory queries. It is expected that provisional acceptance of design and authorization for manufacturing of prototype cask will be granted in 2021.

5.3 Decommissioning of Nuclear Installations/Radiation Facilities

Nuclear installations and radiation facilities are decommissioned after completion of their useful life. The decommissioning process includes administrative and technical actions for the management of radioactive waste to allow the removal of the facility from regulatory control.

The licensing regulations of PNRA issued in 2002 required submission of decommissioning strategy by nuclear installations prior to introduction of nuclear material or fuel into the installations. Accordingly, nuclear power plants submitted decommissioning strategies and upon satisfactory review, these strategies were approved.

The regulatory requirements of PNRA were revised in year 2012 based on the IAEA standards and feedback, according to which

Participants of PNRA - IAEA Workshop on "Regulatory Control / Requirements to address Transition Phase from Operation to Start Decommissioning of Nuclear Facilities"

PNRA - IAEA Workshop on Development and Use of Waste Acceptance Criteria (WAC) in Management of Radioactive Waste

nuclear installations are required to submit Initial Decommissioning Plan (IDP) at the time of initial licensing. IDPs are required to be periodically updated by the licensee after every five years. This practice has to be continued until the submission of a Final Decommissioning Plan (FDP) to PNRA along with the application for acquiring decommissioning license. The FDP is required to be submitted at least three years before termination of the operating license.

K-1 has completed its design life and currently operating beyond design life. K-1 will be the first nuclear power plant of Pakistan to undergo decommissioning. In this regard, K-1 has submitted its Final Decommissioning Plan to PNRA in April 2018 for regulatory acceptance. After thorough review of the submission, PNRA communicated its queries to K-1. Afterwards, during a coordination meeting held in November 2020, K-1 has informed that revised Final Decommissioning Plan will be submitted to PNRA in March 2021.

5.4 Disused Sealed Radioactive Sources

The sealed radioactive sources are widely used in medicine, industry, agriculture and various other sectors. After completion of their intended life, these sources are termed as Disused Sealed Radioactive Sources (DSRS). Internationally, long lived high radioactivity DSRS are returned to the supplier in order to reduce the accumulation of these sources in the country.

Accordingly, PNRA requires that DSRS having a half life of more than 1 year and initial activity greater than 100 GBq are returned to the supplier. The DSRS which are not returned to the suppliers are stored at designated storage sites in the country. PNRA maintains inventory of all such sources. As per the inventory, the DSRS stored at these sites mainly include Co-60, Cs-137, Ir-192 and Ra-226.

Among all the sealed radioactive sources used in the country over the period of twenty years, 13.31 % of DSRS have been returned to suppliers / manufacturers while the remaining 86.69 % of DSRS have been safely stored at designated storage sites in the country. Figure-36 shows the graphical representation of the status of DSRS.

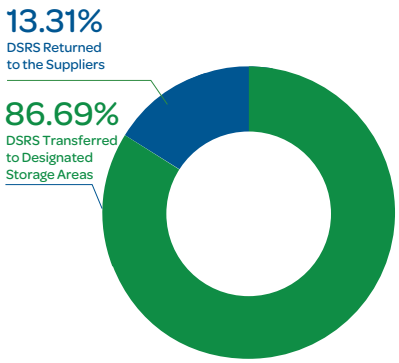
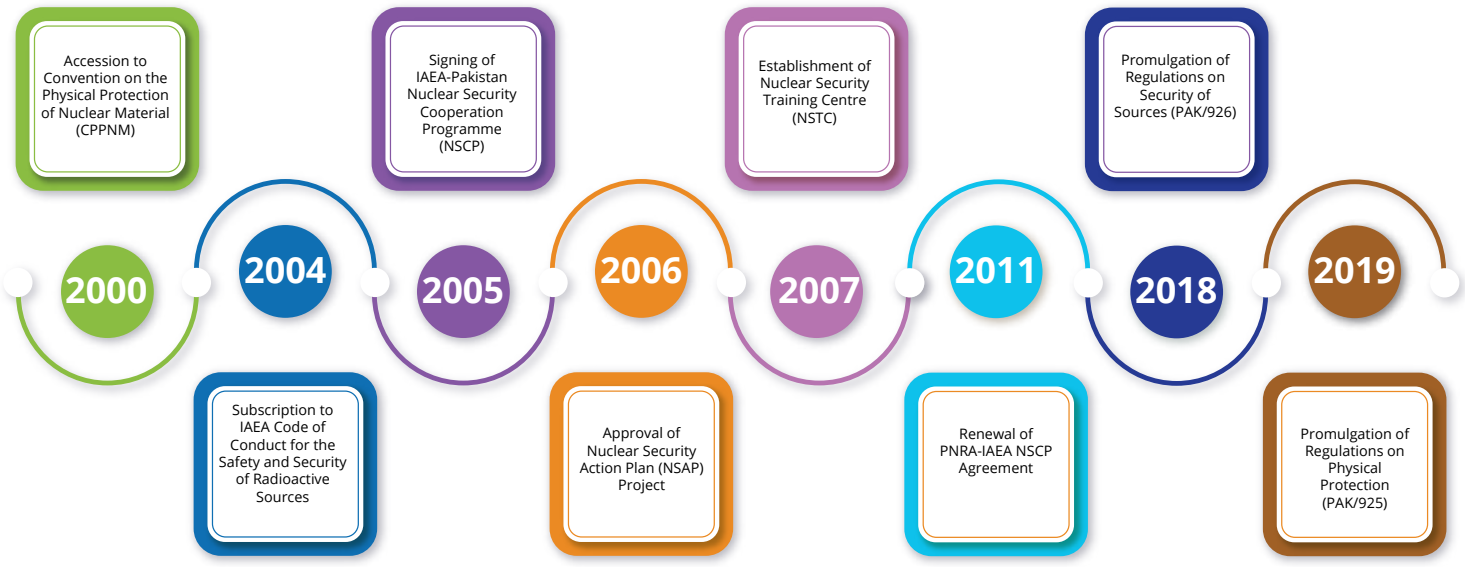


Figure-36: Status of DSRS in the Country

6

REGULATORY REGIME FOR PHYSICAL PROTECTION



The concept of physical protection of nuclear material and radioactive sources was in place and practiced globally since late 1970s. Over the years, efforts and resources were dedicated for strengthening the physical protection in order to prevent the use of nuclear and radioactive material for malicious intent. Accordingly, Pakistan took several initiatives for establishment and sustainability of an effective nuclear security regime in the country. The Government of Pakistan empowered PNRA to ensure that appropriate measures for physical protection of nuclear installations and nuclear material are taken. This Chapter describes PNRA's efforts for establishing, implementing and sustaining regulatory regime for physical protection in the country.

6.1 Evolution and Establishment of Requirements for Physical Protection and Security

The regulatory regime in the country has evolved over the years, which is at par with international standards. Initially, the physical protection was governed by conventional means of security based on prescriptive approach. With the emerging nuclear security threats and associated technological development, the approach was transformed from conventional means to performance based physical protection system consisting of integrated physical protection technologies.

Since its inception, PNRA has established a comprehensive regulatory framework to ensure the physical protection of nuclear material & installation and security of radioactive sources. This framework is based on establishing requirements and their effective implementation to ensure that nuclear and radiation facilities are protected against the potential threats.

Requirements for Physical Protection

The requirements of physical protection of nuclear material and nuclear installations were established under the Pakistan Nuclear Safety and Radiation Protection (PNSRP) Regulations-1990.

Pakistan became a state party to "Convention on the Physical Protection of Nuclear Material (CPPNM)" in 2000. IAEA INFCIRC/225/Rev.4 on the "Physical Protection of Nuclear Material and Nuclear Facilities" was adopted for regulating physical protection at nuclear installations. PNRA further strengthened the physical protection requirements related to submission and approval of physical protection programme through promulgation of "Regulations for Licensing of Nuclear Installation(s)-PAK/909 (Rev.0)" in 2001.

International Workshop on Nuclear Security Culture in Practice held at PNRA HQs.

Pakistan subscribed to the IAEA "Code of Conduct (CoC) for the Safety and Security of Radioactive Sources" in 2004. Accordingly, concrete steps were taken for regulatory oversight and supervision of activities involving radioactive sources. In 2004, PNRA promulgated "Regulations for the Licensing of Radiation Facilities other than Nuclear Installations - PAK/908" and "Regulations on Radiation Protection - PAK/904". These regulations set requirements for import and export of radioactive sources; and security and accountability of radioactive sources.

Establishment of NSAP

In order to strengthen and enhance the existing regulatory capabilities of PNRA for security of radioactive material, PNRA implemented the national Nuclear Security Action Plan (NSAP) Project from 2006 - 2013.

PNRA promulgated "Regulations on Security of Radioactive Sources - (PAK/926)" in 2018 for security of radioactive sources during manufacture, use, storage and transport. These regulations are developed based on national threat; technological advancements; CoC for safety and security of radioactive sources; and relevant IAEA nuclear security guidance. The regulations establish regulatory requirements for the security of radioactive sources which mainly comprise categorization of radioactive sources, security management, vulnerability assessment, event reporting, information protection, response arrangement, security culture, etc.

In 2019, PNRA promulgated "Regulations for the Physical Protection of Nuclear Material and Nuclear Installations - (PAK/925)" on the basis of obligations of CPPNM and its amendment, IAEA recommendations and experience feedback. These regulations establish regulatory requirements for physical protection of nuclear installations and nuclear material in use, storage and during transport. Salient features of Regulations PAK/925 include design of PPS against design basis threat, identification of security areas, information security, graded approach, defense in depth, security culture, contingency planning, etc.

6.2 Nuclear Security Action Plan Project

In order to implement national and international obligations, the Government of Pakistan approved a national Nuclear Security Action Plan (NSAP) Project in 2006 and entrusted PNRA with the responsibility for its implementation. The objective of this project was to strengthen and enhance the existing regulatory capabilities of PNRA to discharge its responsibilities towards security of radioactive sources and facilities. The project focused on the major areas

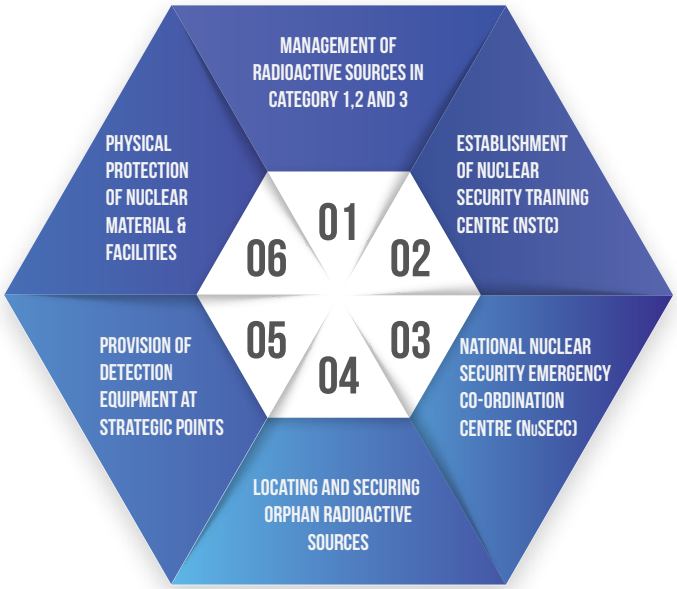


Figure-37: Major Functional Areas of NSAP

International Seminar on Nuclear Safety and Security Challenges of the 21st Century held in Pakistan

which are reflected in Figure-37.

Under the project, assessment of security measures of licensed facilities was performed and accordingly improvements in security systems were recommended. In addition, three inspectorates were established at Peshawar, Multan and Quetta.

PNRA established a Nuclear Security Training Centre (NSTC) in 2007 to provide trainings to the regulators, operators, first responders, front-line officers and law enforcing agencies in the area of physical protection and security. Physical protection interior and exterior laboratories were established under the centre. Over the years, a number of training events were conducted at NSTC.

PNRA also established a National Nuclear Security Emergency Coordination Centre (NuSECC) in 2007 to assess and coordinate response in case of nuclear security events. NuSECC was operational round the clock with a network of six mobile radiation monitoring laboratories. As PNRA had already established National Radiation Emergency Coordination Centre (NRECC) for safety related emergencies, therefore, NuSECC was merged with the NRECC in 2014 so as to act as a sole centre for dealing with safety and security events.

PNRA also initiated measures for locating and securing orphan radioactive sources in the country. In this regard, a public awareness campaign was launched and physical searches were conducted at various locations across the country. A survey was conducted in oil & gas exploration sites, cargo terminals, scrap yards, dry ports and steel mills. As a result of this survey, a few orphan radioactive sources were recovered and safely disposed of. These events were properly reported to the IAEA incident reporting system.

Further, PNRA established an effective regulatory control system to monitor the import and export of nuclear and other radioactive material. In this regard, PNRA provided radiation detection equipment at eight entry / exit points of the country for combating potential illicit trafficking of nuclear and other radioactive material. In addition, PNRA organized more than thirty national / international training courses and trained more than five hundred Customs officials and continued to provide technical support to Customs in training, maintenance and up gradation of equipment.

The NSAP project was completed in 2013 by achieving its intended objective.

6.3 Regulatory Oversight of Physical Protection

PNRA has established a comprehensive mechanism for review, assessment, inspection and enforcement in order to ensure effective regulatory oversight for physical protection of nuclear material & nuclear installations and security of radioactive sources.

Briefing to Deputy Director General, IAEA on Physical Protection Models of Nuclear Power Plant

The regulatory review is performed to determine whether the licensees' submissions comply with physical protection and security requirements. PNRA requires submission of physical protection program during various lifetime stages of nuclear installations and physical protection plan from radiation facilities having Cat-I to III radioactive sources. Over the years, PNRA reviewed 30 physical protection programs of nuclear installations and more than 300 physical protection plans of radiation facilities.

PNRA has also developed an inspection program to verify that physical protection systems and measures are implemented in accordance with approved physical protection program / plan. Further, PNRA requires the licensee to periodically conduct drills and exercises to determine the effectiveness of their physical protection systems.

Annual Meeting of International Network for Nuclear Security Training and Support Centres held in Pakistan

Over the years, PNRA has conducted 25 periodic inspections of nuclear installations and around 2500 inspections of radiation facilities based on the concept of graded approach and associated risk. In addition, PNRA has also witnessed eight physical protection drills performed by the licensees over the time.

Improvement in Physical Protection Measures

Over the two decades, PNRA has ensured through assessment and verification that physical protection of nuclear installation and security of radioactive sources has improved taking into account emerging threats, technological advancement and experience feedback.

6.4 IAEA-Pakistan Nuclear Security Cooperation Programme (NSCP)

The IAEA and Pakistan signed a Nuclear Security Cooperation Programme (NSCP) in 2005 with the objective to strengthen physical protection and nuclear security in Pakistan. PNRA was the designated focal point for coordination and implementation of this programme.

Under the programme, IAEA assisted Pakistan's efforts for capacity building through establishment of infrastructure and provision of trainings in the area of nuclear security.

Accordingly, security systems and equipment were installed at PNRA HQs. building to serve as a model training facility. Physical protection laboratories were also developed under this programme. In addition, some equipment were provided for Radiation Detection Equipment Laboratory.

The NSCP was revised in 2011 to include additional areas of cooperation including physical protection upgrades at nuclear installations and radiation facilities with Cat-I to III radioactive sources. Consequently, security systems were upgraded at K-1 and 27 nuclear medical centres in public and private sectors.

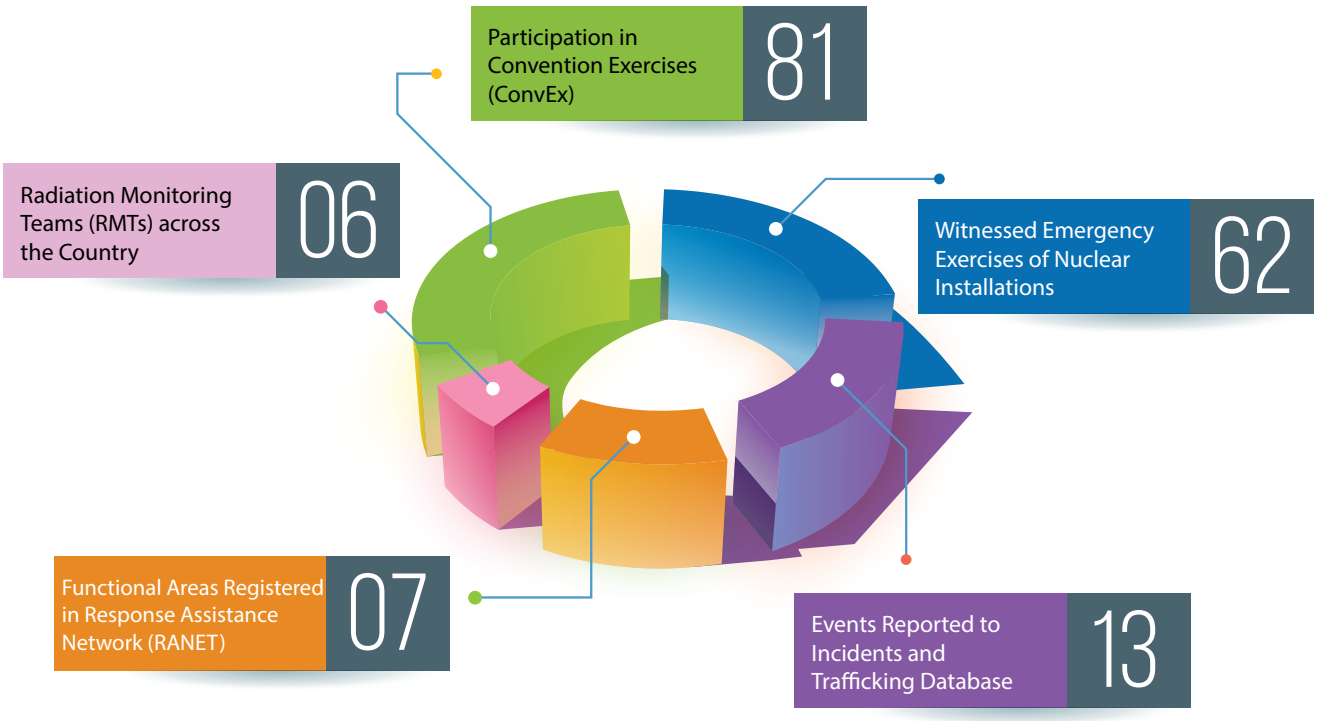
In addition, IAEA provided radiation detection equipment comprising 400 PRDs and 40 RIDs for enhancing capabilities to respond to any nuclear security event across the country.

Over the past two decades, PNRA's efforts have significantly strengthened physical protection regime in the country. Effective regulatory oversight has ensured safe and secure operation of nuclear installations and radiation facilities against potential threats. PNRA is committed to continuously enhance regulatory effectiveness for physical protection and security in line with international obligations, IAEA guidance and experience feedback.

Briefing to International Visitors on Physical Protection Laboratory of PNRA

7

ENSURING READINESS FOR RESPONSE TO RADIOLOGICAL EMERGENCY



Nuclear installations and radiation facilities all over the world are required to be designed, constructed and operated with appropriate level of safety, as per applicable standards and national requirements. Nevertheless, though unlikely, there always remains a possibility of occurrence of nuclear or radiation related incidents or emergencies.

To cope with such events and to protect the public and the environment from harmful effects of radiation, the establishment and execution of adequate emergency preparedness and response measures are available for all nuclear installations and radiation facilities.

In Pakistan, PNRA is responsible to ensure availability of appropriate emergency response plans at nuclear installations and radiation facilities. PNRA is also responsible to advise the federal and provincial governments and other stakeholders regarding implementation of necessary safety and protective measures for mitigation of the consequences of nuclear accidents or radiological emergencies.

Regulatory Requirements for Emergency Preparedness

PNRA has established requisite regulatory requirements for emergency preparedness and response arrangements based on international standards and experience feedback.

7.1 Arrangements for Emergency Preparedness and Response

In order to effectively and efficiently manage emergency situations, well established and coordinated response arrangements are necessary. These arrangements are made for responding to such situations in order to mitigate radiological consequences within and outside the boundary of a facility, if required. PNRA plays a pivotal role in ensuring that these arrangements are in place and tested periodically.

As per PNRA requirements, installation and facilities having potential for a nuclear or radiological emergency are required to formulate on-site and off-site emergency response plans according to a graded approach. The Radiation Emergency Plans (REPs) address the potential emergency situations, provide mechanisms for notifications, describe response actions and explain measures to be taken for mitigation of consequences. Such plans also describe arrangements for medical response, measures for preventing ingestion of contaminated food items and long term protective actions.

Workshop on Decision Making for Implementation and Termination of Protective Measures in Case of Nuclear Accident or Radiological Emergency held at PNRA HQs.

PNRA requires the licensees to submit the radiation emergency preparedness and response plans for review and assessment. As a result of such review, PNRA verifies compliance of the programs with regulatory requirements, identify deficiencies and accordingly provides recommendations for improvement in these plans, if any. Once PNRA accepts these plans, effective implementation of these plans is ensured through inspections of arrangements, exercises and drills.

7.1.1 On-Site Emergency Response Plans

These plans describe the availability of on-site arrangements and mechanisms for managing the emergency consequences within the premises of installation or facility. PNRA reviews and approves on-site emergency response plans of nuclear installations and high hazard radiation facilities.

7.1.2 Off-Site Emergency Response Plans

The off-site emergency response plans describe the emergency preparedness and response measures to be taken by the licensees to mitigate the off-site consequences to general public with the support of off-site organizations such as local and district administration. These plans are prepared by licensees in collaboration with the relevant off-site organizations.

In compliance with the regulatory requirements, nuclear installations have been submitting off-site emergency response plans for review and acceptance of PNRA. Accordingly, over the years, PNRA reviewed and accepted off-site emergency response plans of a number of nuclear installations.

7.1.3 National Emergency Response Arrangements - The NEMS

In 2014, the Government of Pakistan established a national level plan, namely Nuclear Emergency Management System (NEMS) to coordinate and facilitate an integrated emergency response in case of a nuclear or radiological incident. This includes responsibilities and actions of different stakeholders under centralized control. PNRA contributed effectively in development and improvement of the system by sharing its experience and providing technical input. Based on the technical expertise, PNRA has been made responsible to assist in national level response to radiological emergencies.

Role of PNRA in NEMS Operations

PNRA has been playing a pivotal role in 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.

Under the NEMS plan, various stakeholders maintain Radiological Assistance Groups (RAGs) comprising dedicated teams of professionals with appropriate knowledge and skills for managing nuclear or radioligical emergency across the country. PNRA being an important stakeholder is maintaining designated RAG teams at its offices throughout the country. PNRA also provides support in training of RAG teams operating under the NEMS plan.

7.2 Round the Clock Coordination - NRECC

A National Emergency Coordination Centre (NECC) was established at DNSRP of PAEC, the predecessor of PNRA, in Islamabad in 1988 for coordinating and sharing of reliable information and guiding response actions in the country for nuclear or radiological emergencies.

In 1989, Pakistan became a state party to the "Convention on Early Notification of a Nuclear Accident" and "Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency". Under these Conventions, the Government of Pakistan designated NECC as national point of contact responsible for issuing and receiving notifications and information in case of a nuclear accident or radiological emergency. In 1998, the centre was renamed as National Radiation Emergency Coordination Centre (NRECC).

In 2001, after establishment of PNRA as a national nuclear regulator, the

Ground Breaking Ceremony of NRECC Building

responsibilities for managing and maintaining the NRECC were inherited to PNRA. Since then, NRECC has remained operational as a national warning point for fulfilling the responsibilities mandated by PNRA Ordinance and international obligations under the emergency Conventions.

In 2007, PNRA initiated development of a network of Radiation Monitoring Teams (RMTs) for deployment in major cities across the country including Islamabad, Karachi, Chashma, Peshawar, Multan and Quetta. RMTs were aimed to independently evaluate emerging situations in case of radiological emergencies and provide assistance to the licensees, local and national response organizations in radiological monitoring during nuclear accidents or radiological emergencies. RMTs' professionals are equipped with advanced radiation monitoring, personal protective and communication equipment and software for the radiological assessment. RMTs' professionals are well trained, experienced, equipped with Mobile Radiological Monitoring Lab (MRML) and capable to respond to radiological emergency and nuclear security events. These RMTs also work as RAG teams under NEMS. Figure-38 reflects locations of RMTs across the country.

NRECC is activated as per PNRA response plan during emergency situations and exercises. Upon notification of an incident, NRECC functions in one of its emergency response modes as reflected in Figure-39. Each event is classified and responded according to the extent of the actual or potential radiological consequences.

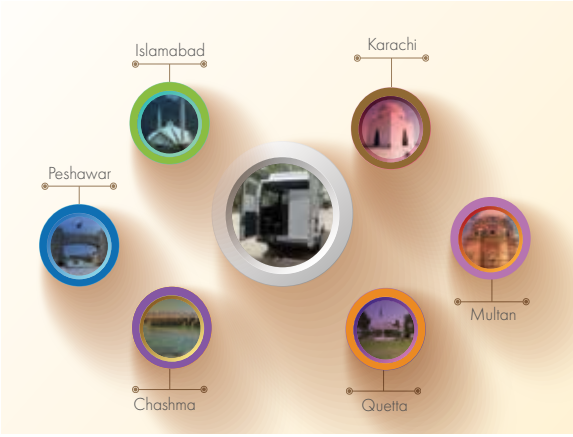


Figure-38: Location of RMTs across the Country

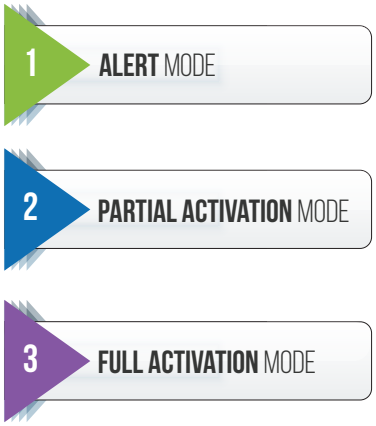


Figure-39: Modes of Activation of NRECC

7.3 Demonstration of Readiness – Emergency Exercises

Emergency exercise is a tool to evaluate the effectiveness of response plans. These exercises are conducted to ensure that preparedness is maintained to respond to any potential nuclear accident or radiological emergency.

PNRA requires its licensees to test the emergency plans periodically through drills and exercises. PNRA witnesses emergency drills and exercises to assess effectiveness of emergency plans. PNRA also tests its own preparedness through internal exercises conducted periodically. Further, PNRA participates in national and international level exercises.

7.3.1 Witnessing Emergency Exercises of Licensees

PNRA requires the licensees of nuclear installations to demonstrate effectiveness of emergency plans before introducing nuclear material in the nuclear installations. This demonstration includes testing of on-site as well as off-site emergency response arrangements. After the NPPs become operational, the licensee periodically conducts emergency exercises to demonstrate their state of readiness and effectiveness of emergency response plans. Over the years, PNRA has witnessed a number of exercises conducted by nuclear installations and provided comments for improvement.

PNRA also requires large radiation facilities in the country to demonstrate implementation of their emergency response plans and procedures through conduct of drills and exercises. Over the years, PNRA has witnessed these drills and exercises by a number of large radiation facilities including nuclear medicine centres and industrial users.

7.3.2 Emergency Exercises Conducted by PNRA

To test its own readiness and response arrangements, PNRA conducts various

Handling of Contaminated Individual during Emergency Exercise

emergency exercises, considering different types of emergency situations in accordance with its response plan for nuclear and radiological emergencies. Various types of readiness exercises conducted by PNRA are shown in Figure-40.

7.3.3 Participation in National level Emergency Exercises

PNRA participates in a number of national level exercises, conducted by various national stakeholders. These exercises are conducted under the NEMS plan to test the effectiveness of coordination and response mechanisms of various national stakeholders. Participation in a number of tabletop and field exercises is a continuous activity of PNRA.

7.3.4 Participation in International Level Emergency Exercises

PNRA participates in various international level emergency exercises conducted by IAEA under the emergency notification and assistance Conventions. These exercises are

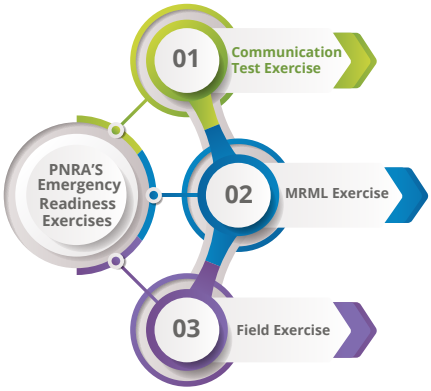


Figure-40: PNRA's Emergency Readiness Exercises

called Convention Exercises (ConvEx). The goal of these exercises is to evaluate and further improve the international framework for emergency preparedness and response.

Pakistan's participation in ConvEx exercises is shown in Figure-41.

7.4 Reporting, Sharing, and Supporting

PNRA disseminates information of various radiation related events, incidents and accidents among concerned stakeholders i.e. licensees, national organizations and the IAEA. This is described in the next subsections.

7.4.1 Reporting of Events under the International Conventions

As a designated national warning point under the "Convention on Early Notification of a Nuclear Accident", PNRA is responsible to share and receive all official notifications issued under this convention. Accordingly, PNRA receives information from IAEA Member States, analyzes the information and shares the lessons learnt with national stakeholders.

7.4.2 Reporting of Events at IAEA NEWS

IAEA has been maintaining a platform for reporting of events related to nuclear or radiation incidents. This platform is known as Nuclear Events Web-based System (NEWS). Information reported on this platform is rated on a scale, known as International Nuclear Event Scale (INES). This scale was designed by the IAEA, in collaboration with other organizations. It is a tool for communicating the safety significance of nuclear and radiological events. Currently, around 80 Member States have designated INES national officers for sharing of information on this platform.

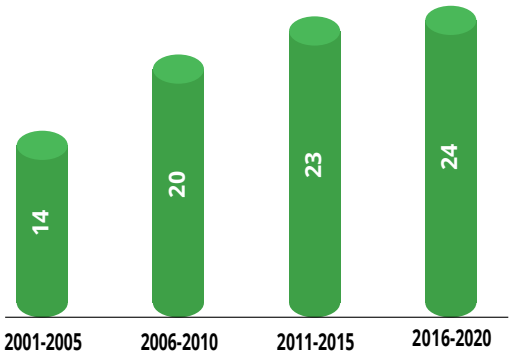


Figure-41: Pakistan's Participation in ConvEx Exercises

Since its inception, PNRA has been participating at this platform. Over the years, a number of events have been reported by PNRA at this forum. PNRA also analyzes global information shared on NEWS. Accordingly, lessons learnt are identified and shared with relevant stakeholders for improvement of radiation safety in the country.

7.4.3 Reporting of Events at IAEA ITDB

In 1995, IAEA established the Illicit Trafficking Database (ITDB) containing data related to illicit trafficking of nuclear and other radioactive material and invited Member States for voluntary participation. The title of this database was renamed as "Incidents & Trafficking Database (ITDB) in 2012. This platform covers the incidents involving unauthorized acquisition, possession, use, transfer or disposal of nuclear & other radioactive material and contaminated items, intentionally or unintentionally, with or without crossing international borders and unsuccessful or thwarted acts.

Joining the ITDB

Pakistan joined ITDB in 2005 and PNRA was designated as the national point of contact for ITDB.

During the period 2001-2020, more than 3000 events have been reported to the ITDB by IAEA Member States. So far, Pakistan has reported 13 events to the database.

7.4.4 Reporting of Radioactive Source Movement

Some radioactive sources being used in the country, such as those used for Industrial radiography and nuclear medicine, require frequent transportation to various locations due to the nature of work. These sources are vulnerable during movement, therefore,

PNRA Officials Participating in ConvEx Exercise

movement of such sources requires robust safety and security measures. Thus, the regulatory framework requires the licensees to report any movement of radioactive sources in the country to NRECC, PNRA before the actual movement of radioactive source. PNRA assesses the potential risks involved and ensures that the required safety and contingency measures are taken. PNRA also shares this information with law enforcement authorities and its regional directorates for conducting inspection during source movement to verify compliance with safety and security requirements.

7.4.5 Supporting the National Stakeholders

PNRA has been supporting national organizations having roles in emergency preparedness and response. PNRA coordinates with various national organizations, particularly with Pakistan Customs on matters related to illicit trafficking, detection of contamination or elevated radiation levels in different commodities being imported into the country and provision of advice and assistance on monitoring. PNRA has provided radiation detection equipment and training on operating this equipment to officials of Pakistan Customs.

A number of training courses have been conducted over the years for officials from various stakeholders such as Pakistan Customs, law enforcement agencies, rescue organizations, Punjab Police and provided hands on training.

Creating Awareness about the Harmful Effects of Ionizing Radiation

PNRA has been coordinating with law enforcement agencies, first responders, frontline officers and academia for creating awareness about the harmful effects of ionizing radiation, imparting trainings on detection of radioactive material and emergency management in case of an event involving radioactive source.

PNRA signed Memorandum of Understanding (MoU) with Pakistan Meteorological Department (PMD) in 2018 for acquiring relevant meteorological data which is needed for performing environmental radiological assessments. Under this MoU, PNRA will obtain online data from PMD. Currently, PNRA is in coordination with National Telecom Corporation (NTC) for providing a dedicated line due to huge amount of data to be transferred from PMD.

7.4.6 Participation in IAEA RANET

As part of the IAEA's strategy for implementation of International Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency, IAEA has established

a mechanism, namely the Response Assistance Network (RANET) for providing international assistance to the IAEA Member States in order to minimize the radiological consequences. This platform is intended to strengthen the worldwide capability to coordinate and provide assistance or advice to Member States within the framework of this convention in case of radiological emergencies.

Being the state party to this convention, Pakistan registered its capabilities with RANET in 2008. PNRA is the national point of contact under this network. The capabilities registered are termed as National Assistance Capabilities (NACs). Initially, Pakistan registered its capabilities in a few areas which were increased later to seven functional areas in the RANET, as reflected in Figure-42.

National Workshops on RANET

Pakistan conducted four national workshops on RANET for testing of mechanisms for the readiness and deployment arrangement of National Assistance Capabilities (NACs).

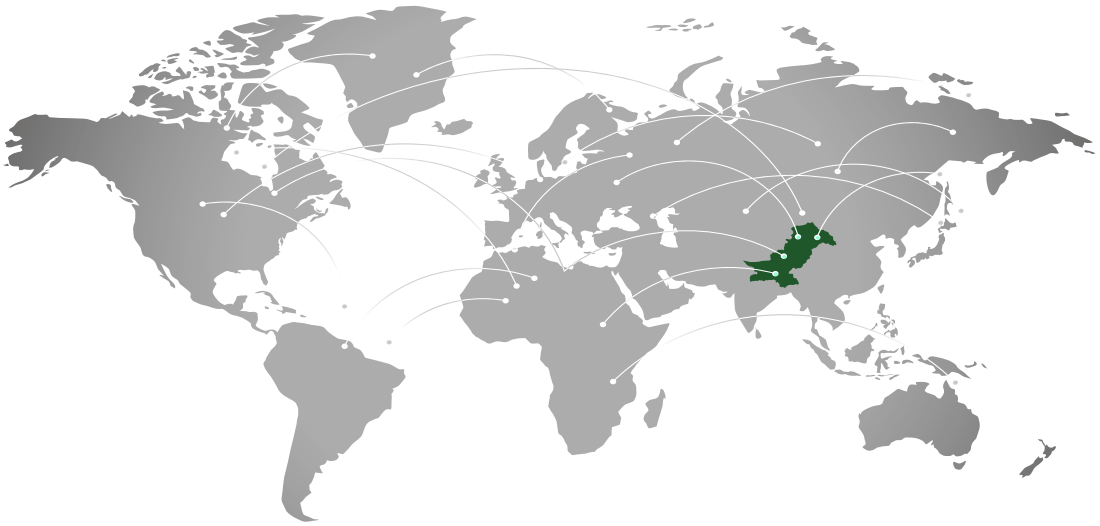
Pakistan also participated in two RANET workshops conducted in Fukushima, Japan in 2013 and 2014 respectively to test the compatibility and harmonization of different Member States in provision of international assistance through this forum.

Figure-42: National Response Capabilities Registered in RANET

Over the years, PNRA has been playing a significant role in strengthening arrangements related to emergency preparedness and response in the country. In this regard, PNRA has been ensuring the availability of appropriate emergency response plans and their implementation at nuclear installations and radiation facilities. PNRA has also been ensuring that the operators of nuclear installations and radiation facilities comply with regulatory requirements for emergency preparedness and response through stringent regulatory oversight.

Participants of National Workshop on RANET

8 GLOBAL CONNECTIONS



679	08	17	1720
INTERNATIONAL EXPERTS VISITED PNRA	**IAEA TC PROJECTS** IMPLEMENTED BY PNRA	PARTICIPATION OF PNRA IN **IAEA RAS PROJECTS**	PARTICIPATION OF PNRA EXPERTS IN **INTERNATIONAL EVENTS**

PNRA believes that collaboration and liaison with international community is important for competence building and updating its regulatory framework to ensure safety and security at nuclear installations and radiation facilities. Sharing of experience feedback with international community helps in improving regulatory effectiveness. The cooperation is also essential for fulfillment of country's obligations under relevant international conventions. PNRA keeps close liaison with International Atomic Energy Agency (IAEA) to fulfill obligations under the international conventions related to nuclear safety, radiological emergencies and physical protection. Further, PNRA maintains a good cooperation and interaction with international organizations and regulatory bodies of other countries for technical and scientific support and strengthening of organizational capabilities. The details of these efforts are described in this Chapter.

8.1 International Commitments - Conventions

Pakistan is a signatory to various IAEA international conventions, including Convention on Nuclear Safety (CNS), Convention on Early Notification of a Nuclear Accident (CENNA), Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (CANARE) and Convention on Physical Protection of Nuclear Material (CPPNM). Pakistan is also committed to implement Code of Conduct on the Safety and Security of Radioactive Sources and Code of Conduct on the Safety of Research Reactors. PNRA's role in fulfilling international commitments is described in the next sections.

8.1.1 Convention on Nuclear Safety (CNS)

The objective of the Convention on Nuclear Safety (CNS) is that all Contracting Parties with operating nuclear power plants take steps to achieve a high level of nuclear safety by establishing and maintaining effective defenses in nuclear installations to prevent accidents and mitigate the consequences of potential radiological hazards to individuals and the environment. The Convention places obligations on the Contracting Parties to implement safety standards that may address issues related to site selection, design, construction, operation, safety verification, human factors, quality assurance, radiation protection and emergency preparedness.

Pakistan ratified the Convention on Nuclear Safety (CNS) in 1997. In order to fulfill the obligations of this Convention, the Government of Pakistan promulgated legislative framework for nuclear safety and

Knowledge Sharing Session on Seventh Review Meeting of Convention on Nuclear Safety

radiation protection and established PNRA as a national nuclear regulatory authority in January 2001.

One of the important obligations of CNS for contracting parties is to prepare and submit national report to IAEA which describes the measures taken to maintain and sustain safety at nuclear installations. In this regard, review meetings of representatives of the contracting parties are held once every three years to discuss and justify their submitted national reports, review and discuss safety issues and learn from each other's experience to further enhance nuclear safety at NPPs. Pakistan has participated in all of seven review meetings so far held starting from 1999. PNRA, as the national contact point for the Convention, coordinates all activities under CNS including preparation of national report of Pakistan, review of national reports of other contracting parties, preparation of response against queries raised by other contracting parties on Pakistan's national report, etc. in consultation with other stakeholders including PAEC, SPD and MOFA.

Recognition of Regulatory Practices

PNRA has successfully represented Pakistan in all the review meetings. The Pakistan's practices in regulating and upholding nuclear safety at nuclear power plants have been recognized internationally as good practices and examples to be followed.

After Fukushima Daiichi accident in the year 2011, PNRA actively participated in the international deliberations held for changes in the CNS guidance documents. PNRA also coordinated the national response for adoption of the Vienna declaration on nuclear safety in 2015.

8.1.2 Convention on Early Notification of a Nuclear Accident (CENNA) and Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (CANARE)

Pakistan acceded to the above two international conventions in September 1989. In compliance with the requirements of these conventions, the Government of Pakistan designated PNRA to supervise matters of these conventions and authorized PNRA's National Radiation Emergency Coordination Centre (NRECC) to be the national warning point. Detailed activities with respect to these conventions are given in Chapter 7 of this report.

8.1.3 Convention on the Physical Protection of Nuclear Material (CPPNM)

Pakistan acceded to the Convention on Physical Protection of Nuclear Material (CPPNM) in September 2000 and also ratified its amendment in 2016. On behalf of the Government of Pakistan, PNRA is the official point of contact for CPPNM.

Pakistan has established a comprehensive nuclear security regime and committed to implement the obligations of CPPNM and its amendment for physical protection, international cooperation and criminalization related provisions.

PNRA has promulgated "Regulations on Physical Protection of Nuclear Material and Nuclear Installations - (PAK/925)" that covers the aspects of physical protection of nuclear installations and nuclear material in use, storage and during transport. These regulations take into consideration IAEA's "Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Rev.5)" and the technical obligations of CPPNM.

8.1.4 Codes of Conduct

Pakistan has subscribed to the IAEA "Code of Conduct on the Safety and Security of Radioactive Sources" and "Code of Conduct on the Safety of Research Reactors". Pakistan has put in place all the necessary arrangements and systems consistent with the recommendations of the codes.

Pakistan has also subscribed the supplementary guidance on the import and export of radioactive sources during 2017-2018 and guidance on the management of disused radioactive sources in 2019 under the code of conduct on safety and security of radioactive sources. PNRA is the official contact point to this code.

The code of conduct, along with its supplementary guidance documents, seeks

to help countries ensure that radioactive sources are used in a manner consistent with the highest standards of safety and security throughout their life cycle.

Pakistan revised its regulatory framework to ensure that it is at par with IAEA code of conduct and its associated guidance documents. PNRA officials have contributed in various IAEA activities related to CoC which includes resource persons/experts in training courses, meetings, and international conferences.

8.2 Multilateral Relations

The foremost international stakeholder of PNRA for cooperation is the International Atomic Energy Agency (IAEA). In addition, PNRA has also maintained liaison at other multilateral platforms dealing with safety and security of nuclear installations and radiation facilities which are summarized in the next subsections.

8.2.1 Cooperation with IAEA

PNRA has been collaborating with IAEA in numerous fields such as nuclear safety, radiation protection, nuclear security and emergency preparedness and response. This collaboration is maintained through participation in various IAEA safety committees and forums; technical cooperation programs; and provision of expert support to IAEA and its Member States. Highlights of PNRA cooperation with IAEA over the years is detailed in following subsections.

a) IAEA Commission on Safety Standards (CSS)

The Agency has constituted Commission on Safety Standards (CSS) at its headquarters. It is a standing body of senior government officials of IAEA Member States, responsible for finalization and approval of safety standards, guides and other regulatory documents relevant to nuclear, radiation, transport & waste safety, security and emergency preparedness and response. PNRA has been representing Pakistan at this forum since 2007.

b) IAEA Safety Standards Committees

IAEA has established various safety standard committees comprising representatives from its Member States to provide guidance and recommendations for the development of IAEA safety standards.

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 (EPReSC). These officers are part of the development process of safety standards.

Visit of Director General International Atomic Energy Agency (IAEA) to PNRA

c) IAEA Nuclear Security Committees and Networks

IAEA Advisory Committee on Nuclear Security (ADSec), comprising selected senior government officials from Member States, is the advisory committee to the Director General, IAEA on matters related to security of nuclear material and radioactive sources. PNRA is participating in ADSec meetings since its inception. The Agency has created Nuclear Security Guidance Committee (NSGC) in 2012 for review and recommendation for development of security related standards and guidance documents. PNRA has represented Pakistan in the committee and actively participated in its activities.

PNRA Role in IAEA Safety Standards Committees

PNRA officials, as members of IAEA Safety Standard Committees, are effectively representing Pakistan's perspective during development of IAEA safety standards. The members conduct an extensive review with the help of relevant national stakeholders for the improvement of draft standards and ensure incorporation of review feedback.

The IAEA also maintains a number of international networks on nuclear security namely, International Network for Nuclear Security Training and Support Centres (NSSC Network) and International Nuclear Security Education Network (INSEN). Main goal of these networks is to strengthen international cooperation and dialogue on nuclear technology, facilitate cooperation between network participants and help them share experience and expertise. Pakistan is participating in these networks regularly.

The International Nuclear Security Education Network (INSEN) was established in 2010 under the auspices of IAEA to promote sustainable nuclear security education by establishing training facilitates. PNRA served as founding member of the network and has contributed in establishment of network's Terms Of Reference (TORs); development of curriculum, text book material for faculty and students; introduction of certified course contents for faculty development in nuclear security; and surveys on the effectiveness of the programs under INSEN.

PNRA launched professional courses for faculty development in its training centre. These professionals serve as resource persons in nuclear security education programs initiated by Pakistan Institute of Engineering and Applied Sciences (PIEAS), courses arranged in INSEN Member States and courses for faculty development organized by Pakistan Centre of Excellence for Nuclear Security (PCENS).

The International Network for Nuclear

Visit of Director Division of Nuclear Security (NSNS) and Head Nuclear Security of Materials and Facilities Section, NSNS - IAEA to PNRA HQs.

Security Training and Support Centres (NSSCs) was established by IAEA in February 2012 with the aim to facilitate cooperation among various nuclear security support centres of Member States. NSSC functions are human resource development, specifically through the provision of a national nuclear security training programme; technical support services for nuclear security equipment lifecycle management; and scientific support services for provision of expertise, analysis, and research and development for nuclear security. PNRA served as a founding member of the network having many years experience of trainings and technical and scientific support to national policy makers, first responders, intelligence agencies, etc.

d) IAEA Systems for Information Sharing

The Agency has established other forums for participation and sharing of information and feedback experience amongst Member States. These include International Nuclear and Radiological Event Scale (INES), International Reporting System for Operating Experience (IRS), Incident and Trafficking Database (ITDB), Radiation Safety Information Management System (RASIMS), Regulatory Cooperation Forum (RCF), Technical Support Organization (TSO) Forum and Global Nuclear Safety and Security Network (GNSSN). PNRA represents Pakistan at all these forums.

e) IAEA Technical Cooperation Program

The Technical Cooperation (TC) Program is a fundamental forum of IAEA through which it helps Member States in building, strengthening and maintaining capacities for the safe, secure and peaceful uses of nuclear technology. The TC program is implemented through technical cooperation projects which are designed based on the national and regional needs in line with the UN sustainable development goals. PNRA benefited from participation in national as well as regional projects.

National projects involve a single country and are designed as per national needs. PNRA has benefited from a number of national level TC projects for its institutional reinforcement, capacity building and strengthening of regulatory capabilities and effectiveness. PNRA has successfully executed eight national TC projects during 2001-2020 under which a number of expert missions; technical meetings, scientific visits, fellowships, workshops, seminars and trainings were arranged for the competence building of its manpower.

Regional projects deliver technical cooperation support across national boundaries and address the needs of several Member States in a specific region. Such projects take into account national

Visit of IAEA Delegation to PNRA for Project Review Meeting

development objectives with consideration of regional development for cooperation agreements, strategies and regulatory framework development. PNRA has benefitted from the several IAEA regional projects aimed for the Asia and the Pacific region. A number of PNRA officials were trained in the area of waste management, emergency preparedness & response, occupational exposure control, regulatory control of radiation sources and safety culture through participation in training courses, scientific visits and fellowships. In addition, PNRA also provided expert support to the Agency in implementing the regional projects.

f) IAEA Coordinated Research Projects

Coordinated Research Project (CRP) is another IAEA forum under which scientific and technical information is exchanged among Member States. IAEA, under the CRP, collaborates with Member States in research and development activities where eminent experts are facilitated to exchange knowledge and scientific research for mutual benefits.

PNRA along with national stakeholders participated in a number of CRPs with the aim to develop the national capabilities through coordinated research efforts at global level. Through these CRPs, national capabilities were developed for performance testing, preventive maintenance and calibration of radiation detection equipment. In addition, mechanism for integration of radiation portal monitors deployed at sea ports was improved. PNRA also contributed in the development of commodities assessment tools and IAEA guidance documents.

g) IAEA General Conference (GC) and International Conference on Nuclear Security (ICONS)

PNRA along with national stakeholders participates in the IAEA general conferences held every year. Further, PNRA participated in International Conferences on Nuclear Security (ICONS) held in 2013, 2016 and 2020 and other conferences held on different areas of nuclear security. Moreover, PNRA officials presented their work and also assisted IAEA in organizing such conferences including chairing various sessions, rapporteurs and member of programme and review committees. Ministerial level segments of IAEA conferences were also attended by senior officials of PNRA.

h) IAEA Nuclear Security Cooperation Program

With the changing threat environment globally in the beginning of this century, Pakistan enhanced its efforts and took many initiatives. One such initiative was

PNRA Officials during Site Visit to Karachi International Container Terminal for Inspection of RPM and Data Acquisition related to CRP Project "Improved Assessment of Initial Alarm from Radiation Detection Instrument"

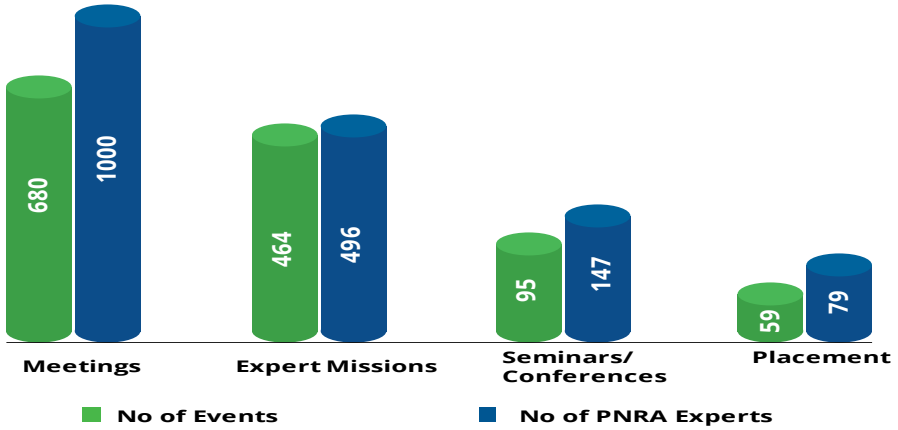


Figure-43: Expert Services Provided to IAEA

nuclear security cooperation programme between PNRA and IAEA. The outcomes and achievements of the program are described in Chapter 6 of this report.

i) Expert Support to IAEA

PNRA provides technical support to IAEA in various activities like expert missions, consultancies, workshops, seminars, conferences, meetings and training courses. This technical assistance includes development of IAEA nuclear safety and security standards; training material and other IAEA documents. Graphical representation of technical support provided to IAEA during the last two decades is presented in Figure-43.

8.2.2 Cooperation under Other Global Platforms

The global platforms for sharing of knowledge and experience for enhancing nuclear safety and security capabilities include United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and Global Initiative for Combating Nuclear Terrorism (GICNT).

PNRA has participated as observer in UNSCEAR from 2006-2011 and as a member since 2011. PNRA has shared national medical exposure data in UNSCEAR survey in 2006. Further, PNRA contributed in occupational and medical exposure surveys of UNSCEAR in years 2017 and 2018 respectively. PNRA has

PNRA Participation in IAEA ORPAS Mission held at Malaysia

also committed for participation in survey on public exposure during 2021-2024.

GICNT is a voluntary forum with the aim to strengthen global capacity to prevent, detect and respond to nuclear terrorism through multilateral activities. PNRA as a member of GICNT Nuclear Detection Working Group (NDWG) and Response & Mitigation Working Group (RMWG) has contributed in the drafting and review of GICNT guidance documents.

8.3 Bilateral Relations

Establishment of bilateral cooperation and relationship with international nuclear regulators and other relevant international organizations is essential for strengthening the nuclear safety and security competence. PNRA has emphasized on developing and maintaining bilateral cooperation with the nuclear regulatory bodies and technical support organizations of other countries for enhancing its regulatory capabilities.

8.3.1 Cooperation with the People's Republic of China

PNRA has established a bilateral relationship with a number of organizations of the People's Republic of China. These include Chinese nuclear regulatory body namely National Nuclear Safety Administration (NNSA), its technical support centre namely Nuclear Safety Centre (NSC) and China Nuclear Power Operation Technology Corporation (CNPO).

Pakistan has been cooperating with NNSA of China in safety evaluation of nuclear installations since 1992. NNSA has assisted PNRA in assessment of licensing submissions of nuclear power plants and nuclear safety class equipment manufacturers of nuclear power plants. In 2006, PNRA invited NNSA to conduct peer review of its technical support capabilities. Moreover, a number of PNRA officers benefitted from fellowships in different regulatory areas at NNSA and workshops / training courses organized by NNSA at PNRA HQs. including post Fukushima actions and review experience of new nuclear power plants in China.

Agreement Between PNRA and NSC

In 2004, the technical support centre of PNRA and NSC signed an agreement for exchange of information and cooperation in the field of nuclear safety and radiation protection. Under this agreement, NSC provided technical consultation and services to PNRA in review and inspection activities.

In 2008, PNRA signed agreement with China Nuclear Power Operation Technology Corporation (CNPO) for the development of physical models of nuclear power plant components and to provide trainings

Meeting of PNRA Officials with the Delegation of China Nuclear Power Operation Technology Corporation (CNPO)

to PNRA personnel in different areas of regulatory oversight.

In March 2013, PNRA signed new long-term cooperation agreement with CNPO for cooperation in training, consultation, scientific research, information exchange, development and technical support for nuclear power plant safety.

8.3.2 Cooperation with Slovak Republic

In 2005, PNRA signed a bilateral agreement with a technical support and research organization of Slovak Republic namely VUJE.

PNRA collaborated with VUJE for capacity building of its technical manpower in the area of nuclear safety, specifically safety review and inspections of pressurized water reactors.

8.3.3 Cooperation with the United States of America

In 2010, PNRA collaborated with the United States Nuclear Regulatory Commission (USNRC) and placed its two officers at USNRC for capacity building in the area of research reactor safety and probabilistic safety assessments. Moreover, both the organizations held four meetings to discuss prospects of exchange of information on issues such as development of severe accident management guidelines, licensing and inspection of fuel cycle facilities and accident analysis.

8.3.4 Cooperation with Nigeria

PNRA signed a Memorandum of Understanding (MoU) with the Nigerian Nuclear Regulatory Authority (NNRA) in 2019 for the capacity building of NNRA technical staff in performing core regulatory functions under the IAEA umbrella. Under this MoU, two senior officials from Nigeria visited PNRA on scientific visit and two batches comprising seven NNRA officials completed two month fellowships at PNRA in the field of review and assessment of NPPs during 2019.

It may be concluded that the collaboration with international community through various forums, committees, networks, TC projects, RAS, CRP, GC and ICONS indicates Pakistan's commitments for fulfillment of national obligations under the IAEA conventions. Moreover, active participation of PNRA in these activities has been very beneficial in strengthening its regulatory capabilities and effectiveness. Furthermore, PNRA provided services to the international community through expert missions, consultancies, seminars, preparation of standards, training material and conduct of training courses in embarking countries. These efforts helped in fostering nuclear safety, radiation protection and nuclear security, both at national and global level.

Signing of MoU between PNRA and Nigerian Nuclear Regulatory Authority (NNRA) for Capacity Building of NNRA Staff

9

ENHANCING REGULATORY CAPACITY

Regulating nuclear installations, radiation facilities and associated activities require knowledgeable, experienced, skilled and competent professionals in the regulatory domain. This needs continuous enhancement in capacity of its workforce in nuclear science and technology in general and nuclear safety and emerging technologies in particular to be able to perform its functions in an effective and efficient manner.

PNRA considers its employees as the most valuable asset and firmly believes that enhancing competence and skills of its workforce is an investment for a better future of the country. Most of the officers recruited by PNRA have acquired graduate and post graduate degrees from reputable universities in engineering and science disciplines; however, their technical knowledge in regulatory functions needs to be further improved.

PNRA has been utilizing numerous means for capacity building to keep itself abreast with the latest technological advancements in the areas of nuclear safety, radiation protection and nuclear security. For this purpose, PNRA has adopted a three-pronged approach including in-house competence development through own resources; trainings arranged at national organizations and trainings at international platforms. PNRA also encourages its employees to improve their educational profile through national and international universities.

Furthermore, PNRA has been utilizing Public Sector Development Program (PSDP) of the Government of Pakistan for enhancing the organizational infrastructure and capabilities. The Government of Pakistan approves such projects and allocates budget to national organizations for the execution of the proposed developmental activities.

This Chapter describes PNRA's efforts for the capacity building of its manpower through various mechanisms and highlights its initiatives for the development of infrastructure and associated services with the assistance of PSDP projects.

9.1 Intake of Regulators - Recruitment

At the time of its inception, PNRA was left with a total of 38 technical officers at its strength which was insufficient for regulating the large number of nuclear installations, radiation facilities and associated activities in the country. To cope with the shortage of workforce, PNRA decided to induct manpower through three approaches simultaneously. The first approach was to directly recruit fresh university graduates having degrees in engineering and sciences to fill the shortage on immediate basis. In the second approach, professionals having experience at industries and other organizations were recruited with a view to be able to handle regulatory responsibilities effectively. In the third approach, PNRA initiated a fellowship scheme at Pakistan Institute of Engineering

Signing of Agreement with PIEAS for Education and Training of PNRA Fellows

and Applied Sciences (PIEAS) and Karachi Institute of Nuclear Power Engineering (KINPOE).

MoU with PIEAS and KINPOE

Memorandum of Understanding (MoU) was signed with PIEAS in October 2001 and with KINPOE in 2006 under which PNRA offered fellowships to candidates for masters degree programs in nuclear engineering, system engineering, nuclear power engineering, mechanical engineering and medical physics before joining PNRA.

A significant number of officers with nuclear knowledge background were recruited through this fellowship program.

The officers recruited during the last 20 years are shown in Figure-44.

9.2 Training Needs Assessment of Regulatory Staff

PNRA performed a systematic Training Needs Assessment (TNA) of regulatory officials in collaboration with Lahore University of Management Sciences (LUMS) in the year 2002-04. The assessment was based on the IAEA four quadrant competency model for competence evaluation of regulatory bodies. This assessment identified gaps in the required competencies. Accordingly, a number of training modules were formulated for junior, intermediate and senior officials to fill the gaps. PNRA repeated the TNA in 2011 and updated the training plan accordingly.

This training needs assessment was recognized as a "Good Practice" by the IAEA Integrated Regulatory Review Service (IRRS) Mission that visited Pakistan in April 2014.

Later, the IAEA re-defined the assessment methodology and revised the mechanism as Competence Needs Assessment (CNA). Based on the updated methodology and increase in manpower over the years, PNRA initiated another round of the competence need assessment of its manpower in 2019-2020 which is still in progress.

9.3 In-House Capacity Building

Since its inception, PNRA has focused its resources and efforts for enhancing competence of its employees through in-house training courses. In this regard, PNRA established a Quality Management & Education and Training (QM&ET) unit in 2002 with the responsibilities to induct new officers and arrange trainings relevant to its regulatory functions.

The first batch of young graduates was inducted through direct recruitment process and joined PNRA in March 2003. A 16 weeks "Basic Professional Training Course (BPTC)" on nuclear safety, radiation safety and regulatory control was arranged for these officers. The syllabus of this training course was the same as that conducted by IAEA in various Member States for regulators with minor improvements and was declared as Level-I. Another course on PWR systems considered as Level-II was arranged for this group of officers which extended for six weeks during the same year. The Level-I

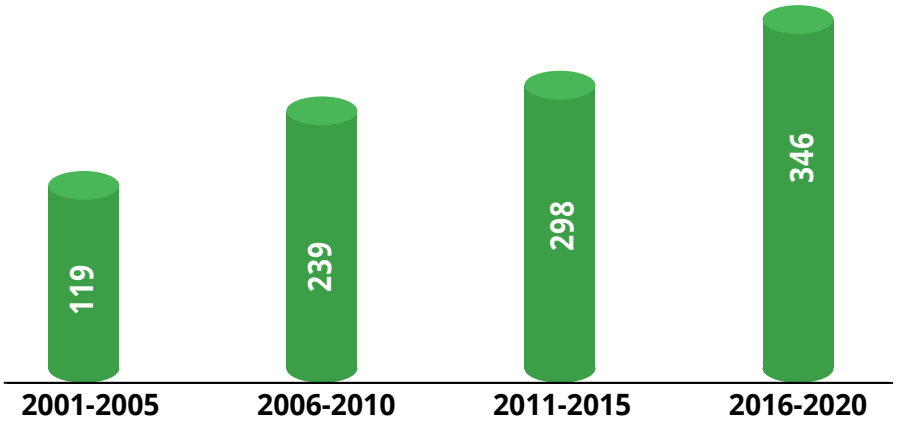


Figure-44: PNRA Manpower Growth over the Years

Inauguration of National Institute of Safety and Security (NISAS) by Director General IAEA

course, excluding the reactor physics part, was again organized at QM&ET for those officers who joined PNRA after completion of Masters from PIEAS in September 2003. The QM&ET unit continued its efforts and arranged different training courses in the field of interest to PNRA, comprising regulatory framework, licensing, authorization, review, assessment, inspection, enforcement and nuclear power plant systems.

Later on, QM&ET was transformed into School for Nuclear and Radiation Safety (SNRS) in 2006 for in-house training of its manpower. Based on the TNA, SNRS organized professional training courses in nuclear safety, radiation protection and regulatory control for PNRA officials and its stakeholders in a sustainable manner.

PNRA realized the need for qualified and skilled human resources in physical protection and nuclear security and established a Nuclear Security Training Centre (NSTC) in 2006. This centre arranged trainings in nuclear security for PNRA officials and other national stakeholders such as licensees, Pakistan Customs, Rescue Organizations, etc. This centre mainly focused on the application of technologies used for prevention, detection and response to a nuclear security related event; locating and securing orphan radioactive sources; methodology to respond to nuclear security events, threat assessment and physical protection.

The two training centres namely the SNRS and the NSTC continued their efforts for

CEO of Certification Services of Pakistan (CeSP) Presenting ISO 9001: 2008 Certification to Director NISAS

the capacity building in nuclear safety and nuclear security areas respectively till the end of 2013. Thereafter, PNRA management decided to optimize the training capacities and merged the training entities SNRS and NSTC together. The new facility was named as "National Institute of Safety and Security (NISAS)". This institute was inaugurated by Director General of IAEA in March 2014.

NISAS is located within PNRA headquarters, Islamabad, with necessary training aids, class rooms and laboratories for hands on training. These labs include radiation detection laboratory; soft panel training simulator; small scale physical cut-away models of nuclear power plant equipment; physical protection mock-up model of NPP and physical protection interior laboratories.

ISO Certification of NISAS

Efforts were made for certification of NISAS as ISO 9001:2008 for which necessary documentation and procedures were developed and the institute was certified accordingly in 2015. Later, with the introduction of new ISO 9001:2015 standards, NISAS upgraded its training systems and accredited with the new ISO standards which is renewed annually.

The institute imparts trainings in nuclear safety, radiation safety and nuclear security for PNRA staff as well as those stakeholders who have a role in maintaining radiation safety and security of radioactive sources in the country. Figure-45 presents the number of training courses and the number of participants attending these courses.

9.4 Competence Development at National Level

There are a number of training institutions, organizations and universities at national level which arrange trainings and provide higher education in PNRA related domains. PNRA utilizes such avenues for competence development of its manpower.

PNRA utilizes training opportunities available at various national organizations to enhance competence of its employees in the relevant areas. In this regard, PNRA coordinates with a number of national training institutes. The most prominent 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 organizations provide trainings in different areas including welding techniques, non-destructive examination, managerial and interpersonal skills and office management, etc. Figure-46 reflects an overview of training courses held at national organizations through which PNRA officers have improved their competence.

Further, PNRA facilitates its employees to pursue higher studies at national universities. A number of officials have benefited and improved their academic qualification, knowledge and skills in different technical and management disciplines from reputed national universities.

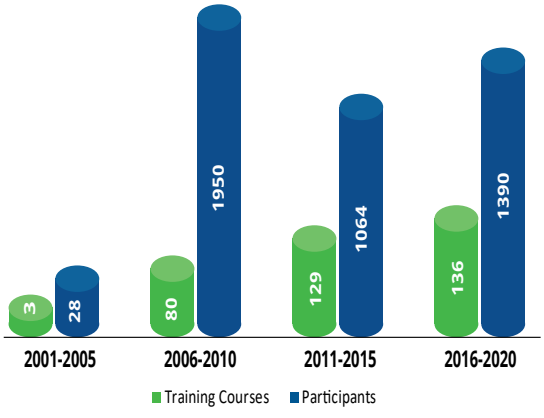


Figure-45: In House Training Courses Conducted at PNRA

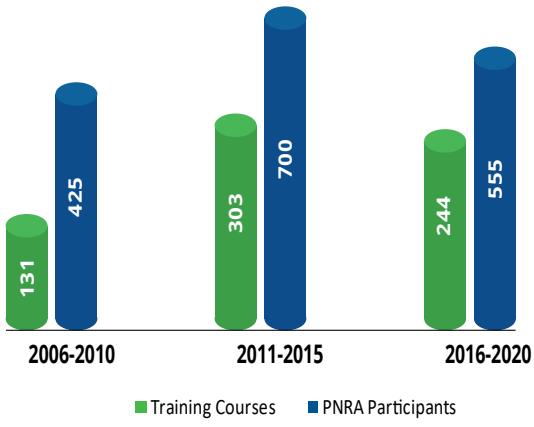


Figure-46: Participation in Capacity Building Events held at National Level

Member (Corporate) PNRA Presenting Shield to Vice President of China Nuclear Power Operation Technology Corporation, Ltd. (CNPO)

9.5 Competence Development at International Level

PNRA encourages its employees to enhance their competence and experience at international organizations and universities. In addition, IAEA provides opportunities to Member States for capacity building of their regulatory staff through technical cooperation program and bilateral arrangements to pursue higher studies at foreign universities.

PNRA works closely with the IAEA and other relevant organizations to explore such opportunities for its workforce. Detail of knowledge enhancement activities at international avenues is described in the next subsections.

9.5.1 Competence Development under IAEA Technical Cooperation Program

The International Atomic Energy Agency (IAEA), under its technical cooperation program, supports its Member States for capacity building in nuclear safety, radiation protection and nuclear security through organizing workshops, fellowships, scientific visits, training courses, etc. PNRA utilizes these opportunities for the competence development of its employees.

9.5.2 Competence Development under Bilateral Cooperation

PNRA has signed Memorandum of Understanding (MoU) 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. These organizations arrange trainings, workshops and provide placement opportunities for capacity building of PNRA officials in different areas relevant to regulatory functions. During the last 20 years, a number of PNRA officials have enhanced their competencies through such programs.

9.5.3 Competence Development through Higher Studies at Foreign Universities

PNRA supports its employees to avail opportunities of higher studies at foreign universities in relevant areas. During the past 20 years, a number of PNRA officials have successfully completed Masters and PhD level studies at various reputed universities in Australia, China, Korea, Malaysia, Switzerland and USA. Figure-47 depicts the number of officers who completed higher studies at foreign universities during the last two decades.

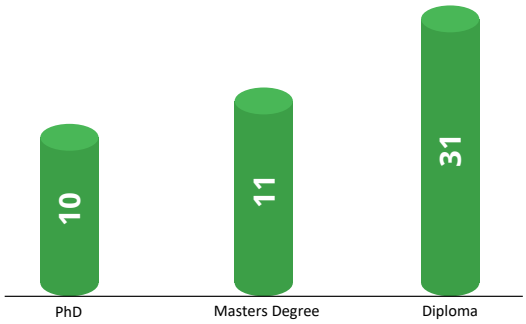


Figure-47: Competence Development through Higher Studies at Foreign Universities

9.6 Capacity Building through PSDP Projects

PNRA has been benefiting from the PSDP projects of the Government of Pakistan under which technical infrastructure of PNRA has significantly improved for nuclear safety, analytical assessment, nuclear security, environmental monitoring, dosimetry and calibration facilities, design assessment of NPPs, emergency preparedness & response and cyber security.

Over the past 20 years, PNRA has successfully executed eight PSDP projects while implementation of two more PSDP projects is in progress. Brief description of these projects is presented in the following subsections.

9.6.1 Centre for Nuclear Safety (CNS)

In 2005, the Government of Pakistan announced its Energy Security Plan, targeting an increase in the existing share of electricity by 20 fold in the next 25 years. Under this plan, the government envisaged to install a series of nuclear power plants. Consequently, capacity building of PNRA was necessary to cope with this expansion.

The regulatory review & assessment and inspection of nuclear installations are among the most important core functions of a regulatory body. These areas require in-depth technical expertise which is difficult to acquire for a newly established regulatory body. Therefore, in many countries these functions are contracted to national or foreign external bodies having such expertise, called Technical Support Organizations (TSOs). Since, such capability was not available anywhere in Pakistan except with the licensee organization, therefore, PNRA used to depend heavily on regulatory body of vendor country for review of safety analysis reports. The assistance so acquired involved a considerable amount of foreign exchange and, therefore, it was imperative for PNRA to develop an in-house technical competence to support licensing of upcoming nuclear power plants.

Keeping this in view, PNRA initiated a project

Signing of Technical Cooperation Agreement between PNRA and Nuclear Safety and Radiation Protection Centre of China

under the Public Sector Development Program (PSDP) of the Government of Pakistan. Under this project, PNRA established an internal technical support centre namely Centre for Nuclear Safety (CNS) by hiring more than 50 professionals in different disciplines of engineering and physical sciences. The objective of establishing CNS was to enhance capacity for performing in-depth safety review supplemented by analytical assessments to support the licensing and regulatory decision making process of PNRA.

With the establishment of CNS, the dependency on foreign regulatory body was gradually reduced thereby saving significant foreign exchange reserves of the country and becoming self-sufficient in review of NPP submissions. Establishment of the CNS has provided a pool of experts to support various regulatory and licensing activities related to evaluation of site, design, construction, commissioning, operation and assessment of design modifications of NPPs. This has strongly contributed in maintaining an independent insight in the safety of nuclear power plants which has enabled PNRA in timely, cost effective and efficient regulatory decision making for existing and new NPPs.

9.6.2 Safety Analysis Centre (SAC)

In view of the Government's plan for installation of advanced design nuclear power plants at Karachi near KANUPP, PNRA envisaged to further expand its technical support capabilities. Consequently, PNRA proposed another PSDP project to the Government of Pakistan in 2009 to establish a dedicated centre at Karachi to further strengthen its analytical capabilities. This project was completed in June, 2016 and as an outcome, capability for performing audit calculations of advanced design nuclear power plants was achieved in the areas of thermal hydraulics, structural and stress analyses, computational fluid dynamics and probabilistic safety analysis.

9.6.3 School for Nuclear and Radiation Safety (SNRS)

PNRA was implementing in-house professional training programs since 2003 without any proper training facility. PNRA realized the need for establishment of a dedicated training facility with necessary labs and established a training centre, under a PSDP project, namely School for Nuclear and Radiation Safety (SNRS) in 2006. The SNRS was established for competence building of PNRA employees and stakeholders in nuclear safety, radiation protection and regulatory control. The school also arranged specialized training courses in regulatory inspections, review and assessments, thermal hydraulics and regulatory framework for enhancing

IAEA-Pakistan Nuclear Security Cooperation Program Signing Ceremony

regulatory competence of PNRA officials. This project was completed in 2012.

9.6.4 Nuclear Security Action Plan (NSAP)

Security of nuclear and radioactive materials attracted world attention after the event of 9/11 by foreseeing that it could be utilized for malicious intent. Therefore, PNRA recognized the need of time and initiated a PSDP project namely Nuclear Security Action Plan (NSAP), duly approved by the Government of Pakistan in 2006.

Details of PNRA activities under this project are described in Chapter 6 of this report.

9.6.5 National Environmental Monitoring Program (NEMP)

PNRA initiated execution of National Environmental Monitoring Program (NEMP) project under PSDP in 2007.

Details of this project are reflected in Chapter 4 of this report. The project was completed in 2014.

9.6.6 National Dosimetry and Protection Level Calibration Laboratory (NDCL)

PNRA ensures that the dose received by individuals working in radiation environment is within the prescribed limits. Therefore, a need was realized for the establishment of dosimetry laboratories for cross verification of the exposure data of radiation workers. Furthermore, it was also recognized that in case of nuclear or radiological emergencies, the first responders may be exposed to radiations. Since, there was no other organization in the country to provide dosimetry services to the first responders; therefore, establishment of dosimetry setup was considered important to cope with such situation in future.

PNRA proposed a PSDP project namely, National Dosimetry and Protection Level Calibration Laboratory (NDCL) which was approved by the Government of Pakistan in 2007.

The objectives of the project were to carry out external and internal dosimetry of radiation workers, cross verify the exposure data of dosimetry service providers and monitor personal radiation doses of first responders in case of nuclear or radiological emergency situations.

Three types of laboratories were established under NDCL project including external dosimetry, internal dosimetry and protection level calibration laboratories respectively. The external dosimetry laboratory is used for monitoring personal radiation doses of PNRA inspectors as well as other radiation workers, whereas, the internal dosimetry

Ground Breaking Ceremony of NDCL and NERSP Laboratories by Director General SPD

Inauguration Ceremony of National Environmental Radioactivity Surveillance Programme (NERSP) Laboratory by Chairman PNRA

laboratory is utilized for assessment of internal contamination of radiation workers on request basis. Furthermore, in order to assist licensees in timely calibration of their radiation detection equipment and share the burden with the existing national level calibration facility, PNRA established calibration laboratories at Islamabad and Kundian. These laboratories are providing calibration services to PNRA directorates and licensees on request. This is a tertiary level calibration laboratory and is traceable to SSDL PINSTECH, Islamabad. The execution of the project was completed in 2014.

9.6.7 PNRA Residential Colony (PRC) Chashma

PNRA is regulating four nuclear power plants and a large number of radiation facilities in Chashma and surrounding region including Sargodha, Bannu, D.I.Khan and Khushab. It has posted a number of technical officers and supporting staff for round the clock regulatory oversight of operating nuclear power plants and radiation facilities. Further, Chashma is a distant area where standard and secured residential facilities are not available in the nearby surrounding areas.

Inauguration of PNRA Residential Colony Chashma by Chairman PNRA

PNRA realized the need for provision of a safe and secure residential facility for the employees and their families in this remote area.

In view to facilitate the employees, PNRA under a PSDP project established a residential colony comprising 48 residential units of different categories. Further, hostels for officers and staff, a guest house, mosque, tuck shop and security barracks were also constructed. The whole complex is constructed over 34 kanals of land. The project was completed in June 2018.

9.6.8 Design Assessment and Analysis of NPPs (DAAP)

In 2016, PNRA foresaw that national organizations may be involved in the design of nuclear safety class equipment and submit applications for design certification. Therefore, it was decided at the management level to improve and strengthen competence of the workforce for assessment of such licensing submissions. Thus, PNRA executed another project under PSDP, namely Design Assessment and Analysis of Nuclear Power Plants (DAAP) duly approved by the Government of Pakistan.

The objective of the project was to further strengthen PNRA's capabilities for design assessment and analysis through capacity building and training of officials. The prime focus was to enhance existing capabilities in assessment and analysis of licensing application of design organization. PNRA acquired software, computer codes and arranged training in specialized areas for its manpower. The project was successfully completed in 2020.

9.6.9 Up-gradation of National Radiological Emergency Coordination Centre (NRECC)

PNRA Ordinance obliges PNRA to provide advice to the government authorities regarding matters related to nuclear safety and radiation protection as well as to ensure that corrective actions are undertaken when unsafe conditions are detected. It is also the responsibility of PNRA under international conventions to provide details about radioactive release, accident progression and possible trans-boundary consequence of any nuclear accident to international community.

Considering the lessons learnt from Fukushima Nuclear Power Plants Accident in Japan and increasing use of radiation sources and nuclear energy in the country, PNRA earnestly felt the need for up-grading National Radiation Emergency Coordination Centre (NRECC) to enhance its capabilities for effectively monitoring the radiation levels in case of a nuclear accident or radiological emergency and advise the Government

Signing of Contract between PNRA and ICCC for the Establishment of Central Data Acquisition & Display System

and relevant organizations to implement protective measures.

Establishment of NRECC Project

PNRA initiated a PSDP project which was approved by the Government of Pakistan in 2015 for the development of the necessary infrastructure including establishment of two regional radiation emergency coordination centres at Karachi and Chashma. The project is expected to be completed in 2021.

As an outcome of the project, PNRA will have arrangements for continuous monitoring of radiation levels throughout the country, advance tools for assessing emergency situation and its consequences for the public and environment, on-line access to meteorological data, reliable and diverse communication means as well as the trained manpower. In addition, the project will enable availability of advanced portable equipment for radiation monitoring teams, mobile radiation monitoring laboratories and a purpose-built building with infrastructure for effective coordination with national and international organizations.

9.6.10 Cyber Security and Digital Safety (CSDS)

Instrumentation and control systems are being digitized at nuclear installations all over the world. Software based digital systems are replacing analogue systems for operations, control, safety and security functions at nuclear power plants. Prime drivers of this change are significant reduction in cost, ease of use/re-use and maintenance. However, digital technology inherits vulnerabilities which may pose risk to the safety of nuclear power plants.

Introduction of software in safety systems, ethernet based communication between safety and non-safety I&C systems; mixing of IT / I&C networks; qualification and licensing; their human-machine interface and safeguarding them against cyber threats are associated challenges. The challenges primarily concern ensuring integrity, reliability, availability and/or confidentiality of software based I&C systems utilized in safety, control, monitoring and security systems; and information related thereto.

For this, PNRA is implementing a PSDP project titled "Reinforcement of PNRA's Capacity and Regulatory Oversight against Vulnerabilities of Digitized Controls and Cyber Threats (Cyber Security & Digital Safety)" to cope with the challenges expected to safety of nuclear installations due to change in technology from analogue to digital systems.

PNRA, under this project, intends to develop a team of experts to be able to establish necessary regulatory infrastructure for ensuring safety of nuclear installations with digital software based safety and safety related systems, assess the impact of cyber security on safety and safeguard PNRA's official network against cyber threats.

PNRA aims to enhance capacity of its manpower in the design and manufacturing of digital software based equipment, safety & cyber security of critical infrastructure, impact of cyber security measures on the safety of critical system, structures and components and cyber security of data, voice and I&C networks.

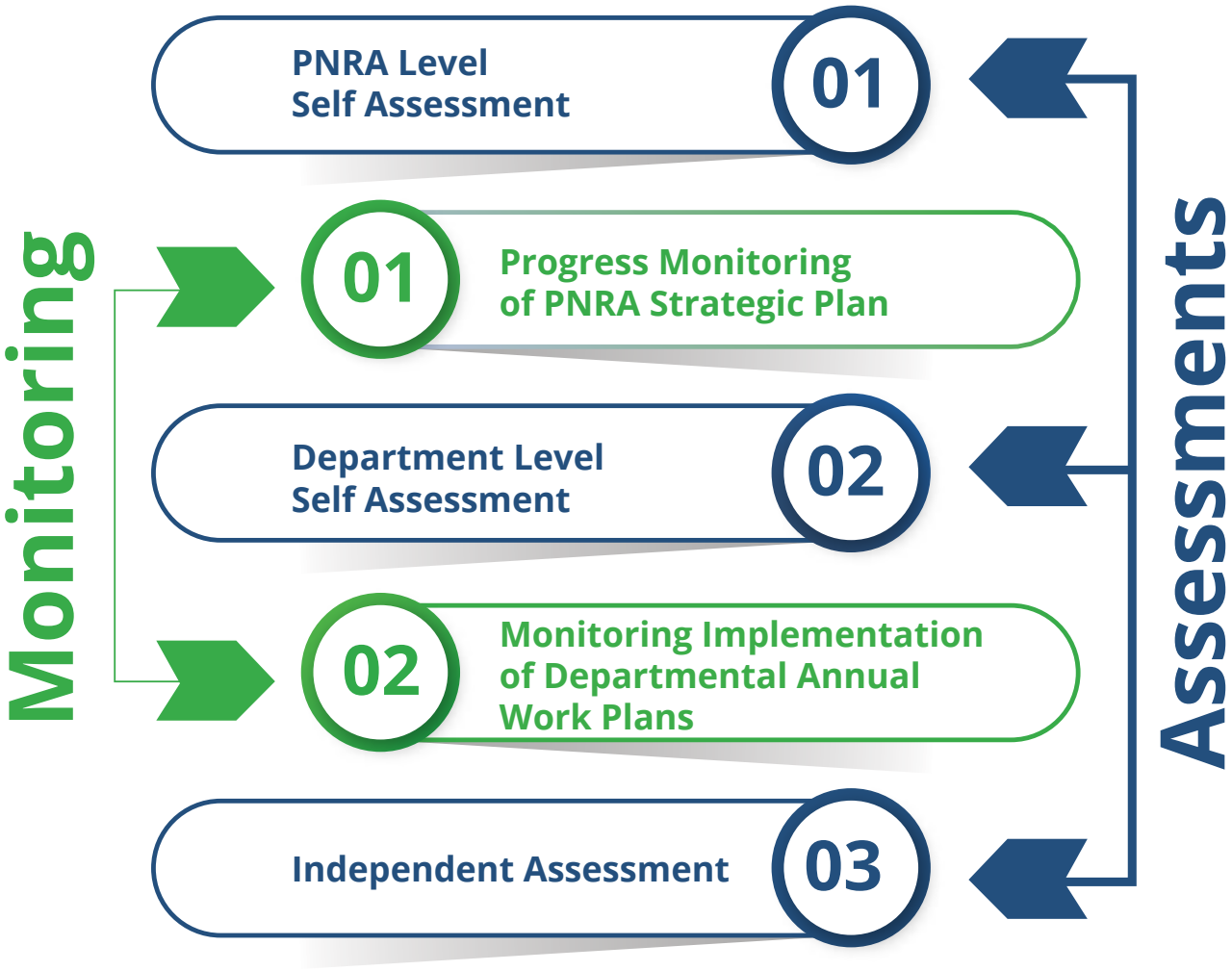
The Government of Pakistan has approved this PSDP project in 2018 which is expected to be completed in 2023.

The inception of PNRA in 2001 posed many challenges; the top being acute shortage of skilled professionals for regulating nuclear installations, radiation facilities and associated activities. Thus a dynamic and multi-pronged approach was the need of hour to overcome manpower shortage and taking appropriate steps for the capacity building.

It was through the right guidance and visionary mindset of the PNRA management; efforts were undertaken for the capacity building of employees at technical and managerial levels that ensured smooth regulatory functions. The three pronged approach of relying on our resources; collaboration with national institutes and international bodies; and the diverse capacity building projects ensured availability of knowledgeable and skilled professionals at PNRA for regulating all matters related to nuclear safety and radiation protection.

10

STRIVING FOR EXCELLENCE- MONITORING AND ASSESSMENT



PNRA is aware that the performance of the organization can be improved with regular monitoring and assessment of the activities being carried out by its various units. Monitoring and assessment always help in identifying gaps in activities which enable the management to re-enforce resources for strengthening weak areas.

Keeping this in view, PNRA developed several mechanisms for monitoring and assessment of its performance. These included self assessment, internal assessment and external peer reviews. These assessments have identified various shortcomings in the processes and practices which were seriously addressed in action plans that resulted in satisfactory improvements in the overall performance of the organization. This Chapter describes various monitoring and assessment methodologies adopted by PNRA for improvement in its performance.

10.1 Monitoring Implementation of Work Plans

PNRA has been regularly developing annual work plans and strategic plans to meet vision, mission and objectives of the organization efficiently and timely. PNRA regularly monitors the progress of implementation of these plans.

Each PNRA department prepares annual work plan in the light of its assigned tasks and functions. Each department prepares and reports progress of implementation of their annual plan on monthly and annual basis. In 2011, PNRA initiated a systematic performance monitoring and assessment of its departments against their annual work plans on quarterly basis. Accordingly, Quarterly Performance Evaluation Reports (QPERs) were issued highlighting areas which required improvements in performance.

Development of First Strategic Plan

PNRA developed its first strategic plan in 2011 for a period of two years i.e. 2012 – 2013 containing organizational goals, strategies and activities for achieving the goals during the specified time period. PNRA conducted monitoring of this plan periodically.

After successful implementation of the first strategic plan, PNRA developed other strategic plans for the years 2015 - 2018 and the years 2019 - 2023. Over the years, PNRA continued the practice of periodic monitoring of these plans and issued annual progress reports identifying the areas requiring improvement. Detailed evaluation reports were also issued on completion of timeline of each strategic plan.

10.2 Self Assessments

PNRA utilizes various self assessment methodologies to assess and evaluate its own actions and performance. These include assessments conducted at department level as well as at organization level. Various types of self assessments performed by PNRA are reflected in Figure-48. Detail of various self assessment mechanisms is described in the next subsections.

Figure-48: Various Types of Self Assessments Performed in PNRA

10.2.1 Strategic Performance Assessment

PNRA developed Strategic Performance Indicators (SPIs) to perform self-assessment at organizational level in 2003. Performance of each indicator is rated on a five level rating scale i.e. satisfactory, minimally acceptable, needs improvement, unsatisfactory and not acceptable. Accordingly, first assessment against these indicators was performed and published in PNRA's first Annual Report 2001-2005. Since then, PNRA has continued this practice and every year the evaluation is shared with the public through PNRA annual report.

PNRA further elaborated this assessment process in 2013 by defining specific performance elements against each SPI. In 2019, PNRA initiated revision of indicators and subsequent elements which is in progress.

10.2.2 Department Level Self Assessment

In 2010, PNRA initiated a practice of conducting departmental level self assessment. Every department of PNRA performs its self assessment biennially.

PNRA departments performed self assessments as per defined frequency and corrective actions were identified and implemented for improvement in different areas.

10.2.3 Safety Culture Self Assessment

PNRA took the initiative to perform a Safety Culture Self Assessment (SCSA) in 2013. In this regard, assistance was also sought from IAEA. A dedicated team performed this assessment during 2013-2016. The assessment methodology and findings were shared internationally which were highly appreciated.

10.3 Internal Regulatory Audit

Regulatory Audit is a tool to independently evaluate and improve the effectiveness of various organizational units. PNRA initiated internal regulatory audit of its departments in 2011. Independent teams comprising personnel from different departments of PNRA perform regulatory audit of each department after every two years. Audit reports containing recommendations and suggestions for improvement are issued and departments prepare corrective action plans. Implementation of these plans is regularly monitored. Apart from department level audit reports, integrated audit reports are also issued after each audit which highlights overarching organizational issues for consideration of management. Over the years, PNRA has conducted four regulatory

IAEA Expert Delivering Lecture on Safety Culture Self Assessment

audits and issued integrated audit reports in years 2011, 2014, 2016 and 2018 respectively. Further, during the year 2020, PNRA conducted Follow-up audit on the status of recommendations and suggestions issued in the audit reports.

10.4 Licensees' Feedback on Regulatory Performance

PNRA has developed a mechanism to assess its regulatory performance through acquiring feedback directly from its licensees in order to enhance its regulatory effectiveness. This feedback is obtained on a pre-developed questionnaire comprising specific queries on various aspects of regulatory processes and functions.

Feedback from Radiation Facilities

PNRA obtained feedback from licensees of radiation facilities twice, first in 2013 and second in 2020. Accordingly, the evaluation reports containing areas for improvement were shared within the organization for improvement.

In 2018, feedback from nuclear installations was obtained and a number of actions were initiated for improvement.

Furthermore, during the year 2020, PNRA initiated the process to acquire feedback from licensees of diagnostic X-ray facilities. For this purpose, a new questionnaire was developed in national language 'Urdu' and distributed to more than 5000 diagnostic X-ray facilities. Responses from the licensees are being received and will be evaluated next year.

10.5 IAEA Peer Review Missions

The IAEA has developed mechanisms for independent review and evaluation of Member State's regulatory regimes for nuclear safety, security, emergency preparedness and response etc. The Agency constitutes teams comprising knowledgeable and experienced professionals from IAEA and different Member States for conducting peer reviews on formal request of Member States. The review includes areas like regulatory framework, oversight capabilities and practices of the concerned regulatory body and compares it with international safety and security standards. This enables the review team to identify observations, recommendations and good practices. PNRA has invited different international peer review missions from IAEA in the past for evaluation of its regulatory regime for nuclear safety, details of which are described in the next subsections.

10.5.1 Integrated Regulatory Review Team (IRRT) Mission

PNRA invited the first IAEA Integrated Regulatory Review Team (IRRT) Mission in December 2003 for full-scope review of capabilities, performance and practices of the newly established regulatory body. The IRRT mission thoroughly evaluated the regulatory framework and activities being performed for the protection of human health and environment. The mission prepared a report containing recommendations and suggestions for further improvements and also identified some "good practices" at PNRA. The IRRT concluded that Pakistan had made good progress towards establishing an independent and sustainable nuclear regulatory regime in the country.

10.5.2 Radiation Safety Infrastructure Appraisal (RaSIA) Mission

PNRA hosted another IAEA review mission on Radiation Safety Infrastructure Appraisal (RaSIA) in 2005. This mission focused on the review of elements for radiation safety of regulatory infrastructure and practices. RaSIA mission concluded that Pakistan had a well-developed legal infrastructure for radiation safety and an effective system of licensing, inspection and enforcement for the control of radiation sources.

10.5.3 Education and Training Appraisal (EduTA) Mission

In 2003, PNRA initiated in-house training program for the competence development of its manpower through professional trainings in regulatory domains. The training became a regular activity for which appropriate training facility was developed. PNRA arranged trainings identified through TNA conducted in 2004 in a sustainable manner. In 2013, PNRA invited the IAEA Education and Training Appraisal (EduTA) mission to

Participants of Education and Training Appraisal (EduTA) Mission to PNRA

assess the framework, infrastructure and training curricula developed for education and training particularly in the fields of radiation, transport and waste safety. The mission identified several recommendations for further improvements in education and training program.

10.5.4 Education and Training Review Services (ETRES) Mission

In November 2013, PNRA hosted IAEA Education and Training Review Services (ETRES) mission. This mission evaluated national level arrangements and infrastructure for education and training in nuclear and radiation safety. The Mission report contained several recommendations and suggestions for improvement. This activity assisted PNRA to develop a comprehensive picture of nuclear safety education and training at national level. These missions have highly applauded PNRA at the international arena for its competence developments efforts for its employees.

10.5.5 Integrated Regulatory Review Services (IRRS) Mission

Pakistan invited an Integrated Regulatory Review Services (IRRS) mission of IAEA in 2014. The purpose of the mission was

Education and Training Review Services (ETRES) Mission to PNRA

IRRS Team Coordinator during the Introductory Session of IRRS Mission to PNRA

to assess the legislative and regulatory infrastructure established for nuclear and radiation safety in Pakistan and to evaluate regulatory effectiveness and efficiency of PNRA. The IRRS team identified a number of good practices as well as recommendations and suggestions for improvements to enhance the effectiveness of the PNRA regulatory framework and processes in line with the IAEA Safety Standards. The IRRS team recognized that many of the issues identified during the review had already been identified during PNRA's self-assessment. Accordingly, PNRA devised an action plan to implement the recommendations and suggestions of IRRS mission and periodically monitored the progress of implementation and shared with relevant stakeholders. A follow-up IRRS Mission is planned in near future.

10.5.6 IAEA Office of Internal Oversight Services (OIOS) Mission

The Office of Internal Oversight Services (OIOS) mission visited Pakistan in 2014 to conduct audit of IAEA Technical Cooperation (TC) Projects. The mission selected four TC Projects of PNRA and visited various offices and laboratories. The team inspected the equipment procured through the IAEA TC Projects and its utilization for the intended functions. The mission concluded that all the intended activities were successfully completed and utilized allocated resources appropriately.

10.6 Bilateral Peer Review Mission of PNRA Technical Support Centre

PNRA invited a peer review mission of Chinese regulatory body namely, National Nuclear Safety Administration (NNSA) in 2006. The objective of this mission was to perform assessment of organizational structure, functions and responsibilities of Centre for Nuclear Safety (CNS), the newly established internal technical support centre of PNRA. The mission concluded that CNS has a well established setup and its capacity building program is fruitful for PNRA to develop a professional team having expertise in review and assessment and analytical analysis to support regulatory decisions in licensing activities of nuclear power plants.

It can be concluded that various mechanisms for assessment & evaluation of performance of the organization and continuous monitoring identified various shortcomings in internal processes and practices in a timely manner. PNRA management formulated different action plans for elimination of the gaps. These actions have been fruitful for improvement in the overall performance of the organization.

11 HONORS AND RECOGNITIONS

11.1 Civil Awards

Mr. M. Anwar Habib
Ex-Chairman PNRA
Hilal-e-Imtiaz
2018

Mr. Zaheer Ayub Baig
Chairman PNRA
Hilal-e-Imtiaz
2019

Mr. Mahboob Ali
Ex-Member Executive PNRA
Sitar-e-Imtiaz
2017

11.2 NCA Awards

Mr. M. Shakilur Rahman
Ex-Member Executive PNRA
NCA Award
2015

Mr. M. Saleem Zafar
Member Corporate
NCA Award
2017

Mr. M. Siddique Javed
Senior Principal Engineer
NCA Award
2016

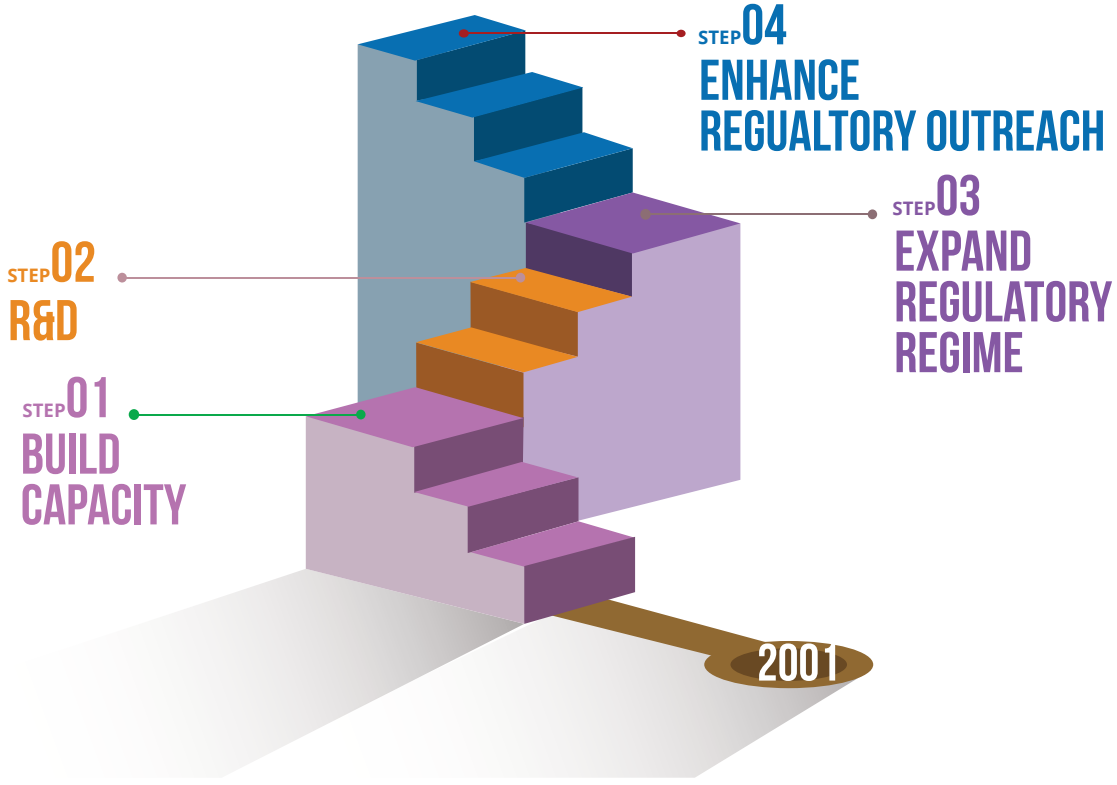
Mr. Shahbaz Ali Nasir Bhatti
Principal Engineer
NCA Award
2020

Mr. Mohammad Riyasat
Principal Computer Technician
NCA Award
2018

11.3 Commendation Card

Hafiz M. Zubair Arif
Principal Scientific Officer
CJCSC Commendation Card
2019

12 WAY FORWARD



PNRA has completed twenty years of its existence in pursuit of its mandate and mission for protecting people and environment from the harmful effects of ionizing radiation. In order to achieve continual excellence in a rapidly advancing world, there is still a long way to go with future challenges.

12.1 Emerging Challenges and Fields of Regulatory Interest

PNRA considers the current and emerging challenges described below as opportunities to learn from and evolve into a more responsive, competent and transparent regulatory body.

12.1.1 Regulating Nuclear Fuel Cycle

The nuclear fuel cycle comprises front-end industry such as mining, processing, fuel fabrication, etc. and back-end facilities like spent fuel storage, storage of radioactive waste, etc. In future, PAEC is planning to indigenize the nuclear fuel cycle for its civilian nuclear power plants for which PNRA needs to be well-prepared and enhance its competencies for fulfilling the impending regulatory responsibilities. Keeping this in view, PNRA has started work on the development of regulations on nuclear fuel cycle well in advance.

12.1.2 Regulating Design and Manufacturing of Systems, Structures and Components Important to Safety

Pakistan has around 50 years of experience in operating different types of NPPs and research reactors. With this vast and rich experience, Pakistan is aiming towards indigenization of design and manufacturing of mechanical, electrical and Instrumentation and control (I&C) equipment as well as pre-service / in-service inspections (PSI / ISI) of NPPs and design of safety related civil structures.

Pakistan is also aiming for indigenization of the design process of NPPs and research reactors. PNRA needs to build capacity of its manpower to be able to assess the submissions of design organizations and service providers. In this regard, preparation of regulatory framework is in progress.

12.1.3 Regulating Decommissioning of First Nuclear Power Plant

PAEC has shown intention to permanently shutdown K-1 for decommissioning in August, 2021 by following the deferred dismantling strategy. PNRA is responsible for ensuring that decommissioning activities are conducted safely; radioactive material and spent nuclear fuel are disposed of properly and that the radiation exposures are within the prescribed regulatory limits during the decommissioning process.

Being first of its kind activity in Pakistan, PNRA has to be well competent to regulate all stages of decommissioning of K-1 including removal from regulatory control. PNRA has performed comparative study of various regulatory frameworks in this regard. Accordingly, PNRA has issued administrative regulatory requirements for decommissioning. Currently, PNRA is in process of finalizing codes and standards to be followed for this purpose.

12.1.4 Cyber Security

Instrumentation and control (I&C) of nuclear installations is being transformed by using more advanced digital equipment instead of conventional analogue systems and components. This transformation, although have many benefits such as reduction in size of equipment, flexibility, prompt and user friendly in operation; however, it carries some vulnerabilities such as qualification, common cause failures and cyber security issues due to involvement of computer software. Thus, there is a need to develop regulatory framework and guidance documents to regulate the cyber security and safety of digital I&C equipment. In this regard, PNRA has undertaken a PSDP project with the aim to develop associated regulatory requirements and research infrastructure by establishing laboratories, keeping in view the worldwide best practices.

12.1.5 Expansion of PNRA Infrastructure for Strengthening Regulatory Oversight

PNRA will have to expand its physical presence in the country owing to the expansion in number of regulated installations and

facilities. Some existing offices may need to be upgraded in future where new NPPs are proposed to be constructed and operated. Similarly, the China Pakistan Economic Corridor (CPEC) project is expected to create opportunities for transit of goods through Pakistan in near future. Thus, PNRA will have to establish its offices with necessary radiation detection gadgetry near the entry-exit points of the country, particularly Gawadar Port and Khunjrab Pass on China border in order to provide support to law enforcement agencies. PNRA has recently established its office in Gilgit to regulate the users of ionizing radiation in Gilgit-Baltistan region. However, keeping in view the expansion of radiation users in nuclear medicine & industrial sectors and diagnostic X-ray, new centres will have to be developed in other areas (e.g. Lahore and Sukkur).

12.1.6 Research and Development

Research and development (R&D) are important factors which help in achieving regulatory excellence. Since its inception, PNRA has been working closely with national and international academic institutions for conducting research in diverse areas related to nuclear and radiation safety. So far, PNRA has performed R&D in different nuclear safety areas including seismic and tsunami analysis; air craft impact assessment of containment; assessment of emergency planning zones; radiation dispersion assessment; use of risk insight in design, mitigation of severe accident consequences; restriction and fabrication of radioactive waste (radioiodine) matrix. In the domain of radiation safety, R&D has been initiated for dose minimization of therapeutic patients through image reconstruction, minimization of doses of skin cancer patients using Monte Carlo techniques, radiation safety in radioisotope production & internal dosimetry, etc.

In future, PNRA intends to increase its cooperation with academic institutions (including research laboratories) in specific areas of nuclear safety and radiation protection. This includes risk assessment (level-2 and level-3), severe accident management & mitigation of consequences, safety evaluation of emerging technologies (SMRs, NPPs), evaluation of emerging medical diagnostics & teletherapy techniques (proton and boron, neutron and carbon therapy, cyber knife, gamma knife, etc.), dose reconstruction techniques, nuclear waste management (decommissioning of NPPs and cyclotron, repository design and accelerator driven systems, etc.). PNRA anticipates to integrate the insights of R&D activities in the regulatory processes.

12.1.7 Design and Manufacturing of Radiation Sources

Use of radiation in industry, agriculture and medicine has grown exponentially over the last decade in Pakistan. Radiation sources today are used in a variety of equipment in medical diagnostics and radiotherapy, industrial irradiation, radiographic imaging, etc. Efforts are underway to start manufacturing of radioactive sources and radiation generators within the country. Ultimately, PNRA needs to strengthen its regulatory framework for regulating these activities in line with international standards.

12.1.8 Capacity Building in Advanced and Emerging Fields

As the use of nuclear technology evolves with every passing day, new technologies are surfacing. These include Generation – IV reactors and novel reactor design such as Small Modular Reactors (SMRs). Similarly, new modalities in medical and industrial sectors are also evolving with time. However, current regulatory regimes, not only in Pakistan, but also worldwide, are in the process of developing regulatory requirements and mechanisms to regulate these designs and modalities. Accordingly, PNRA will have to build, in advance, its capacity to develop the regulatory framework for licensing and regulatory oversight before their utilization in Pakistan.

Above are some examples where PNRA has been working or planning to work; executing efforts to improve capacities in emerging technologies; and planning to expand its presence in the country to strengthen its regulatory oversight. PNRA is determined for fulfilling its regulatory responsibilities in line with future developments in the areas of nuclear and radiation safety.

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