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PAKISTAN NUCLEAR REGULATORY AUTHORITY

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Message from the Chairman



Jamshed Azim Hashmi
Chairman
Pakistan Nuclear Regulatory Authority
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My colleagues and I are pleased to present this report of the achievements of the Pakistan Nuclear Regulatory Authority (PNRA) in its first five years, that is, the period from 2001 to 2005.

An independent and competent regulatory authority is a prerequisite for the safe operation of nuclear installations and radiation facilities in a country. PNRA was created for this purpose under the Pakistan Nuclear Regulatory Authority Ordinance, 2001. Broadly, the Authority is responsible for protecting the public, workers and the environment from the harmful effects of radiation; safeguarding the investments made in nuclear facilities by reducing the consequences of nuclear incidents; and protecting the nation from the misuse of radiation sources.

An important element of our role is developing and implementing the legislative and regulatory framework for nuclear and radiation safety. In this regard, PNRA has formulated and notified a number of regulations in the Gazette of Pakistan.

Since its inception, PNRA has brought about significant improvements in the regulation of radiation facilities. A registry of ionizing radiation sources has been established to track all radioactive sources imported into Pakistan. Through various initiatives, PNRA has encouraged a large majority of diagnostic radiation facilities to get registered, obtain licences and enter its safety net.

As a national nuclear regulator, PNRA represents Pakistan in several international organizations and is responsible for fulfilment of national commitments accruing from bilateral and multilateral agreements as well as international conventions. We presented Pakistan's National Reports in the review meetings of the IAEA Convention on Nuclear Safety and demonstrated Pakistan's commitment to fulfilment of obligations. We also ensured that all the obligations under the Conventions on "Early

Notification of a Nuclear Accident", "Assistance in the Case of a Nuclear Accident or Radiological Emergency" and "Physical Protection of nuclear materials" were fulfilled.

Efforts are in progress to further build emergency preparedness and response coordination, and cooperation with national and international organizations.

Alongside its routine work, PNRA has been striving for continuous improvement of its regulatory performance. Towards the end of 2003, we invited a mission of the International Regulatory Review Team (IRRT) of the International Atomic Energy Agency (IAEA) to conduct a full-scope review of its practices. The Team was of the opinion that PNRA has all the prerequisites of a good regulatory body and fulfils its national and international commitments. In 2005, an IAEA Radiation Safety Infrastructure Appraisal (RaSIA) Mission was invited to review PNRA's work on radiation, waste and transport safety aspects. Successive IAEA peer reviews and appraisals demonstrated that Pakistan's regulatory infrastructure continues to develop in line with international standards. As a further step in this direction, with the approval of the Government of Pakistan, PNRA also established, in June 2005, a technical support organization - the Centre for Nuclear Safety - for its institutional strengthening and capacity building.

Continuous and thorough reviews and assessments by PNRA revealed that the operation of nuclear installations in the country remained safe and reliable in 2001-05 and that all commitments resulting from international agreements and conventions were fulfilled.

We are deeply cognizant of our growing role and responsibilities in the coming years: to meet the country's future power needs, the Government of Pakistan envisages an expansion in the nuclear power program that will increase power production from the current 437 MWe to 8,800 MWe by 2030. In this regard, PNRA has proactively identified, planned and initiated a number of necessary actions.

Building a sound relationship with the public is important at PNRA, and I am confident that readers will find this report a very useful introduction to PNRA, its work, and the status of nuclear and radiation safety in our country.

Abbreviations and Acronyms

ACISS	Advisory Committee on Draft International Safety Standards
ACRD	Advisory Committee on Research and Development
ALARA	As Low as Reasonably Achievable
ANSN	Asian Nuclear Safety Network
ASME	American Society for Mechanical Engineers
C-1	Chashma Nuclear Power Plant, Unit 1
C-2	Chashma Nuclear Power Plant, Unit 2
CENS	Centre for Nuclear Safety in Central and Eastern Europe
CIT	COMSATS Institute of Information Technology
CNS	Convention on Nuclear Safety; Centre for Nuclear Safety
HMC	Heavy Mechanical Complex
IAEA	International Atomic Energy Agency
IRRT	International Regulatory Review Team
ISO	International Standards Organization
KANUPP	Karachi Nuclear Power Plant
LUMS	Lahore University of Management Sciences
M&E	Monitoring and Evaluation
MCR	Main Control Room
MRML	Mobile Radiological Monitoring Laboratory
NERS	Network of Nuclear Regulators of Countries with Small Nuclear Program
NOC	No Objection Certificate
NRECC	National Radiation Emergency Coordination Centre
NSD	Directorate of Nuclear Safety
PARR	Pakistan Research Reactor
PINSTECH	Pakistan Institute of Nuclear Science and Technology
PNRA	Pakistan Nuclear Regulatory Authority
PHWR	Pressurized Heavy Water Reactor
PWR	Pressurized Water Reactor
R&D	Research and Development
RaSIA	Radiation Safety Infrastructure Appraisal
RNSD	Regional Nuclear Safety Directorate
RPO	Radiation Protection Officer
RSD	Directorate of Radiation Safety
SRS	Sealed Radiation Source
STUK	Finish Nuclear and Radiation Safety Authority
USNRC	United States Nuclear Regulatory Commission
WSD	Directorate of Transport and Waste Safety

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Vision

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

Mission

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

1 INTRODUCTION TO PNRA

The Pakistan Nuclear Regulatory Authority (PNRA) was established by the Government of Pakistan in January 2001, with the promulgation of the Pakistan Nuclear Regulatory Authority Ordinance, 2001, as an independent regulatory body. This step was taken to ensure effective separation of regulatory activities from the work of nuclear energy promotion. The leadership of PNRA comprises of a Chairman, two full-time Members and seven part-time Members. The Chairman reports directly to the Prime Minister. The organization structure of PNRA is presented in Figure 1.

PNRA is empowered to control, regulate and supervise all matters related to nuclear safety and radiation protection in Pakistan. In this regard, it is empowered to develop and enforce rules and regulations, and issue guides for nuclear safety and radiation protection; develop and execute policies and programs for the protection of life, health and property against the risk arising from ionizing radiation; regulate the nuclear and radiation safety aspects of nuclear installations and radiation facilities; grant authorization, or issue licences, to nuclear installations or radiation facilities and their operators for the use of nuclear material and radioactive sources; and inspect all such facilities to ensure that regulations concerning safety measures are properly followed. PNRA also issues No Objection Certificates to importers and exporters of radioactive sources and Radiation Free Certificates for exportable food items.

Apart from on-site operations, transportation and disposal of radioactive materials also fall under PNRA's purview.

In addition, PNRA is the lead agency for ensuring that national preparedness for nuclear and radiological accidents is maintained by the operating organizations or licensees. It is also the point of contact for international agreements and collaborations concerning nuclear and radiological emergencies.

These core responsibilities are supported by related activities, such as: awareness building of concerned workers and the general public about nuclear and radiation safety issues; liaison with relevant government ministries and public administration bodies to improve implementation of safety measures in their spheres of work; and collaboration with national institutions for research in nuclear and radiation safety.

Activities are carried out according to well-established regimes that cater to national as well as international aspirations. As a young and forward-looking organization, PNRA lays great stress on enhancing its regulatory effectiveness and efficiency, particularly through capacity building and institutional strengthening measures.

INTRODUCTION TO PNRA

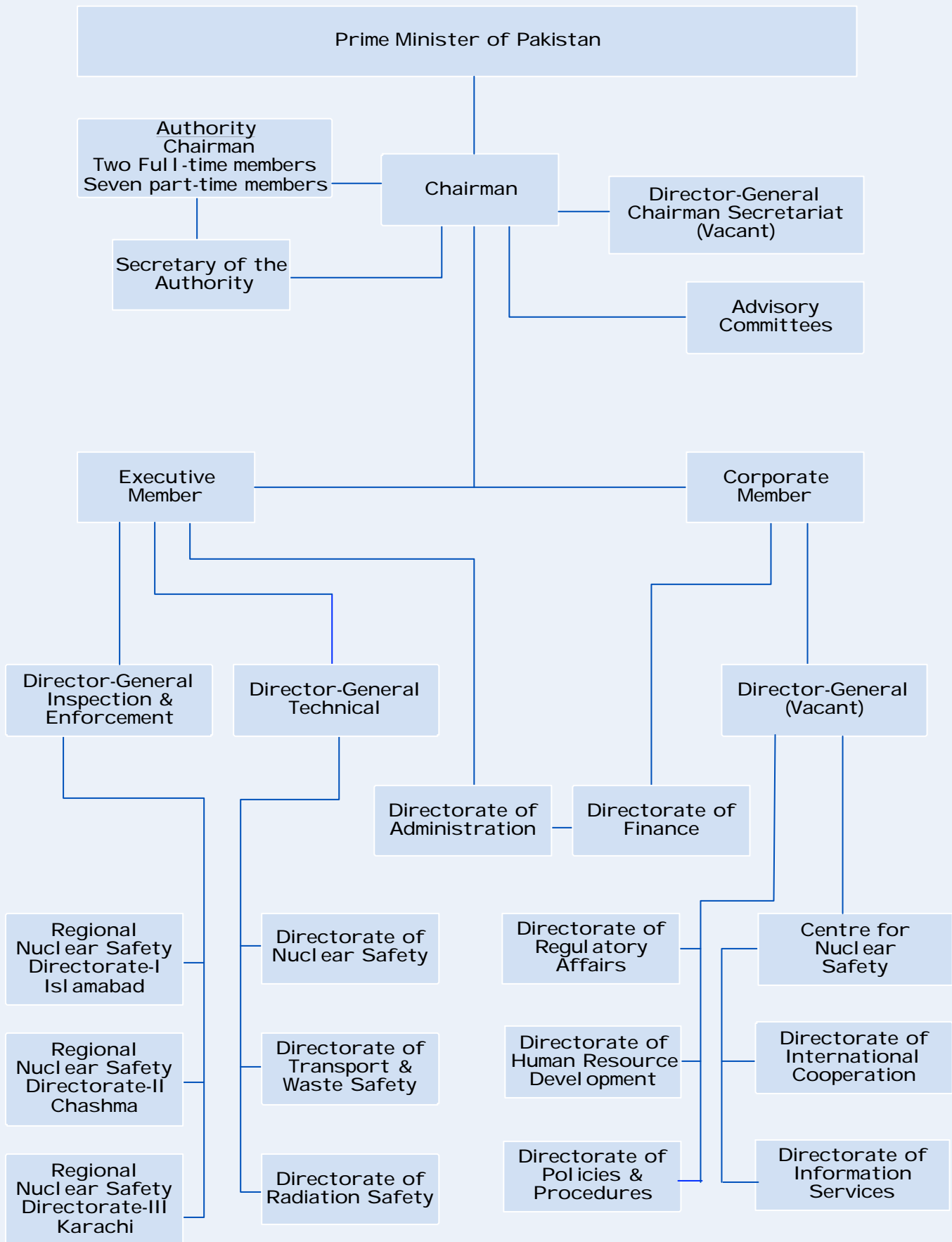


Figure 1: Organization Structure of PNRA

2 REGULATORY FRAMEWORK

The creation of PNRA, a fully independent regulatory body, reflects the commitment of the Government of Pakistan to ensuring optimum nuclear and radiation safety in the country. Using its powers under the Pakistan Nuclear Regulatory Authority Ordinance, 2001 (PNRA Ordinance), and keeping in view the requirements of international conventions, PNRA made significant progress in building the regulatory framework for nuclear safety.

The hierarchy of the regulatory framework of PNRA is depicted in Figure 2. PNRA formulates regulations that are based on the PNRA Ordinance and binding on the licensees. In addition, non-mandatory guides and guidelines are issued to provide technical guidance for meeting regulatory requirements.

REGULATIONS

PNRA issued the following seven regulations during 2001-2005:

- ▶ Regulations on Radiation Protection (PAK/904)
- ▶ Regulations for the Licensing of Radiation Facility(ies) other than Nuclear Installation(s) (PAK/908)
- ▶ Regulations for Licensing of Nuclear Installation(s) in Pakistan (PAK/909)
- ▶ Regulations on the Safety of Nuclear Power Plants Design (PAK/911)
- ▶ Regulations on the Safety of Nuclear Power Plants Quality Assurance (PAK/912)
- ▶ Regulations on the Safety of Nuclear Power Plants Operation (PAK/913)
- ▶ Regulations on Radioactive Waste Management (PAK/915)

PNRA also drafted regulations on "Safety of Nuclear Power Plant Siting", "Nuclear Accident or Radiological Emergency Management", and "Licensing of Nuclear Safety Class Mechanical Equipment Manufacturers". These are currently under review and are expected to be gazetted in the near future.

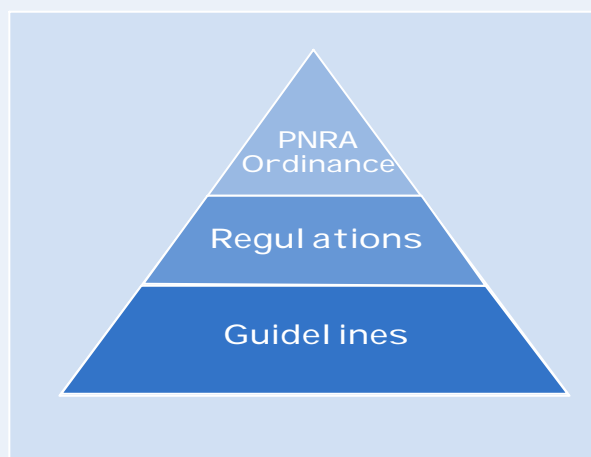


Figure 2: The PNRA Regulatory Pyramid

Notably, under the PNRA Ordinance, the regulations that were issued before PNRA's inception still apply until the Authority issues its own regulations. Such previously issued regulations include the Pakistan Nuclear Safety and Radiation Protection (PNSRP) Regulations, 1990; Treatment of Food by Ionizing Radiation Regulations, 1996; Export Policy and Procedures Order, 2000; Import Trade and Procedures Order, 2000; Licensing Procedure for Research Reactors in Pakistan; and Regulations for Licensing of Nuclear Research Reactor Operating Personnel.

TECHNICAL GUIDES AND GUIDELINES

To facilitate licensees in complying with its safety regulations, and effecting and maintaining the required improvements at their facilities, PNRA developed and adapted a number of technical guides and guidelines. These concerned safety of nuclear installations, radioactive waste management, medical exposure control, and use of sealed radiation sources.

3

NUCLEAR SAFETY

The PNRA Ordinance provides the legal basis for PNRA to regulate all matters related to nuclear safety at nuclear installations in the country. To ensure their safe operation, PNRA follows a graded approach based on the assessment of risk to workers, the public and the environment. The Authority has established a Directorate of Nuclear Safety (NSD) to oversee nuclear safety matters. NSD formulates the necessary regulations, guides and procedures for effective implementation of safety norms at nuclear installations, in addition to carrying out review, assessment, inspection and licensing activities.

REVIEW AND ASSESSMENT

KARACHI NUCLEAR POWER PLANT

Karachi Nuclear Power Plant (KANUPP) started commercial operation in 1972 and completed its design life of 30 years in 2002.

When the licensee applied for the renewal of the plant's operating licence, re-licensing activities in accordance with Regulations PAK/909 were initiated.

PNRA conducted a safety assessment of the plant to identify significant weaknesses so that suitable corrective actions could be taken. The assessment report, issued in September 2001, identified 24 safety concerns. The plant is currently in process of refurbishment to fulfil all the necessary safety requirements.



▲ **Karachi Nuclear Power Plant (KANUPP), a 137-MW_e Pressurized Heavy Water Reactor (PHWR)**

CHASHMA NUCLEAR POWER PLANT, UNIT 1

Chashma Nuclear Power Plant, Unit 1 (C-1) was connected to the grid on June 13, 2000 and attained full power in September 2000. After all regulatory requirements had been met, the plant's formal operating licence was issued in October 2004 valid up to December 2010. The plant underwent three refuelling outages, which were conducted in September 2002, April 2004, and October 2005 and monitored closely by PNRA. During these outages, several safety tests were performed by the licensee and regulatory inspections were performed by PNRA.



▲ **Chashma Nuclear Power Plant, Unit 1, a 325-MW_e Pressurized Water Reactor (PWR)**



▲ **Scenes from the ceremony at which C-1's Operating licence, valid up to December 2010, was issued.**



CHASHMA NUCLEAR POWER PLANT, UNIT 2

ThesecondunitofChashmaNuclearPowerPlantis being built by China under a turnkey project. Formalities to issue a construction license to the plantareunderway.

Thefirstpartofthelicensingprocesswastheplant's site registration. PNRA registered the site after reviewing and assessing the SiteEvaluationReport andconfirmingthat otherrequirements suchasNo Objection Certificates (NOCs) from relevant governmentdepartments hadbeenfulfilled.

Complying with regulatory requirements, C-2 submitteditsapplication for a constructionlicence along with therequiredtechnical reports. When a detailedanalysisofthesetechnicalreportsrevealed nosafetyissuesrelatedtofoundationdesign,PNRA gaveprovisionalpermissionforpouringconcretein the base-mat of the nuclear island, which commenced on December 28, 2005. Thelicense for the construction of the plant was issued on March 23, 2006 after PNRA has conducted a completereviewoftherequireddocumentationand C-2 has agreed to fulfil all the regulatory requirements.

Environmental ImpactofNuclear Power Plantsin Pakistan

Tokeeptheenvironmentcleanoftheeffectsofthenuclear industry, PNRA exercises constant vigilance over the radioactive releases to the environment. The annual gaseousandliquideffluentsreleasedfromKANUPP and C-1, includingradioactivematerials, remainedwellbelow regulatory limits in 2001-05. No detectable effect or concentrationof radio-nuclideshasbeenobservedinthe environmentduetoradioactiveeffluentreleases and no radiationdamagetopopulationandenvironmenthasbeen observed.

Itmaybeconcludedthatthenuclearinstallationsunder thepurviewofPNRAareoperatinginasafemanner, and donothaveanyharmfuleffectonthehealthofworkers, thepublicortheenvironment.

PAKISTAN RESEARCH REACTORS I AND II

PakistanResearchReactorsIandII(PARRIandPARR II) are situated at the Pakistan Institute of Nuclear ScienceandTechnology(PINSTECH)inIslamabad. Theyareusedmainlyforresearchstudiesinphysics, isotope production, and training of engineers, scientistsandtechnicians.

Severalregulatoryinspections were carried out by PNRAinspectorsatthetworeactors, whichresulted in improvements in the facilities' emergency procedures, operation record-keeping and data entry, and periodic testing program. Following review, assessment and inspection activities, the operating licences for the two reactorswerealso renewed.

HEAVY MECHANICAL COMPLEX 3

In2003, theHeavyMechanicalComplex3(HMC-3) expressed interest in manufacturing nuclear-grade mechanicalequipment. Asone ofthe large projects in Pakistan's heavy engineering sector, HMC-3 is envisagedtoplayapivotalroleinself-reliance, indigenization and import substitution, andinprovidingcontinuedtechnicalsupporttothe nuclearindustryinPakistan.

To initiate thelicensingprocess for HMC-3, PNRA formulated licensing requirements based on international licensing and certification systems, suchasthoseofAmericanSocietyforMechanical Engineers(ASME) and theInternational Standards Organization (ISO), as well as those adopted by other regulatory authorities. These requirements weremadeavailabletoHMC-3inDecember2003 and, atthesametime, workwasinitiatedtodevelop formal regulations for licensing, review and assessment, and inspection and enforcement of nuclear-grademechanicalcomponents.

HMC-3submitteditslicenceapplicationinJanuary 2004. Afterfulfilmentofalltherequirements, PNRA authorized HMC-3 to manufacture safety class 2 and 3 nuclear grade equipment (i.e., pressure vessels, tanks and heat exchangers). The manufacturing licence was issued on July 19, 2005, validforfive years.

LICENSING OF OPERATING PERSONNEL

The qualification and training of operating personnel is of great importance in ensuring safety at nuclear installations, and PNRA ensured that this area received due attention. PNRA sets the personnel qualification criteria in terms of basic engineering qualifications, training, examinations, and medical and psychological fitness; approves the training syllabus of the operating personnel; witnesses the written examinations conducted by the management at each plant; conducts oral and operating examinations; and awards licences to operating personnel. Operating examinations are conducted in the Control Room or on plant simulators. Operators' licences are awarded for a period of one year and renewed annually.

INSPECTION OF NUCLEAR INSTALLATIONS

While the responsibility for ensuring safety at nuclear installations lies with the licensees, PNRA performs routine as well as unplanned and reactive inspections to verify that the licensees take all the required safety measures. For this purpose PNRA has established three Regional Nuclear Safety Directorates (RNSD-I, II and III) at the sites of nuclear installations, i.e., Islamabad, Kundian and Karachi. Resident inspectors have also been posted at the two nuclear power plants, KANUPP and C-1. In addition the RNSDs conduct regulatory inspections of all the licensed nuclear and radiation facilities of their respective regions, ensuring that facilities in all parts of the country receive focused attention.

PNRA conducted various types of inspections throughout 2001-05 to verify that the provisions of the PNRA Ordinance, related regulations, terms and conditions of licences and approved technical specifications were being met at nuclear facilities. All such inspections are conducted in accordance with the PNRA Inspection Program and cover operation, maintenance, and personnel training activities, radiation protection, waste management, emergency preparedness, and safety culture aspects of the plant. Resident inspectors at KANUPP

and C-1 conduct daily inspections of the plants, including the Main Control Room (MCR).

The routine inspections are conducted against an inspection plan, while different types of reactive inspections are performed in response to unusual events and situations. Inspection reports identifying deficiencies are issued and followed up until corrective actions are completed by the licensee. Quarterly inspection reports summarizing the activities of the Regional Directorates are also issued.

Promoting a Safety Culture

In consonance with international practice, PNRA is placing increasing emphasis on promotion of a 'safety culture' at nuclear facilities as a necessary component of its overall nuclear safety regimen. At facilities where a safety culture prevails, all personnel are deeply conscious of the need for safety measures, even in relatively insignificant aspects such as housekeeping. In addition, a safety culture encourages openness so that errors can be detected or pinpointed soon rather than later, without fear of retribution. Such a culture also rewards initiatives taken to enhance safety. PNRA conducted special inspections to determine the status of the safety culture at KANUPP (in December 2004) and C-1 (in July 2005). These inspections identified the areas where improvements were needed to foster a safety culture at the utilities.

4 RADIATION SAFETY

PNRA regulates all matters related to radiation protection of nuclear installations and radiation facilities in the country under the powers conferred by the PNRA Ordinance. The Authority has established a Directorate of Radiation Safety (RSD) to formulate necessary regulations, guides and procedures for effective implementation of safety norms in relation to radiation protection and the safe use of radiation sources, and to carry out related review, assessment, inspection and licensing activities.

Types of Radiation Facilities in Pakistan

- ▶ Nuclear installations
- ▶ Medical therapeutic and diagnostic radiology centers
- ▶ Nuclear medical centers
- ▶ Agricultural research centers
- ▶ Industrial radiography units
- ▶ Industrial irradiators
- ▶ Other research facilities

REVIEW AND ASSESSMENT

As with nuclear facilities, PNRA exercises its regulatory control over radiation facilities in accordance with the requirements of its regulations and the terms and conditions of the licences awarded to the facilities. It verifies the licensees' compliance with safety requirements through reviews, assessments and inspections, providing technical assistance or taking enforcement actions where necessary.

NUCLEAR INSTALLATIONS

Each nuclear installation is required to have in place a Radiation Protection Program, which is reviewed by PNRA. Throughout the operating life of the plant, PNRA ensures that the licensee fully implements its radiation protection program. The licensee is also required to maintain and submit a record of the radiation doses to plant personnel.

From 2001 to 2005, the collective and personnel radiation doses to KANUPP and C-1 personnel remained well within safe limits.

Notably, nuclear facilities in Pakistan apply the "As Low as Reasonably Achievable" (ALARA) philosophy in operations where staff radiation exposure is unavoidable. Experience has shown that this

approach leads to even lower exposure levels than anticipated.

RADIATION FACILITIES

Key objectives of PNRA's radiation safety efforts at radiation facilities are: ensuring that the facilities are properly designed for their intended work; ensuring that the facilities have proper layout and shielding to minimize exposure; keeping track of all sealed radiation sources (SRS) in the country; ensuring the safety and security of SRS while in use; ensuring that workers, the general public and the environment are protected against any ionizing radiation that accrues from the practices of radiation facilities; regulating the import and export of SRS; and verifying that exported food products are radiation-free.

A major focus of PNRA has been the registration of facilities that are yet to be licensed. By exempting earlier licence fees in 2004-05, PNRA persuaded a majority of diagnostic radiation facilities, mainly operators of X-ray machines to obtain licences. All the nuclear medical centres in the country are now licensed with PNRA, while more than half of diagnostic radiology units have obtained licences. A list of licensed medical radiation facilities in Pakistan is available on the PNRA website (<http://www.pnra.org>).

The need to ensure the safety and security of SRS has long been recognized by the Government of Pakistan. Since its establishment, PNRA has continued to update the national registry of SRS to keep track of the sources 'from cradle to grave'. Presently, the inventory is maintained using an in-house computerized database.

The unsealed radiation sources used in agricultural, medical, and research facilities are also under the regulatory purview of PNRA. The manner in which these sources are disposed of has important safety implications. Most of these sources are short-lived and PNRA ensures that they are properly disposed of after they have decayed.

RADIATION SAFETY

One of PNRA's major responsibilities is to ensure that the public is not unduly exposed to radiation at diagnostic x-ray facilities, radiation therapy and nuclear medical centres. To this end, PNRA routinely carries out inspection and enforcement activities at such facilities, ensuring that radiation exposure of workers, patients, and the public remains optimized and within regulatory limits.

LICENSING OF RADIATION FACILITIES

PNRA issues authorization and licences to users of radiation sources and equipment after carefully reviewing the safety aspects of planned activities. The licensing process entails systematic assessment and inspections by PNRA to ensure that the applicant is capable of safe and secure use and maintenance of radiation materials and equipment. Licensees are encouraged to implement the requirements of regulations on facility design, shielding and radiation protection infrastructure.

Improvement due to Regulatory Inspections

Regulatory inspections and safety recommendations have played an important role in the enhancement of public safety. During an inspection, PNRA inspectors observed that a Labour Room of a major hospital was located adjacent to the X-Ray Room causing unduly radiation exposure to the newborn infants and mothers. The Labour Room was shifted to a safer part of the building on PNRA's recommendation.

AUTHORIZATION OF IMPORT AND EXPORT OF RADIATION SOURCES AND EQUIPMENT

PNRA regulates the import and export of nuclear and radioactive materials and apparatus. Licensed importers and exporters are required to obtain an NOC from PNRA and comply with the national regulations. Before the NOC is granted, PNRA verifies that safety is ensured at all stages of the import and export process.

Another commitment of PNRA is to ensure that food exports are radiation-free. As part of its commitments, PNRA analyzes food samples and issues Radiation-Free Certificates.

INSPECTION ACTIVITIES

As mentioned earlier, PNRA established three Regional Nuclear Safety Directorates, RNSD-I, II and III, to conduct regulatory inspections of nuclear installations and radiation facilities in the country and to verify that regulatory safety standards are observed. During inspections, PNRA verifies, among other matters, that personal protective gear is provided to workers who need it; a qualified Radiation Protection Officer (RPO) is available; personal and area monitoring equipment are present and functioning; radiation dose records for workers are maintained and indicate that doses are within safe limits; and adequate physical protection and security measures are taken. PNRA's regulatory activities led to improved measures for minimizing radiation exposure of the general public.

As a policy, import of sealed radiation sources containing long-lived radio-nuclides is prohibited unless the suppliers or manufacturers undertake to accept the return of these sources when they are no longer useful for their intended purpose.



▲ **IAEA Expert Mission on Self Assessment of Regulatory Effectiveness at PNRA Headquarters**

5 NUCLEAR WASTE AND TRANSPORT SAFETY

The PNRA Ordinance empowers the Authority to regulate and control all matters related to safety in the management and disposal of radioactive waste and transportation of radioactive materials in Pakistan. PNRA has established the Directorate of Transport and Waste Safety (WSD) to develop and implement the necessary regulations, guides and procedures to regulate licensees' activities in these spheres.

The transportation of radioactive materials requires a number of special safety measures, such as appropriate packaging and labelling, to protect the public and the environment from possible hazards. PNRA has undertaken a variety of steps to ensure that the safety standards observed in this sensitive process are in line with international regulations.

Radioactive waste is generated when radiation sources are utilized for various purposes. The generation and management of radioactive waste is a distinct focus of PNRA, because radioactive waste, like other radioactive materials, poses the risk of ionizing radiation exposure for workers, the environment and the general public.

The broad strategy PNRA prescribes for minimal waste generation is optimal reuse and recycling of radioactive materials, and maximum use of short-lived radio-nuclides (which emit radiation for a shorter period).

REVIEW AND ASSESSMENT NUCLEAR INSTALLATIONS

PNRA closely monitors waste generation and management at the two operational nuclear power plants, KANUPP and C-1. It also reviews and suggests measures for improving the radioactive waste management program at these installations.

For both the plants, periodic assessments were conducted to verify that waste reduction and management activities were being undertaken as per regulatory requirements. It was ensured that radioactive effluents and emissions were monitored, treated where needed, and released to the environment only after their radioactivity had reached acceptable discharge limits. Records of total releases and environmental monitoring were maintained.

RADIATION FACILITIES

Radioactive waste from radiation facilities is mostly generated from the utilization of sealed radiation sources. At present, spent radiation sources are disposed of at two designated sites in the country. PNRA conducted regular inspections to verify that

storage and disposal practices at these sites were in compliance with regulatory requirements.

INSPECTION OF WASTE MANAGEMENT AND DISPOSAL

The Regional Nuclear Safety Directorates regularly conducted inspections of storage facilities and radioactive waste management programs to assess the safety of waste collection, classification, treatment, storage and disposal practices. The assessments were based on operator records as well as observations during regulatory inspections. At health facilities in particular, PNRA played an important role in facilitating the safe management of radioactive waste. Health facilities were assisted in taking measures to minimize storage of waste materials at their premises, and guided in economical packing, transportation and disposal at the designated sites.

In compliance with national regulations, highly radioactive solid waste was kept confined in shielded steel tanks/bins and stored in concrete-lined trenches at designated locations in the country.

SAFE TRANSPORT OF RADIOACTIVE MATERIALS

PNRA regulates the transportation of all radioactive materials in the country to minimize risk to the general public, workers and the environment.

Radioactive materials can be transported in many ways, depending on the weight of packages, characteristics and composition of the radioactive contents, the distance to be shipped, and the availability of transportation facilities and transport infrastructure. Shipment packages are required to be appropriately labeled for easy identification.

Figure 3 shows a typical label required to be posted on packages during transportation. Facilities engaged in export or import of radioactive material are inspected regularly by PNRA. During such inspections, among other aspects, shipping documents are reviewed and it is verified that the shipments meet national and international requirements. Import/export permissions are issued only after satisfactory compliance with regulatory requirements. Through PNRA's efforts, the package design of radio-pharmaceuticals being transported to medical centres in the country has improved and is in line with international standards.



Figure 3: A Typical Label

6

EMERGENCY PREPAREDNESS

From the design stage to the end of operating life, each nuclear power plant and radiation facility in the country is closely regulated and monitored by PNRA. Despite extreme care by licensees and PNRA, however, unexpected events may occur, posing risks to the health of workers, the general public and the environment. To mitigate the possible consequences of any events that might occur during the operational life of a nuclear or radiation facility, licensees are responsible for maintaining emergency preparedness. PNRA ensures that this important responsibility is fulfilled by each licensee, and takes further measures to ensure that national arrangements are in place to respond to any major incident.

PLANS AND DRILLS

PNRA ensures that onsite and offsite emergency preparedness plans, duly approved by the Authority, are in place at nuclear and radiation facilities. PNRA also assesses the effectiveness of these emergency plans by observing emergency drills that are conducted periodically to verify the state of preparedness. During observations of such drills, PNRA pays special attention to emergency response systems and recommends improvements where necessary. The follow-up to these recommendations is verified at the next periodic drill.



▲ *National Radiation Emergency Coordination Centre*

NATIONAL RADIATION EMERGENCY COORDINATION CENTRE (NRECC)

PNRA is the National Focal Point for emergency notification and for seeking assistance in case of a nuclear/radiological accident. For this purpose, the National Radiation Emergency Coordination Centre

(NRECC) was established at PNRA. NRECC functions as the focal point for round-the-clock reporting and monitoring of nuclear and radiological accidents. It also coordinates the response measures at national and international level.

Upon perceiving that an operational event or accident condition may arise at their facilities, licensees are required to inform NRECC immediately. The licensee informs the population in the vicinity of the facility in consultation with local governmental authorities. NRECC is required to disseminate accident information to the designated national and international authorities and the general public after verifying the authenticity of the report.

NRECC notifies the concerned PNRA personnel via an established chain of command, and coordinates radiological monitoring in support of the licensee and other authorities. For independent analysis, the NRECC also mobilizes its Mobile Radiological Monitoring Laboratory (MRML), equipped with radiation monitoring equipment, personnel safety equipment and a system of communication with PNRA and other relevant national organizations.



Interior view

▲ *Mobile Radiological Monitoring Laboratory*

▼ *External view*



7

NATIONAL AND INTERNATIONAL COOPERATION

Open communication, transparency and cooperation are important values at PNRA, and are regarded as essential features of relations with national and international stakeholders for regulatory effectiveness and efficiency. Indeed, three of PNRA's twelve strategic performance indicators (page 16) pertain to the trust it inspires among its licensees, the general public and the Government.

In its regulatory approach, PNRA departs from conventional top-down methods and, instead, adopts a facilitative approach, working with licensees to help them appreciate safety concerns, develop responsive practices, and improve their protection measures in line with international trends.

Regulatory decisions are based on regulations and guides, and made without undue delays, with clarity and transparency. The incidence of enforcement activities is minimal because PNRA motivates compliance by promoting a safety culture.

On important issues, such as regulatory changes, extensive consultation is conducted with the licensees, particularly the Pakistan Atomic Energy Commission (PAEC), to incorporate their perspectives and thereby increase the efficiency of the new initiatives.

This section discusses the ways in which, in a relatively brief span of five years, PNRA has conducted and initiated collaborations with national and international organizations for enhanced nuclear and radiation safety, and its efforts to build public awareness regarding nuclear and radiation issues.

NATIONAL LINKAGES

LIAISON WITH GOVERNMENT BODIES

To ensure that its regulatory activities are carried out as effectively and efficiently as possible, PNRA works in cooperation with other government bodies where needed. This also enables the concerned government institutions to better play their roles in maintaining and improving nuclear and radiation safety in the country. PNRA has forged linkages with various Federal Government organizations in the implementation of regulations concerning their domains, including the Federal Ministries of Law, Environment, Foreign Affairs, Interior, Health, and Transport and Communication, as well as the Public

Administration, Civil Aviation Authority, and other related institutions.

Collaboration with National Academic Institutions

For some of its research activities, and as a long-term strategy for human resource development, PNRA has started exploring partnerships with reputed academic institutions in Pakistan, such as COMSATS Institute of Information Technology (CIIT), Air University and the Lahore University of Management Sciences (LUMS).

Building National Linkages for Nuclear and Radiation Safety

PNRA conducted a meeting in August 2005 with liaison officers from various ministries to forge cooperative administrative arrangements with the provinces (through the Federal Government) regarding the implementation of regulations in the areas of health, environment and other public domains. Such a federal-provincial regulatory arrangement will be in line with the international best practice and enhance nuclear safety throughout Pakistan.



NATIONAL AND INTERNATIONAL COOPERATION



Figure 4: The homepage of PNRA's website

RELATIONS WITH THE PUBLIC

Over the last five years, PNRA has established a public awareness program regarding nuclear and radiation safety.

The key tools for public awareness and education include press releases on safety issues and an interactive website (www.pnra.org), the homepage of which is shown in Figure 4. The website provides useful information about PNRA, a list of regulations and guides, and applications for licensing and other related documents. In January 2004, PNRA also published a supplement about its activities in a national daily newspaper.

INTERNATIONAL COOPERATION REPRESENTATION AND FULFILMENT OF OBLIGATIONS

As a national nuclear regulator, PNRA represents Pakistan in several international organizations and is responsible for fulfilment of commitments arising from international conventions as well as bilateral and multilateral agreements. Recently, PNRA became a "second point of contact" for IAEA, responsible for direct liaison with the international agency in matters of nuclear safety and security, technical cooperation, and conventions.

Pakistan is a party to four international conventions, including the Convention on Nuclear Safety (CNS); Convention on Physical Protection of Nuclear Material; Convention on Early Notification of Nuclear Accidents; and Convention on Assistance in the Case of Nuclear and Radiological Accidents. Pakistan is in

complete fulfilment of its obligations under these conventions.

Along with the other 55 Contracting Parties, Pakistan is required to submit a report every three years on national implementation of the obligations under CNS. PNRA led the development and presentation of the second and third National Reports from Pakistan, participating in the Third Review Meeting in April 2005 to present the Third National Report. After the peer review of the reports, Pakistan posed several questions on the national reports submitted by other Contracting Parties and responded to questions on its own report; the country's active participation demonstrated its commitment to fulfilment of obligations under the Convention.

BILATERAL AND MULTILATERAL COOPERATION

PNRA enjoys strong bilateral relations with the National Nuclear Safety Administration (NNSA) of China. NNSA provided technical assistance and services to PNRA in the licensing assessments of nuclear power plants C-1 and C-2 as well as Heavy Mechanical Complex 3.

Pakistan is also a member of the Centre for Nuclear Safety in Central and Eastern Europe (CENS), which was established in 2002 and works under a subsidiary of the Swiss and Slovak governments. In addition, PNRA and the United States Nuclear Regulatory Commission (USNRC) are exploring bilateral agreements for the exchange of personnel and safety-related information.

In 2004, Pakistan became a member of the Network of Nuclear Regulators of Countries with Small Nuclear Programme (NERS), an international network of nuclear regulators and inspectors dedicated to the free exchange and dissemination of nuclear regulatory information. PNRA hosted the eighth working session of NERS from May 16 to 20, 2005, in which representatives of Finland, Switzerland and Slovenia participated.



▲
The eighth working session of NERS is in progress.

In addition, PNRA is working with the Finnish Nuclear and Radiation Safety Authority (STUK) and technical support organization (VUJE) of Slovak Republic. It also joined the Asian Nuclear Safety Network (ANSN) with the aim of sharing and creating knowledge among Asian states.

Asian Nuclear Safety Network

PNRA has joined the Asian Nuclear Safety Network (ANSN) with the aim of knowledge sharing among Asian states. A Nuclear Safety Knowledge portal has been developed to pool, use and create safety related knowledge.

PNRA is currently engaged in a number of IAEA technical cooperation projects, including:

- ▶ Strengthening of Nuclear Safety Regulatory Authority;
- ▶ Further improvement of Regulatory Performance for Pakistan Nuclear Regulatory Authority;
- ▶ Applicability of Agency Nuclear Safety Standards for Nuclear Power Plants;
- ▶ Development of Technical Capabilities for Sustainable Radiation and Waste Safety Infrastructure;
- ▶ Development of Asian Nuclear Safety Network;
- ▶ Developing Technical Capabilities for the Protection of Health and Safety of Workers exposed to Ionizing Radiation;
- ▶ Strengthening Radiological Protection of Patients and Medical Exposure Control; and
- ▶ Establishing National Capabilities for Response to a Radiological and Nuclear Emergency.

From 2001 to 2005, PNRA hosted 112 IAEA experts' missions, including full-scope peer review missions, an International Regulatory Review Team (IRRT) mission, Radiation Safety Infrastructure Appraisal (RaSIA) missions and various other types of meetings and events. These events largely helped PNRA in the capacity building of its human resource.

PNRA also plays an active role in five of the IAEA's standards committees, including the Commission on Safety Standards, Transport Safety Standards Committee, Nuclear Safety Standards Committee, Radiation of Safety Standards Committee, and the Advisory Committee for Nuclear Installations. For effective participation in international standards development, PNRA established an Advisory Committee on Draft International Safety Standards (ACISS) to review IAEA safety standards, prepare Pakistan's recommendations, and analyze their application and implications in Pakistan.

TECHNICAL COOPERATION WITH IAEA

PNRA's cooperation with IAEA in the area of technical projects has been highly successful. In 2001, PNRA was involved in two projects concerning nuclear safety and radiation protection.

NATIONAL AND INTERNATIONAL COOPERATION

In December 2003, Pakistan invited an IRRT mission to conduct a full-scope review of its regulatory activities. The findings of the review were generally quite positive, with the Mission concluding that Pakistan had made good progress towards establishing an independent and sustainable nuclear regulatory regime. The Mission also identified a number of "Good Practices" at PNRA, which were noted for sharing with other regulatory bodies. The report of the IRRT Mission included a few recommendations and suggestions for the improvement of PNRA's regulatory performance. The report is available on PNRA's website (<http://www.pnra.org>).

The suggestions and recommendations of the Mission are being implemented by PNRA. The follow-up IRRT Mission will be conducted in 2007.



▲ The International Regulatory Review Team (IRRT) Mission at PNRA ►

IAEA Radiation Safety Infrastructure Appraisal (RaSIA) Mission

An IAEA team conducted a RaSIA mission in Pakistan from March 28 to April 11, 2005. The overall conclusions of the mission were:

Pakistan has a well-developed legal infrastructure for radiation safety and an effective operational system of licensing, inspection and enforcement for the control of radiation sources. The Regulatory Authority has achieved effective independence. Successive IAEA peer reviews and appraisals demonstrate that the Pakistan regulatory infrastructure continues to develop in line with international standards. There are some opportunities for procedural improvements, in particular regarding the national register of sources and the need to bring all x-ray generators fully under the control of the regulatory authority.



PNRA is a forward-looking organization, deeply committed to improving its own regulatory effectiveness and efficiency, and thereby affording greater nuclear and radiation protection to workers, the general public and the environment in Pakistan. Nearly all of PNRA's international collaborations discussed in Section 7 are geared to enhance the capacity of its own team through exposure to cutting-edge approaches and state-of-the-art technologies, as well as intensive technical training. Collaborations with the IAEA are especially fruitful in this regard.

In addition, PNRA has taken a number of internal measures to ensure that it continually improves its performance and its contribution to the country. Among these measures are initiatives to develop a pool of trained, competent and dedicated personnel; a knowledge-based organizational structure that channels expertise and energies for priority concerns; an institutional structure that ensures regulatory independence; and a stringent self-evaluation mechanism that drives PNRA toward excellence in all spheres of its activities.

ESTABLISHMENT OF CENTRE FOR NUCLEAR SAFETY

Soon after its inception, a need was felt at PNRA for a dedicated technical support unit to focus on the deeply technical but multifaceted task of internal capacity building and institutional strengthening. PNRA's proposal for such a unit was approved by the Government of Pakistan in October 2004 and a "Centre for Nuclear Safety (CNS)" was established in June 2005.

The initial focus of CNS remained on:

- ▶ Creating national and international opportunities for the capacity building of PNRA personnel, such as specialized training, professional exchange visits, and participation in nuclear safety research;
- ▶ Procuring software tools for confirmatory and audit calculations for regulatory analyses;
- ▶ Developing a documentation base, including an Information Centre; and
- ▶ Developing and strengthening bilateral links with nuclear regulatory bodies of other countries and international organizations.

Within a short period, the Centre for Nuclear Safety signed four bilateral agreements with regulatory bodies and technical support organizations of other countries.

DEVELOPING THE NEXT GENERATION OF REGULATORS

The technical and specialized nature of its work makes it essential for PNRA to work proactively to develop its current and future team. At the time of its establishment, there was a severe shortage of technical staff at PNRA. Therefore, three fast-track recruitment drives were conducted in which sixty young scientists and engineers were inducted. Further recruitment is underway against a longer-term needs assessment.

Simultaneously a systematic training needs assessment of PNRA staff was performed in collaboration with LUMS, based on which a responsive training policy and strategy were devised. The PNRA training needs assessment was considered a 'good practice' by the IRRT mission when it visited PNRA in December 2003.

PNRA's Training Needs Assessment Replicated as International Good Practice

PNRA's training needs assessment was noted by an IRRT mission as an international best practice and became a milestone in the development, not only of PNRA, but also of many other regulatory bodies in the world. The study was referred and duplicated in Romania, Thailand, Indonesia and Malaysia, and was also used in developing the basic Nuclear Safety Professional Course in France.

To develop the next generation of regulators, PNRA established the School of Nuclear and Radiation Safety. The School conducted a number of intensive professional training courses for new recruits, as well as other courses on technical and management topics for new as well as senior officers.

In addition, PNRA initiated a fellowship program with the Pakistan Institute of Engineering and Applied Sciences (PIEAS) under which students are sponsored in postgraduate courses in nuclear/system engineering and medical physics. Successful candidates join PNRA.

TOOLS FOR CONTINUOUS IMPROVEMENT

As mentioned in Section 7, PNRA also benefitted from several training and learning opportunities with IAEA. A large number of PNRA staff participated in IAEA's regional (Asia) programmes, technical cooperation projects, regional training courses, technical meetings, project workshops, expert missions, and other conferences and meetings.

RESEARCH AND DEVELOPMENT

In view of the expanding nuclear power program of the country, more stringent plans on nuclear safety aspects were made. PNRA plans to develop and revise its regulations in the light of developments in international standards, recommendations from different stakeholders, and its own experience in the field of nuclear and radiation safety. Recognising that research and development (R&D) is essential for this undertaking, PNRA constituted an Advisory Committee on Research and Development (ACRD) in 2004. The Committee serves as a point of liaison with the scientific community, national research institutes, academia and other stakeholders in research on nuclear and radiation safety; it plays the important role of bringing together different stakeholders to collaborate in required research projects.

PNRA is also identifying further topics for research, awarding research projects to national universities, and offering research contracts leading to MPhil and PhD degrees.

The creation of ACRD signifies PNRA's commitment towards promoting and conducting R&D for enhanced safety at nuclear installations and radiation facilities, in cooperation with the national scientific community, public universities and other stakeholders.

MONITORING, EVALUATION AND IMPROVEMENT

Soon after its establishment, PNRA initiated a self-assessment program for monitoring and evaluating its regulatory performance. The monitoring and evaluation (M&E) system is based on 12 strategic performance indicators, against which a progress review is compiled and presented to the Prime Minister of Pakistan every year.

Currently, PNRA rates itself qualitatively, based on management decisions, against a five-tier rating scale.

PNRA's performance for 2001-2005 is summarized in Figure 5. Efforts are under way to make the assessment quantitative and to incorporate the review of trends in performance against each indicator. This is expected to make the M&E system even more rigorous and useful. An agreement was reached with the Lahore University of Management Sciences for systematic regulatory self-assessment.

In addition to conducting self-assessments, PNRA invited international organizations for external auditing and evaluation of its performance. The most notable events in this regard were the IRRT Mission and the RaSIAM Mission, both of which found PNRA's performance to be comparable with international regulatory standards.

PNRA's Strategic Performance Indicators

- 1- *Ensures acceptable level of safety being maintained by licensees.*
- 2- *Ensures regulations and procedures in position and understood by licensees.*
- 3- *Strives for continuous improvement of its performance.*
- 4- *Appropriate action taken to prevent degradation of safety and to promote safety improvements.*
- 5- *Takes appropriate steps for human resource development and has competent and certified regulatory staff.*
- 6- *Ensures that adequate legal provision exist for enforcement, i.e., dealing with non-compliance or licence violations.*
- 7- *Performs its functions in a timely and cost-effective manner.*
- 8- *Ensures that a well-established quality management system exists.*
- 9- *Ensures that adequate resources available for performing its functions and Technical Support Centre(s) available for specialist assistance when required.*
- 10- *Performs its functions in a manner that ensures the confidence of the operating organization.*
- 11- *Performs its functions in a manner that ensures the confidence of the general public.*
- 12- *Performs its functions in a manner that ensures the confidence of the government.*

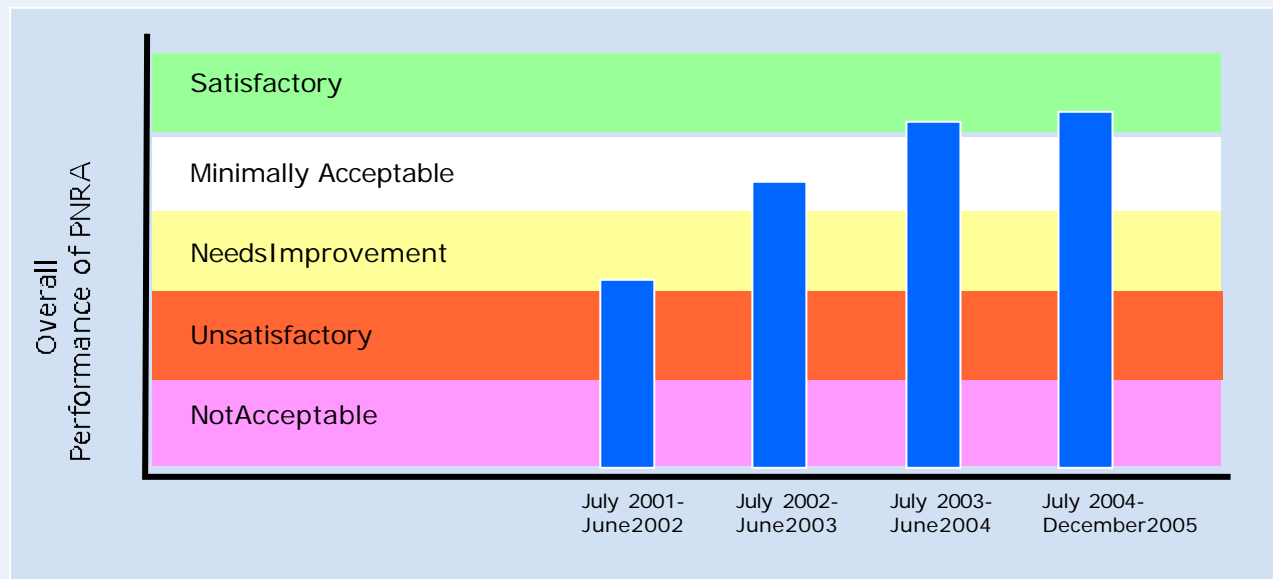


Figure 5: PNRA's Performance -- 2001-2005

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