CONVENTION ON NUCLEAR SAFETY

Report by the Government of

Islamic Republic of Pakistan

for the

Sixth Review Meeting, 2014

Prepared on behalf of the

Government of Pakistan

by the

Pakistan Nuclear Regulatory Authority

in collaboration with the

Pakistan Atomic Energy Commission

August 2013

Pakistan Nuclear Regulatory Authority

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ABSTRACT

The Pakistan Nuclear Regulatory Authority submits this Sixth National Report of Pakistan for peer review at the Sixth Review Meeting of the Convention on Nuclear Safety at the International Atomic Energy Agency. The report presents the appropriate steps taken by the Government of Pakistan to meet the main objectives of the Convention — to achieve and maintain a high level of nuclear safety by enhancing national measures and international cooperation. It also describes how Pakistan meets the obligations of each article of the Convention — specifically by the articles that address the safety of existing nuclear installations, the legislative and regulatory framework, the regulatory body, responsibility of the licence holder, priority to safety, financial and human resources, human factors, quality assurance, assessment and verification of safety, radiation protection, waste safety, emergency preparedness, siting, design, construction and operation.

This report also includes the progress on actions taken to improve safety in response to Fukushima Dai-ichi accident as presented in the National Report for the second Extraordinary meeting of the CNS held in August, 2012.

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Part I

1 Introduction

1.1 General

The Convention on Nuclear Safety (CNS) was signed by Pakistan on 20th of September 1994 and subsequently ratified on 30th of September 1997. The Government of the Islamic Republic of Pakistan is taking appropriate measures to install and operate nuclear power plants for generation of electricity. As a matter of policy, highest priority is accorded to safety in nuclear installations.

The Sixth National Report (6NR) of Pakistan to the Convention on Nuclear Safety has been prepared by the Pakistan Nuclear Regulatory Authority (PNRA) in collaboration with Pakistan Atomic Energy Commission (PAEC) in fulfillment of obligations under the Convention on Nuclear Safety on behalf of the Government of Pakistan.

The Sixth National Report (6NR) is an updated version of the Fifth National Report; however, it can be used as a stand-alone document. The 6NR begins with an introduction in Part I, followed by Part II which covers the progress made after the Fifth National Report. This also includes the progress on actions taken to improve safety after Fukushima Dai-ichi accident as presented in the National Report for the CNS Second Extraordinary Meeting. Brief description of the future challenges is presented in Part III and the report then continues with Articles 4 to 19 in Part IV. Annexures are included to supplement information and data to elaborate the article's text, where required. Part IV of the report generally follows the Articles of the Convention on Nuclear Safety and the guidance provided by the INFCIRC/572. Progress on implementation of the IAEA Nuclear Safety action Plan is presented in Annexure XIII.

The Government of the Islamic Republic of Pakistan is committed to make all possible efforts in achieving and maintaining a high level of safety and has met its obligations under the Convention on Nuclear Safety.

1.2 Electrical Energy Market in Pakistan

The present installed electricity generation capacity of Pakistan is around 23,000 MWe. Major sources of electricity generation in the country are fossil fuel fired thermal power plants and hydroelectric plants, which fall under the purview of the Water and Power Development Authority (WAPDA). The share of electricity production from nuclear energy to national grid is about 3.2% and renewable (wind) is contributing only 50 MWe of the total power generation as indicated in the following table.

In 2011-12, the share of electricity generation from nuclear energy in the national grid increased from 3.2% to 4.9%.

Table 1.2-1: Pakistan's Electricity Generation Capacity

Generation Type	*Capacity Share*
Thermal (Fossil Fuels)	16,000 MW
Hydroelectric	6,500 MW
Nuclear	700 MW
Renewables	50 MW
Total Installed Capacity	23,000 MW

1.3 National Policy Pertaining to Nuclear Installations

Pakistan has been experiencing an acute energy shortage of around 6000-8000 MWe which is adversely affecting the economy, business sector and social sector. Being deficient in fossil fuel reserves and taking into consideration environmental issues, Pakistan considers nuclear power and renewable energy sources as viable options in the overall energy mix for the socio-economic development of the country. After the Fukushima Dai-ichi accident, Pakistan continued its cautious policy regarding use of nuclear power technology, but with more stringent controls on safety. Progress on actions related to upgrades/ modifications at NPPs in the light of Fukushima Dai-ichi experience feedback is presented in Part II (Section 2.2) of the report.

In fulfillment of the Energy Security Plan of the Government, PAEC intends to construct more units. Accordingly, new sites are being identified for detailed evaluation.

The Government of Pakistan is fully cognizant of its responsibilities regarding preservation and improvement of the quality of the environment. Organizations at various levels of the Government have been established, under legislation and statutes, to regulate salient sources of environmental degradation and to carry out research on climatic changes due to global warming, etc.

PNRA is the competent authority for regulating nuclear safety and radiation protection aspects of nuclear installations. PAEC undertakes promotional activities in the use and application of nuclear energy including research, development, education, etc., on behalf of Government of Pakistan. PAEC owns and operates all nuclear installations in Pakistan.

Pakistan has more than 40 years of nuclear power plant operating experience. The safety record of the operation of nuclear power plants has been quite satisfactory as concluded from the findings of the national regulatory reviews and inspections. This has also been substantiated by international peer reviews.

1.4 Ongoing National Program Related to the Nuclear Installations

The national program related to nuclear installations is focused on:

a. Continued safe operation of nuclear installations.

b. Construction of new nuclear installations to meet energy requirements.

c. Strengthening and capacity building of regulatory infrastructure in the country.

d. Strengthening and capacity building of research and development in the country.

KANUPP underwent a long maintenance outage that started from December 2010 and continued till May 2011. After completion of a number of design modifications, safety assessments and safety upgrades required for relicensing, PNRA extended the operating licence of KANUPP up to December, 2016. In 2011, KANUPP underwent three (03) unplanned shutdowns. In 2012, KANUPP underwent eight (08) shutdowns, out of which 06 were due to reactor trips. KANUPP is presently conducting Periodic Safety Review (PSR).

Chashma Nuclear Power Plant Unit-1 (C-1) has been operating safely and has so far undergone eight refueling outages, including two refueling operations during the reporting period. C-1 also conducted a Periodic Safety Review (PSR) as per regulatory requirement for renewal of operating licence after ten years of operation in 2009-2010. C-1 tripped six (06) times in 2011 and once in 2012.

Some significant events that took place at KANUPP and C-1 were reported to the international community through World Association of Nuclear Operators (WANO) and IAEA International Reporting System of Operating Experience (IRS). Three incidents were reported to IRS and NEWS during the reporting period. One of the incidents was rated at INES Level 1 while the others were rated at INES level 0.

Reviews of Final Safety Analysis Report and other regulatory submissions of Chashma Nuclear Power Plant Unit-2 (C-2) were conducted and PNRA awarded operating licence to C-2 in February 2012. C-2 is now in commercial operation and has undergone its first refueling outage in the first quarter of 2013. Review of the C-3/C-4 combined Provisional Safety Analysis Report (PSAR) was conducted by PNRA in 2011 (Annexure III) and construction licence was awarded to C-3 and C-4 in May, 2011 and December, 2011 respectively. Construction of C-3/C-4 units started in 2011 and civil work for the construction and installation of equipment remained in progress during the reporting period. Major milestone of dome placement for C-3 was achieved in March 2013. Additional NPPs are being planned in Pakistan to meet the energy requirements in line with the Energy Security Plan of the government of Pakistan.

During the reporting period, three (03) regulations and four (04) regulatory guides have been issued whereas two more regulations are under various stages of development.

Self assessment of regulatory activities using the IAEA SAT software was also carried out as part of preparation for IAEA-IRRS Mission.

The human resource development in PNRA continues to expand in terms of increase in manpower and technical competence through various basic, intermediate and advanced level training courses through PNRA School for Nuclear and Radiation Safety (SNRS) and regular participation in international events e.g. workshops, training courses, fellowships etc. In addition, various activities are being executed to carry out countrywide environmental radiation surveillance, and to establish dosimetry and calibration laboratories, under the Public Sector Development Program of the Government of Pakistan.

Part II

2 Progress after the Fifth Review Meeting and Special Reporting

2.1 Progress after the Fifth Review Meeting

Progress made after the Fifth Review Meeting in significant areas is presented below:

2.1.1 Regulatory Framework

Following national regulations were officially notified in the Gazette of Pakistan:

i. Pakistan Nuclear Regulatory Authority Enforcement Regulations – (PAK/950)

ii. Regulations on Transaction of Business of Pakistan Nuclear Regulatory Authority-(PAK/901)

iii. Regulations on the Safety of Nuclear Research Reactor(s) Operation – (PAK/923)

In addition, a few regulations underwent revision / amendments:

a) Regulations for Licensing of Nuclear Installation (s) in Pakistan-PAK/909 (Rev.1)

b) Regulations on Radiation Protection (PAK/904)

c) Regulations on Radioactive Waste Management -Pak/915 (Rev.1)

d) Regulations for Licensing of Nuclear Safety Class Equipment, Components and Transport Packaging Manufacturers – PAK/907 (Rev.1)

The following regulations are under preparation:

a) Regulations on Decommissioning of Facilities Using Radioactive Material (PAK/930)

b) Regulations on Physical Protection of Nuclear Installations and Nuclear Material (PAK/925)

2.1.2 Organization of PNRA and PAEC

The organizational structure of PNRA has been modified to reflect Capacity Building arrangements and all projects except CNS have been transferred to the Director General, Capacity Building under the Member, Corporate. The reason for this change was to emphasize the importance of long term and sustainable development of human resource in the regulatory disciplines.

Further, a legal cell was established under D.G (Inspection and Enforcement) in order to strengthen enforcement process and look after legal matters related to nuclear and radiation safety. The new PNRA organizational chart is given in Annexure V.

PNRA also continued the policy of rotating newly inducted employees for working in various directorates of PNRA so that the new inductees get familiarized with the functional domains of PNRA and receive the necessary knowledge/ experience for performing their duties in a more efficient manner. This policy has contributed in the training of regulatory staff on fast track.

Organizational structure of PAEC remains the same as before and is shown in Annexure-VI.

2.1.3 KANUPP Operation after re-licensing

KANUPP underwent a long maintenance outage that started from December 2010 and continued till May 2011. During this period, KANUPP completed all major activities as required by PNRA including assessment of remaining useful life of main equipment such as steam generators and fuel channels. The activities performed by KANUPP were thoroughly assessed by PNRA to verify compliance with the regulatory requirements and to ensure that the plant can operate safely. Based on the review and assessment and observations made during regulatory inspections, KANUPP was conditionally allowed to make the reactor critical and subsequent power operation on June 06, 2011. KANUPP was further asked to submit additional assessment reports for any further extension in operating licence of KANUPP. KANUPP operating licence was further extended up to December 31, 2016 in April, 2012. The extension is a result of thorough assessment of remaining useful life of steam generators and integrity of fuel channels.

KANUPP achieved 40 years of commercial operation on November 28, 2012. KANUPP also surpassed its previous record of 1994 of the highest annual gross generation (586 million KWhr). An event of INES level 1 involving leakage of Heavy Water from Reactor Feeder Pipe of KANUPP was reported to NEWS in 2011.

A special WANO Peer review mission was conducted at KANUPP in April, 2013. Following major improvements have been made as a result:

i. Distraction conditions in the MCR have been minimized.
ii. Procurement process for essential spare parts has been expedited.
iii. Plant performance indicator of emergency AC showing improvement.
iv. Changes of multiple to single access control helped in reduction of personal contamination control.

Furthermore, the WANO team appreciated the efforts of plant managements that have been taken or are underway in response to lesson learned from Fukushima Dai-ichi accident apart from evaluating the status of corrective actions against previous Areas for improvement (AFIs).

2.1.4 C-1 Operation

Chashma Nuclear Power Plant Unit-1 (C-1) has been operating safely and has so far undergone eight refueling outages including two refueling operations during the reporting period.

According to regulatory requirements for renewal of ten yearly operating licence, C-1 submitted Periodic Safety Review (PSR) reports (one-hundred and ninety-three reports) to PNRA in 2010.

Based on the review of PSR reports and resolution of all queries raised during the review to the satisfaction of PNRA, the operating licence of C-1 was revalidated up to 2020. One incident of C-1 reactor Trip on Steam Generator –A level Hi Hi was reported to the IAEA-IRS in 2011.

The following improvements are being implemented as outcome of WANO Peer Review which was conducted at C-1 in April 2012:

i. Development and implementation of maintenance personnel training and re-training program.
ii. Establishment of Operational Decision Making process.
iii. Establishment of Equipment Performance Monitoring Program.
iv. Strengthening of Internal Operating Experience Program.
v. Establishment of Self Assessment Program.
vi. Establishment of Integrated Improvement Plan.
vii. Establishment of Radioactive Waste Reduction Program.
viii. Development of Centralized Chemical Management Program.

2.1.5 C-2 Commissioning & Operation

C-2 is among a few plants which requested and hosted a WANO Pre-Start-up Peer Review during its commissioning phase in July 2010. Installation Verification Program was regarded as a strength whereas several AFIs were pointed out. These were related to lack in preparedness of Human Resource in Operations and Maintenance Divisions, timely preparation of maintenance procedures, insufficient self-assessment and human performance program. C-2 operating organization started work on the AFIs. This included balancing of manpower between C-1 and C-2, implementation of self assessment program, request for a Technical Support Mission on Human Performance Improvement Program, preparation of ~ 400 maintenance procedures, procurement of five year spares etc.

Review of regulatory submissions, including Final Safety Analysis Report of Chashma Nuclear Power Plant Unit-2 (C-2) was conducted and Fuel Load Permit was issued to PAEC at the end of December 2010.

C-2 achieved its first criticality on 22 February 2011 and grid connection was made on 15 March 2011. Requisite tests were conducted at low power, power ascension and full power to verify plant performance and response as per design intent.

As per requirement of Regulation for Licensing of Nuclear Installation(s) in Pakistan (PAK/909), C-2 was required to submit application for Operating Licence within six months after completion of commissioning. In compliance, C-2 submitted its application along with submissions required under the regulations. Assessment of these submissions and verification of the fulfillment of commitments made by the licensee in response to review and assessment and inspections were undertaken by PNRA. The Operating Licence was awarded to C-2 in February, 2012 which is valid till December, 2021. One of the events of Reactor Trip was reported to the IAEA-IRS in 2011.

C-2 remained shutdown from March 31 to April 20, 2012 in order to comply with the Limiting Condition for Operation (LCO). The LCO became applicable due to unavailability of one of the two Emergency Diesel Generators. A number of shutdown jobs, originally planned for second planned outage, were re-scheduled and performed during this outage.

C-2 has completed its first operational cycle and underwent a refueling outage in first quarter of 2013. Upon completion of refueling outage activities, the plant started its second operation cycle in April 2013.

2.1.6 C-3/ C-4 Site Evaluation, Preliminary Design Evaluation and Construction

The Site Evaluation Reports (SER) for construction of Chashma Nuclear Power Plant Units 3 and 4 (C-3 and C-4) were reviewed and the sites were registered in February 2011 and December, 2011 respectively.

PAEC applied for the issuance of Construction Licence of C-3 and C-4 along with the required documents including the plants' PSAR, Probabilistic Safety Analysis (PSA) report and Overall Quality Assurance Program (OQAP), etc. in October, 2010. Detailed review of these documents was completed in 2011. PNRA granted permission to C-3 to pour concrete in the foundation of the nuclear island in March 2011 and issued a construction Licence on 28 May 2011 after resolution of all safety issues. The Construction Licence for C-4 was granted on 14 December, 2011. PNRA continuously monitors the construction activities including equipment manufacturing.

2.1.7 Openness and Transparency

Pakistan has continued its policy of transparency, openness, and sharing its experience with others. The activities at the nuclear power plants are reported to, and kept open to reviews at national and international level, by PAEC.

Reports about the nuclear power plants (including event reports) submitted by PAEC to PNRA are in the public domain. Significant events are reported by PAEC to WANO, and to IAEA by PNRA through INES and IRS.

PAEC invites international Review Missions to its nuclear power plants. The WANO Peer Review Program presently aims to review each nuclear power plant every 6 years, with another review between successive Peer Reviews, in the form of an IAEA OSART Mission, a WANO Follow-up Mission or an internal review mission from within the owner organization. Accordingly, two WANO Peer Review Missions have been received, at KANUPP and C-1 during the reporting period.

KANUPP and C-1 issue a brief daily production report, monthly technical reports covering all aspects of their operation and maintenance, annual reports analyzing their safety performance, quarterly performance indicator reports to WANO, reports about events and their analysis (besides those reportable under PNRA regulations), reports about their significant outages, technical reports on specific topics. KANUPP also sends a monthly report to COG. Besides being analyzed and reviewed by the PAEC corporate office, all these reports are available to PNRA. PAEC issues an annual report which includes the significant aspects and achievements at the nuclear power plants as well. PAEC also maintains its own web-site.

PNRA has also established open communication, cooperation and linkages with national and international organizations for improvement in regulatory performance. PNRA keeps the general public informed about its activities through a frequently updated website and a regularly published annual report. Draft regulations are also placed on the PNRA Website for comments.

Special activities and unusual events at radiation facilities are also reported through timely press releases.

A full scope IRRS mission is scheduled to be conducted to review the PNRA performance in April 2014. For this purpose, a preparatory meeting was held during March 2013 and self assessment is in progress.

In addition, PNRA presents its performance on selected subjects in the annual meetings of NERS. PNRA has presented its national reports before the review meetings of the Convention on Nuclear Safety for peer review and routinely places National Reports to the CNS on the PNRA public website.

2.1.8 Lessons learnt from Emergency Exercises/Drills

As a result of emergency exercises, the need for reliable communication/notification arrangements which can withstand disastrous conditions was felt. As such, arrangements for provision of Satellite Telephone Sets for plants and AECC are being made.

EPZ for KANUPP was initially 3 km. After Fukushima Dai-ichi accident, the EPZ was revisited and set as 5 km.

EPZ at CNPGS were revised after the Fukushima Dai-ichi accident. Impact of simultaneous accident at both units on EPZ is being assessed. Reassessment of surveillance program for emergency equipment/ supplies expected from other off-site support organizations following extreme external hazards is being taken into consideration.

At KANUPP and CNPGS, a team of multi discipline reserve force (Operation, Maintenance, Health physics etc.) has been formed for assistance during severe accident.

2.2 Update of Activities undertaken to improve nuclear safety in response to Fukushima Dai-ichi accident.

Post Fukushima assessments of each nuclear installation were conducted 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 term, medium term and long term activities. These were also presented in the Second Extraordinary meeting of the Convention on Nuclear Safety, held in August 2012. The following table describes updated status of activities under FRAP.

Topic 1 : External Events			
KANUPP			
Earthquake Hazard			
Task	**Target**	**Activity Status**	**Results**
Surveillance walk-down of seismic supports to identify any weaknesses or potential new hazards to critical equipment, and their resolution	28-02-13	Completed	Study Report completed. During fresh walk down some additional safety related equipment have been identified for strengthening such as DG local panels, cable trays, seismic instrument etc. All these equipment have been strengthened.
Study to incorporate auto shutdown if SSE is detected	31-01-12	Completed	Feasibility study concludes that seismic auto-shutdown is not required due to location of KANUPP on low seismic region and based of OEF received from Canada
Detailed visual inspections of all the structures, especially the structures important to safety	29-02-12	Completed	Visual inspections of all the structures, important to safety have been performed. In general building conditions are found satisfactory.
Re-evaluation of seismic capacity of all structures for the revised seismic input of 0.2 g	28-02-13	Completed	KANUPP structures are safe against 0.2g.
Confirmation of seismic qualification of existing diesel fuel tanks & mounting	28-02-13	Completed	Diesel fuel tanks and mounting platform are qualified for 0.2g.

platform			
Re-assessment of earthquake hazard based on the new IAEA methodology (without field work)	31-08-12	Completed	Report "Seismic Hazard Assessment of K-1" concludes that the estimated PGA by using new generation attenuation relationships varies from 0.02 to 0.19. Therefore, 0.2g value was adopted for SSE for the site.
Identify failure of seismically non qualified equipment systems making safety, safety related & safety support SSCs vulnerable to Tsunami	29-02-12	Completed	As per preliminary report on" Assessment of Tsunami Potential in Southern Pakistan", Tsunami hazard is meager. However, identified seismically non-qualified equipment has been anchored during RLOs and recent walk down after Fukushima Dai-ichi accident.
Seismic Pipe stress analysis for the piping layout of the new systems being installed under FRAP (interconnection with EFW, FIJW, DSW, VCW, Spent Fuel Bay)	31-12-12	Completed	It is concluded that integrated Emergency Water Injection (EWI) is safe against normal operating, thermal and the earthquake loads.
Perform seismic anchoring of tanks located in tank area (BFW-TK1, DMW-TK1, RFW-TK2, PW-TK1)	31-12-12	Completed	Report concludes that tanks (DMW-TK1, BFW-TK1, RFW-TK2 and PW-TK1) qualify seismically for the given response spectra at 0.2g and are in accordance with the criteria laid down in ASME Section VIII and AISC.
Re-assessment of earthquake hazard (with field work) based on the new IAEA methodology	31-03-14	In Progress	Field work has been completed in Sindh and will start shortly in Baluchistan.-
Tsunami / Flooding Hazard			
Task	**Target**	**Activity Status**	**Results**
Fresh Estimate of Tsunami hazard for KANUPP	31-03-14	In Progress	Preliminary study completed. Detail study is in progress.
Explore efficacy / availability of tsunami warning system at least for NPPs (presently	31-07-11	Completed	Enlisted with Tsunami Early Warning System (TEWS) of Pakistan Met Dept (PMD) for dissemination of

Pakistan is not member of international network.)			TSUNAMI warnings. Fax machine installed in MCR.
Identification of the equipment vulnerable to unprecedented tsunami/flooding and feasibility to improve resilience	30-06-13	Completed	Flooding hazard due to tsunami is not possible. Safety and safety related equipment is 39 ft (11.89 m) above MSL. The topographic survey and hydrology study report issued on 24-12-12. It concludes that existing drains are sufficient for benchmark rain intensity (65 mm/hr).. However, measures are being taken to enhance the safety grade level against flooding ≥ 3 ft.
Feasibility of tsunami wall on sea side of the plant or around vulnerable equipment / systems	31-12-11	Completed	Construction of Tsunami wall is not found feasible since Plant elevation of 39 ft (11.89 m) above MSL provides adequate natural protection against flooding from historically recorded tsunamis/ floods.
Fresh study of Hazards flooding due to maximum probable precipitation	31-12-12	Completed	The topographic survey and hydrology study issued on 24-12-12. It concludes that existing drains are sufficient for benchmark rain intensity (65 mm/hr). However, provision has been made to raise the protection level of all safety related structures, against external flooding by 1m above existing ground level (removable barriers on entrances).
Ascertain the ability of 8 ft high concrete wall constructed around plant to sustain tsunami	31-09-12	Completed	This wall has been constructed by KANUPP for security purpose it cannot withstand against any kind of tsunami thrust.
Identify/ protect (100% against flooding) smallest set of equipment necessary and sufficient to prevent core damage	31-12-12	Completed	Distribution room has been completely protected against flooding.
Construction of 8 ft flood retaining wall around FIJW and EFW room	31-12-13	In Progress	Design work of seismically qualified retaining wall completed. Contract has been awarded for construction of wall.

Storms/ Cyclones Hazard			
Task	**Target**	**Activity Status**	**Results**
Study of Cyclones including effects of different categories of Cyclones	29-02-12	Completed	Study report issued describing the effects of different categories of cyclones.
Re-assessment of structures for wind loading	31-12- 12	Completed	Important structures (reactor building, turbine building, service building, stack etc) of KANUPP will in general, withstand the wind loads resulting from design speed (100 mph) without collapse.
Fresh Study of hazard due to cyclones & rain	31-12-13	In Progress	The wind speed against 100 and 1000 years return period has been estimated as 45 m/s and 62 m/s respectively. The safety related structures are designed against wind speed of 45 m/s. Ability to withstand wind speed of 62 m/s is being checked.
Crash impact studies as a consequence of various aircraft / missiles	30-06-12	Completed	The horizontal impact of Military plane and commercial aircraft on KANUPP containment pose no threat to structural stability of containment.
Fire Hazard			
Task	**Target**	**Activity Status**	**Results**
Explore other nearby sources for providing assistance for Fire fighting	31-03-12	Completed	City district government will provide assistance for controlling the fire emergency. Memorandum of Understanding (MoU) signed with other nearby PAEC establishments for sharing resources.
Explore redundancy in Fire Tenders	31-07-13	In Progress	Expected date of delivery of new fire tender at site is 31-07-13. Parking shed for new fire tender considering the earthquake and flooding effect will also be constructed.
Evaluate Fire ring integrity from seismic point of view	28-02-13	Completed	Fire water ring is qualified for revised seismic hazard.

Feasibility Study of using Concrete Pump for Fire fighting	31-03-12	Completed	Requirement for obtaining the concrete pump is being dealt at Corporate office.
C-1/C-2			
Earthquake Hazard			
Task	**Target**	**Activity Status**	**Results**
Seismic walk-down of SSCs to identify any non-conformances and potential new hazards to critical equipment from external natural hazards	31-01-13	Completed	No new hazard identified. Only minor deficiencies like some loose anchor bolts, minor rusting of some of the supports found and corrected .The focus of walkdown was on interaction of seismic and non-seismic components.
Enhance seismic structures surveillance program	31-08-12	Completed	Baseline data for all safety related structures for C-2 collected. For C-1 this data is updated. It can now be ensured that no threat to safety related structures at both plants exists.
Feasibility study of auto shutdown if SSE is detected	30-09-12	Completed	• Not found feasible. • For C-2, upon actuation of seismic trigger, the Earthquake Monitoring system and its software calculate the actual response spectra and compare it to stored design floor spectra to check whether OBE has been exceeded. In this case, after a post earthquake walkdown, a controlled shutdown is initiated. CAV is also calculated and accounted for in the decision making in case of exceeding limit of OBE. • For C-1, the earthquake monitoring system directly generates OBE alarm upon detecting

			acceleration greater than OBE acceleration (0.125 g).
Study combined effect of earthquake and dam break/ flooding to determine how much it differs from DB	31-12-14	In Progress	Completed for external flooding potential.
Determine, improve the worst earthquake / flooding that the plants can sustain with minor back fits (identify the most vulnerable equipment)	31-12-15	In Progress	Based on walk-downs and engineering judgments, no back-fits related to seismic design have been identified. Seismic margin assessment of C-2 is planned as a long term item and recommendations if any will be incorporated. Finished Floor level of all safety structures were measured and found in conformance with design basis. All entrances are 2m higher than the water level estimated for worst external flood. Margins for all entrances of safety related structures will be increased by one meter further by modifying the existing entrances in such a way that a withdrawable /insertable wall may be used on as need basis.
Identify potential failure of seismically non qualified equipment/ systems making safety, safety related & safety support SSCs vulnerable to flooding	31-10-12	Completed.	Interaction of non-seismic (NS) chilled water system and NS service air system on nearby seismically qualified systems was checked. No adverse interaction identified. None of the Non Seismic SSCs was identified whose failure during an earthquake will result in a concurrent external flooding to damage a safety system. During the walkdown, Some room cranes were found not parked at safe distance from the equipment. Some fire related portable equipment found

			unsecured. These deficiencies have been removed
Acquire PSHA capability and estimate the probability of earthquake exceeding DBE and consequent flooding exceeding DBE	31-12-14	In Progress	Preparation of Historical Earthquake Catalogue for the region in collaboration with other organizations is underway.
Tsunami / Flooding Hazard			
Task	**Target**	**Activity Status**	**Results**
New study of flooding hazard potential for Chashma Site using updated historical information and considering Chashma Barrage break as a result of upstream dam break and other potential new scenarios	31-12-12	Completed	Completed for external flooding potential.
Re-assessment of Emergency Control Centers (ECCs) robustness of both C-1 and C-2 against flooding and earthquake	30-04-12	Completed	Re-assessment has been completed. For flooding, no hazard is identified. Entrance is two (2) meters higher than design basis flood level. ECC is an underground building designed for SSE. For earthquake, it could not be ascertained whether the collapse of floor above the ECC will block its entrance. Currently there are two entrances. One of the entrances is planned to be modified in such a way that it will remain unblocked after the earthquake.
Other External Hazards			
Task	**Target**	**Activity Status**	**Results**
Reassessment of vulnerability against hazards like storms, tornados, etc.	15-04-12	Completed	Last decade data for local meteorology reassessed. No significant change found.

Review any studies conducted to evaluate plant response to aircraft crashes of different types in different conditions, the worst case scenario emerging from these studies and its applicability to C-1/ C-2	31-12-12	Completed	This hazard is ruled out based on SDV as mentioned in section 3.1.2.3.3 of Pakistan's Special National Report for the 2nd Extraordinary meeting. There is an existing EOP for loss of MCR (habitability).
Fire Hazard			
Task	**Target**	**Activity Status**	**Results**
Explore ways to improve the fire fighting capabilities based on external support	01-10-12	Completed	CNPGS through its Emergency Plan, already have Liaison with Fire fighting services within 25 Km. This has now been extended to 100 km through involvement of district governments by virtue of provincially approved offsite emergency plan.
Revisit design basis of Fire Protection System	31-12-13	In Progress	Only fire detection basis will be reassessed based on case to case basis i.e. during investigation of fire related items. The fire incident investigation procedure now includes a check of related fire detector design.
Improve Resilience of Fire Brigade station to external Hazards	31-12-13	In Progress	Soft sheds will be used. Budget allocated
Augment equipment and training for Rescue and Recovery Operations	31-12-13	In Progress	A MOU with district Rescue service has been established for imparting training related to rescue and recovery operations for CNPGS personnel. CNPGS has a plan to strengthen its equipment base needed for typical rescue and recovery operations.
Perform Fire PSA for C-1 and C-2	31-12-15	In Progress	Acquisition of Plant specific component Data for development of Fire PSA Model is in progress.

Topic 2 : Design Issues			
KANUPP			
Electrical Power			
Task	**Target**	**Activity Status**	**Results**
Development of Integration scheme for external 300 kW, 400V mobile DG with Essential power supply	31-01-13	Completed	Integration scheme with external essential buses has been developed for connecting the 300 KW DG conveniently from outside the building.
Provision for energizing the plant essential buses through FIJW-DG1/2 (400 KW each)	31-01-13	Completed	The spare capacity of FIJW-DGs is being used to provide power supply to essential selected loads in case of SBO to enhance defense in-depth.
Installation of a new 80 kW, 400V DG set and its integration scheme to provide electrical supply to respective rectifiers / inverters to charge 24V DC and 220V AC UPS batteries for emergency lighting, instrumentation and monitoring and MOVs of ECCS.	30-06-13	Completed	A 80 KW, 400 V, 50 Hz DG has been installed in the tank area (at higher elevation safe from earthquake and flooding).
Shifting of emergency lighting from 230 VDC to 220 V AC (UPS)	31-12-13	In Progress	Fluorescent Lamps have been procured. 04 Distribution Room Panels have been installed, while 02 MCR panels are being installed. Necessary cabling and commissioning is in progress
Provision of alternate power supply to essential MOVs of ECCS	31-01-13	Completed	In case of SBO, MOVs of ECCS can now be operated from 220V AC UPS supply.
Feasibility study to arrange trolley mounted DGs from other organizations	31-12-11	Completed	The required capacity DGs are available in the market. Quotation of different rating DGs has been obtained. However, it seems comparatively more feasible to purchase 300 KWe or acquire from other PAEC establishments. Purchasing of 300 kW DG is

			underway.
Increase diesel fuel storage capacity onsite	31-12-13	In Progress	Feasibility study completed. Present storage capacity of on-site 9,500 IG diesel fuel is sufficient for 6 days. Crediting the inventory of 5000 IG diesel of one VSS diesel storage tank would increase on-site diesel inventory to 09 days. Furthermore, another new seismically qualified diesel fuel storage tank of 5000 IG is being constructed at VSS area.
Feasibility of use of natural gas in one of the Diesel generators for diversity	31-12-11	Completed	Use of Natural gas in Diesel Generators was not found feasible.
Procedure for conserving DC power to prolong its availability	30-06-11	Completed	Procedure has been modified to prolong 230V DC Power availability from 1 to 7 hrs. However, a DG of 80 kW has been installed to charge 24V DC and 220V AC UPS for indefinite time.
Feasibility of laying 2 km power cable (safe from external natural hazards) to connect a remote AC source to the plant electric power system (in case the EDGs are disabled and radiation hazard exists near the plant)	15-02-13	Completed	Feasibility Study ruled out the laying of 2 km cable due to availability issue of cables in case of external natural hazards. However, an integration scheme has been developed for connecting the mobile / fixed DG.
Review the location / protection of DGs from Tsunami Hazard	31-12-12	Completed	EDGs safety grade level against unforeseen flooding has been raised by 3 ft above ground level.
Improve Protection of Diesel Fuel against Natural Hazards	31-12-12	Completed	On-site VSS storage diesel fuel storage tank used for filling of vehicle has been protected against unforeseen flooding. Inventory of this tank may be used for make up in DFO tanks through bowser.
Procurement of bowser for transferring of diesel fuel from VSS fuel storage tank.	30-06-13	Completed	500 L bowser for transferring of diesel fuel from VSS fuel storage tank to diesel fuel oil (DFO) tanks has been procured.
Feasibility study for continuous charging DC batteries by Mobile DGs to increase	31-03-12	Completed	As per study, 80 KW DG has been installed at Tank Area (at higher location safe from earthquake and

availability (at least 10 hours)			flooding) for continuous charging of 24V DC and 220V AC UPS batteries.
Emergency Core Cooling			
Task	**Target**	**Activity Status**	**Results**
Feasibility study to determine the need of increasing pumping heads of EFW system	29-02-12	Completed	Present pumping head is adequate to cope with SBO condition.
Provision of additional points for fresh water injection and use of fire fighting system (as a last resort) for emergency core cooling	31-12-13	In Progress	Injection points identified for addition of water in EFW, FIJW, VCW, DSW and SFP systems. Interconnection with the existing system is in progress. After hydrostatic and commissioning test the interconnection scheme will be implemented during next available shutdown.
Feasibility study of passive cooling such as natural circulation after shutdown and in case of SBO	31-03-12	Completed	Due to higher elevation of BFW storage tank and other tanks, water can be injected through gravity in cold condition. In addition a diesel driven pump is being installed in tank area to force the available inventory of water into boilers.
Feasibility of steam-driven pumps to feed the boilers in extreme case	31-12-11	Completed	Use of steam turbine driven pump for providing feedwater to boilers was not found feasible due to low pressure and low steam flow after plant shutdown especially in case of SBO.
Conduct feasibility for water addition in Calandria/ Vault water system	31-12-12	Completed	Feasibility study concludes that water addition into vault cooling system found feasible while Water addition into calandria not found feasible.
Feasibility of simple diesel engine operated pumping sets for cooling in extreme cases	31-12-11	Completed	A pump having rated flow of 100 igpm at 100 psig discharge pressure will serve the objective adequately for all systems/cases.
Review flow capacity of EFW, FIJW, IJW against water availability.	31-12-11	Completed	EFW system existing capacity (EFW-TK1 & RFW-TK2) can provide heat sink for 2 days in case of SBO.

			FIJW system has been proved to be adequate for SBLOCA & IJW (recirculation) can be used for indefinite period. In summary extended SBO of 11 days can be catered at KANUPP subject to availability of heat sinks (crediting inventory of EFW-TK1 & RFW-TK1 and FIJW-TK1).
Containment Integrity			
Task	**Target**	**Activity Status**	**Results**
Assessment of hydrogen hazard	31-01-13	Completed	Study revealed that there is need for hydrogen re-combiners in KANUPP containment.
Feasibility and need for (passive) hydrogen recombiners and hydrogen igniters	31-01-13	Completed	Limited conservative analysis carried out to determine the number and location of PARs. The report has been reviewed through COG and found to be in line with current Canadian approach.
Installation of PARs	30-06-14	In Progress	Quotation for 12 PARs received. Necessary evaluation has been done and purchase is in process
Provision of hydrogen monitoring equipment under PAMs.	31-12-13	In Progress	A case has been initiated for procurement of H_2 gas analyzer system (Industrial Grade).
Identification of measures that can be taken in the worst case scenario to ensure containment integrity	31-01-12	Completed	Dousing spray system, fan coil units and containment bleed-off system (≤ 3 psig) to depressurize containment are provided in the design. For DBAs KANUPP containment is overdesigned (27 psig) in term of peak pressure and temperature (22 psig and 237 °F). During Severe Accident condition containment pressure may increase up to 40 psig in 04 days on depletion of VCW inventory. Containment structure can sustain 1.6 times the design pressure
Review adequacy of DSW for severe accident	31-03-12	Completed	DSW system proves to be capable of suppressing reactor building pressure for all the analyzed single and dual failure scenarios in KFSAR

Feasibility of operating motorized relief valves (dampers) manually when power is not available	31-03-12	Completed	Operation of motorized dampers during SBO was not found feasible because of loss of instrument air and control power supply. Furthermore, there is no provision in the design to operate the motorized dampers manually.
Feasibility of installing system for relieving containment pressure automatically / manually	31-12-13	In Progress	An unfiltered manual relief system has been proposed for depressurization of containment in case of severe accident. Unfiltered venting of containment in emergency condition is not desirable option. Study of Containment Filtered Ventilation (CFV) system has been conducted and under review phase.
Preparation of Procedure to decide when to vent the containment.	31-12-13	In Progress	Guidelines will be prepared for such action during the development of KANUPP SAMGs.
Study Feasibility of provision of independent power supply to essential MOVs	28-02-13	Completed	Study completed. Alternate power supply through 220V AC UPS has been provided to ECCs MOVs during Jan-Feb 2013 plant shutdown.
Possibility of providing another building / containers to relieve the existing containment.	30-06-12	Completed	Not found feasible for single unit.
Ultimate Heat Sink			
Task	**Target**	**Activity Status**	**Results**
Demonstration of Passive cooling (in cold condition) such as natural circulation	31-03-12	Completed	Due to elevation difference of boilers and feedwater tank, a limited quantity of water can be entered into the boilers during cold condition. Therefore, a diesel driven pump is being installed in tank area to pump the available inventory of water into boilers. Moreover, fire water system, fire tender may also be used to add water in boilers.
Integrity Assessment of Intake Bay Structure	31-12-12	Completed	Report concludes that Pump House Intake Conduits will not collapse in case of revised SSE of 0.2g.

Spent Fuel Cooling			
Task	**Target**	**Activity Status**	**Results**
Re-assessment of Spent Fuel Pool (SFP) seismic design	31-03-12	Completed	Spent fuel storage bay can withstand the seismic forces due to 0.2g earthquake.
Assessment of safe dry times of spent fuel	30-04-12	Completed	The calculations of safe dry time show that operators would have more than 19 days to act before the whole bay water reaches boiling temperature and uncovering of the top of spent fuel occurs after 140 days.
Provision of measures against loss of cooling or drainage of SFP	31-12-13	In Progress	In case of loss of recirculation ample time (19 days) is available to restore cooling before boiling starts in the bay. Arrangements for water addition in the bay through diesel driven pump, fire water ring and fire tender are being made.
Estimation of source term of spent fuel when water is lost or configuration is disturbed in SFP	31-03-12	Completed	Source Term of spent fuel has been estimated.
Study of criticality hazard of enriched (10%) fresh booster fuel assemblies stored at new fuel storage area in case of tsunami	31-01-12	Completed	There is no critically hazard of 32 fresh booster bundles kept in any geometry. The bundle will remain subcritical in case of flooding.
Study of criticality hazard of SFP in case of earthquake & tsunami due to presence of used enriched booster fuel	31-03-12	Completed	There is no critically hazard of 32 used enriched booster bundles in case of any earthquake.

C-1/C-2			
Electrical Power			
Task	**Target**	**Activity Status**	**Results**
Preparation of conceptual proposal for providing additional AC Power Source covering extreme natural hazards, all NPPs, interconnections of all installations, provision of trolley mounted small DGs, hookup of individual essential loads/buses, cables to remote connection points, resources available with the other organizations.	30-06-12	Completed	Assessment completed. Procurement process initiated. For each plant several mobile DGs for following loads will be added: • 1 for fire water pumps • 1 for RHR pump • 1 for Battery charger • 1 for Emergency air compressor and spent fuel pool cooling pump. • 1 for meteorological tower instrumentation. Guideline prepared for reducing (optimizing) load on EDGs for the conditions where diesel fuel is required to be conserved to prolong availability of onsite fuel.
Study to increase the storage capacity of Diesel fuel	01-11-12	Completed	• C-1 and C-2 are maintaining maximum level in its fuel storage tanks. • Onsite availability of lube oil has been enhanced.
Arrangements for supply of Diesel fuel in case of natural disaster	31-12-11	Completed	MOU signed with the District management for the supply of Diesel fuel to CNPGS site. A complete database of all contact numbers of fuel suppliers within 50 KM radius has been acquired.
Feasibility for increase in DC Power capacity	31-12-12	Completed	Idea dropped. Instead, an independent DG capable of Charging DC batteries and supplying full DC bus load indefinitely is planned.
Identify any reliability concerns with existing arrangements to cope with loss of off-site power	01-08-12	Completed	Ventilation system was identified as a possible area of concern. This has been addressed by provision of portable industrial fans in the building.
Review, improve PM program of EDGs	01-08-12	Completed	Preventive Maintenance Program for EDGs at both units revised.
Feasibility of laying 2 km power cable (safe	01-09-12	Completed	Laying cable to connect remote AC source was found

from external natural hazards) to connect a remote AC source to the plant electric power system (in case the EDGs are disabled and radiation hazard near the plant)			not feasible. The idea has been replaced with provision of one fixed DG in a new building hardened against BDB EQ. Feasibility study is underway.
Improve Protection of Diesel Fuel against Natural Hazards	31-12-12	Completed	Some gaps regarding water ingress were identified. Fire doors of all EDG entrances have been made water tight.
Explore other sources of Diesel Fuel	01-08-12	Completed	Sources have been identified. Contract with separate commercial suppliers for C-1/ C-2.
Arrange sharing of Diesel Fuel being units (C-1 and C-2)	31-12-13	In Progress	The feasibility study has proposed a temporary pump and hose system to transfer fuel between and among units in time of need. Procurements has been initiated.
Preparation of procedure for conserving DC Power to prolong availability	31-12-13	In progress	Instruments loops affected by each sub-breaker in each panel fed by each of 6 UPS identified and procedure is under preparation.
Assess the duration after SBO before fuel damage becomes inevitable, any cliff edge effects which can affect this scenario , and actions which can be taken to prevent them	31-12-12	Completed	Assessment Done. • For C-1, 7.33 days if AAC source (3 SBO DGs) is available. • For C-2, 7.33 days if AAC source is available • If complete SBO (Loss of all AC), 8 hours. For this case, after 2 hours batteries will deplete and availability of instrumentation to monitor SG level or feedwater flow will not remain available.
Study to power the minimum instrumentation for SAF system and core monitoring from the SAF DG, considering availability of water source also.	31-07-12	Completed	The study concluded that after the provision of independent diesel generator for battery charger, power to instrumentation of SAF system and core monitoring is ensured in long term. Additionally, portable flow meters are available to monitor SAF flow for steam generators and have been tested to indicate correct flow.

Emergency Core Cooling			
Task	**Target**	**Activity Status**	**Results**
Exploration of possible additional points for water injection into steam generator using temporary pumping sources in extreme case	31-12-12	Completed	Additional points identified. Firewater system can be connected to Steam generators. Necessary attachments prepared. The same points may be connected to independent water supply systems temporary stationed outside the Nuclear Auxiliary Building. For this service, procurement of a diesel driven pump is in process. The capacity and head of the pump is enough to feed a depressurized steam generator (i.e. depressurized using local operation of main steam line relief valve) The capacity of the point is found comparable to the minimum flow rate required to ensure heat sink.
Feasibility study of interconnecting SAF system with Safety Injection system (SIS)	31-12-12	Completed	Study completed and found feasible. Details related to interconnection are in progress with the help of designer.
Revisit procedure for use of Fire Fighting system for emergency cooling through steam generators	01-10-12	Completed	Auxiliary Feedwater pump of C-1 and C-2 is designed to take suction from firewater tank through flexible connection. Relevant Procedure for this provision, i.e. inclusion of steps related to manually and locally aligning Aux feed pump to firewater source incorporated.
Feasibility of installing Cavity flooding system at C-1	31-12-12	Completed	Back fitting of Cavity Flooding System was not found technically feasible in C-1.
Containment Integrity			
Task	**Target**	**Activity Status**	**Results**
Installation of PARs at C-1 (as in C-2)	30-04-14	In Progress	Estimated average concentration is in the same range as potential combustion. Safety Margin is insufficient in SBO. Designer has determined that C-1/ C-2 don't

			need CFVS because other solution may become available in 72 hours, before the Containment reaches design pressure in 130 hours.
Feasibility of Filtered Venting System for C-1 and C-2	31-12-12	Completed	Designer viewpoint is that no such system is needed as enough time (130 hrs) is available for the containment to reach its ultimate bearing capacity. Filtered Venting systems for C-1 and C-2 are in the process of procurement.
Review Efficacy of Hydrogen Recombiners at C-2	31-12-12	Completed	Study is underway to optimize the locations of PARs based on better estimation of Hydrogen distribution using international feedbacks/ developments.
Preparation of Procedure to decide when to vent the containment.	30-09-12	Completed	SCG-2 (Depressurize Containment) exists for C-2. However it will be made more plant specific.
Ultimate Heat Sink			
Task	**Target**	**Activity Status**	**Results**
Re-assessment of the consequences of Loss of Ultimate Heat Sink	31-12-11	Completed	WUH provides alternate UHS for 30 days after loss of primary UHS (CJLC) without any external make-up. Possible measure which may be taken (e.g. connection of Fire water with component cooling water system) is in progress for the cliff edge (complete unavailability of UHS fans)
Improvement in design of Essential service water pumping station entrance to prevent inundation in case of extreme flooding	31-12-13	In Progress	Finished Floor level of all safety structures were measured and found in conformance with design basis. All entrances are 2m higher than the water level estimated for worst external flood. Margins for all entrances of safety related structures will be increased by a further 1m by modifying the existing entrances in such a way that a withdrawable /insertable wall may be used when required.

Spent Fuel Cooling			
Task	**Target**	**Activity Status**	**Results**
Estimation of source term for spent fuel if water is lost or configuration is disturbed, in SFP	01-10-12	Completed	Potential for criticality in disturbed configurations eliminated. Enough conservatism exists against inadvertent criticality. Criticality is not possible if geometry is intact, even without boron and for full capacity of SFP with 3.4 % enrichment. A new study of re-criticality of slumped/ disfigured fuel was conducted. Source term for spent fuel if water is lost or configuration is disturbed, in SFP has been estimated using ORIGEN and a confirmatory analysis using MELCOR is in progress.
Determination of safe dry time (Fuel un-covered) of SFP	01-08-12	Completed	The limiting case was considered, with 7 normal offloads and 1 fresh discharged core. Boiling will occur in 8 hours, loss of shielding in 29 hours and fuel uncovery in 46 hours. Total pool dry-out in 66 hrs.
Study of measures against SFP loss of cooling or drainage	31-12-13	In Progress	• The PM procedures are being updated to include regular checking of SFP siphon breakers. SFP Monitoring is being added in APOs/ EOPs. • Make-up to pools may be done using building fire hydrant and fire tenders (demonstration done) • Make-up may also be done using portable pump. • Previously, C-1 fuel used to be stored in one pool only and the other pool remained isolated. Administrative procedures for storage of freshly discharged spent fuel in two pools to minimize heat load are now in place • For drain-down accident, feasibility of a modification related to provision of a spray cooling

			system is underway. Target for feasibility study completion is 31-12-2013. • Provision of a permanent pipe for pool makeup which can be connected, as and if required, mobile water source stationed outside of the fuel building.
Topic 3 : Severe Accident Management			
KANUPP			
Task	**Target**	**Activity Status**	**Results**
Revisiting the existing engineering judgment based SAMGs	30-06-11	Completed	Some minor corrections / revisions completed
Availability of all necessary equipment / gears for implementing EOPs, SAMGs	30-06-13	In Progress	Data is available from C-1/C-2 and other PAEC establishments regarding radiological equipment. Requirement for necessary emergency assistance through national emergency response organizations for portable diesel generators, diesel fuel, power cable / connectors, diesel driven fire pump, fire hose, dousers, petrol boats, personnel transportation, etc. is being handled by corporate office
Develop / improve EOPs for external Postulated Initiating Events (PIEs). Define transition point to SAMGs	31-12-13	In Progress	EOP for external hazard such flooding is being prepared. EOP for Spent Fuel Cooling has been issued. Revised EOP for earthquake has also been issued.
Review / ensure functionality of TSC in accident conditions on the basis of Fukushima experience	31-03-12	Completed	Technical Support Committee (TSC) has been established to assist the Emergency Management Group in bringing the plant in stable condition and to minimize the radiological consequences in case of severe accident. A Station Instruction has been prepared in this regard. Critical parameters display facility is available in ECC and AECC.
Development of a reserve force (ERT) of	31-03-12	Completed	A multi discipline team (Operation, Maintenance,

workers for coping with severe accident consequences			Health physics etc) has been formed which will be required for assistance during severe accident.
Supporting Analyses for SAMGs	31-12-12	Completed	Capability development task completed.
Revision of SAMGs based on supporting analyses	31-12-13	In Progress	Existing Limited Scope SAMGs are being revised.
C-1/C-2			
Task	**Target**	**Activity Status**	**Results**
Increase in minimum inventory of Boric Acid to cover potential emergencies at C-1	31-12-11	Completed	One additional boric acid tank is already maintained available as a good practice. Commercial Grade 25 tons is available, usable for accident purposes (based on isotopic tests). Allocated 12.5 tons for each plant. Operational inventories (10 Tons each plant) will be nuclear grade and *clearly separated from commercial grade.* Additional 10 ton inventory of commercial grade Boric acid is ensured to be kept available in store.
Preparation of C-1 SAMGs	31-12-14	In Progress	Contract is being signed for preparation of SAMGs which will be completed in 16 months.
Preparation / Enhancement of onsite Emergency Plan Implementation Procedures (EPIPs) to address external natural hazards in light of Fukushima Dai-ichi accident	31-01-13	Completed	Procedure 'Emergency Response to Natural and Hazardous events (External potential initiating events) has been issued which is an enhancement of previous procedure.
Enhancement of capability of Technical Support personnel for severe accidents		Continual Action	• Procedure regarding roles and responsibilities of Technical Support personnel during severe accidents issued. • A joint seminar with PNRA and IAEA was

			arranged in Dec. 2012 to enhance capacity building of Technical support personnel. • Periodic Exercises/drills to test the capability of Technical support personnel and consequential follow up actions.
Development of a reserve force of workers to cope with severe accident consequences at C-1/C-2	31-12-13	In Progress	Necessary competencies and qualifications have been identified. Plant operations and maintenance staff is enough all the times. Mainly more radiation protection and environment monitoring staff will be needed. Database for other organizations in country which have these capabilities is however compiled. A cross training program is being developed to increase the number of such personnel. This includes measures to keep information about the Reserve force updated.
Preparation of proposal for common alternate ECC/ resource center for Chashma site	31-12-13	In Progress	A conceptual design and location has been identified. Detailed technical proposal is under preparation.
Availability of necessary equipment / gears for implementing SAMGs	31-12-13	In Progress	CNPGS have portable and diesel driven air compressor set, portable RMEs, portable temperature and flow measurement devices, cranes, excavators, drainage pumps, flexible piping, portable communication devices, lead aprons, breathing apparatus, firefighting suits, portable shielding devices, etc. CNPGS has appropriated budget for addition of earth moving machinery, snorkels and portable Radiation Monitoring Equipment in context of extreme natural hazards. More equipment as needed by plant specific SAMGs will be added as pointed out during SAMG development.

Topic 4: National Organizations			
PNRA			
Task	**Target**	**Activity Status**	**Results**
Initial review of PNRA regulations related to safety of nuclear power plants	31-12-11	Completed	The initial review identified certain modifications in following two regulations: • PAK/910 "Regulations on the Safety of Nuclear Installations-Site Evaluation"; • PAK/911 "Regulation on the Safety of Nuclear Power Plant Design". The modifications cover the following: i. Periodic re-evaluation and re-assessment of all hazards (natural or man-made) – PAK/910; ii. Provision of reliable filtered venting system independent of any AC power with limited operator action for operation – PAK/911; iii. Provisions for withstanding and recovering from extended station blackout (SBO) to withstand potential initiating events (PIEs) of very low probability (internal and external) and any event that may occur as a consequence to the PIEs – PAK/911; iv. Consideration of low probability independent events to occur simultaneously – PAK/911; v. Consideration to control hydrogen within the spent fuel storage building in the event of loss of spent fuel cooling and to maintain integrity and functionality of fuel building-PAK/911; vi. Combined means to provide emergency power (such as by means of water, steam or gas turbine, diesel engines, batteries or mobile power generators) having reliability and form consistent with the safety requirements of the systems to be supplied, and performing their safety functions for longer durations on the assumption of a single

			failure – PAK/911; vii. Encourage introduction of passive design features in the plant systems specially the emergency core cooling systems, Hydrogen recombining systems and spent fuel pool cooling systems. -PAK/911 The above proposed modifications are aimed to further enhance the safety of nuclear power plants and to withstand the impact of hazards (natural and man-made) and events of very low probabilities with consequential extended loss of AC power sources (off-site as well as on-site).
Revision of PNRA regulations in the light of feedback from Fukushima Dai-ichi accident	31-12-14	In progress	Documentation Preparation Profile has been prepared and initial review is in progress at relevant work units of PNRA.
PAEC			
Task	**Target**	**Activity Status**	**Results**
Review of progress of all NPPs on FRAP		Continual Action	The progress is being reviewed on six monthly basis.
Follow-up of the implementation of FRAP	31-12-14	In Progress	Details of activities uptil June 2013 are given in current table.
Topic 5: Emergency Preparedness and Response and Post-Accident Management (Offsite)			
KANUPP			
Task	**Target**	**Activity Status**	**Results**
Reassessment of EPZs and corresponding emergency response actions	30 -06-12	Completed	EPZ for KANUPP which was initially 3 km has been enlarged to 5 km. Currently stock of 100,000 KI tablets is available. Additional 100,000 tablets have been procured. In addition 25,000 imported KI Tablets case is also under process. This inventory has been

			maintained keeping in view enlarged EPZ in case of any severe accident. At present, PDMA will provide necessary assistance as per KOFREP. SOPs for sheltering, KI tablets distribution and evacuation have already been prepared and approved.
Revision of Emergency Plans	15-09-12	Completed	KONREP revised. Recovery plan developed. AECC has been shifted from hostel to a house. Availability of CPDS and Met data in AECC. Installation of DG, communication equipment, gamma monitor etc in AECC.
Exploration of alternate communication links at plant and AECC	30-12-13	In Progress	Arrangements for provision of Satellite Telephone Sets for plants and AECC are being made.
Revisit / enforce / support improvement of National Disaster Management Authority (NDMA) / Nuclear Emergency Management System (NEMS) plans	15-09-12	Completed	PDMA setup would work as per existing KOFREP. Requirement for necessary assistance from Pakistan Navy for barge / trolley mounted diesel generators, portable diesel generators, diesel fuel, power cable / connectors, diesel driven fire pump, fire hose, dousers, petrol boats, personnel transportation, etc. is being handled through corporate office. Draft NEMS implementation plan received and comments submitted by KANUPP in September 2012.
Provision of Post Accident Monitoring equipment	31-03-14	In Progress	To be installed during long shutdown of 2013-14
Enhancement of Emergency Preparedness Infrastructure	31-12-13	In Progress	Provision of budget for purchase of emergency radiological equipment for AECC has been kept in 2012-2013. Supply order for 50 EPDs has been issued. TLD reader has been indented. Supply order of TLD issued. For Gamma Spectrometry system supply order has been issued. Tritium monitoring (liquid scintillation counter) indent is yet to be raised. After acquiring of above equipment a small scale

			laboratory will be set up in KANUPP colony (AECC) by the end of 2013. Existing MRML will be upgraded.
C-1/C-2			
Task	**Target**	**Activity Status**	**Results**
Improvement of EPPs	31-12-12	Completed	• Census of PAEC colonies was done again. The census will now be re-done after every 5 years. (Next in 2017). The EPP will be updated accordingly. The info will improve evacuation procedure. • CNPGS has arranged provision of Satellite image of the site in its Emergency Control Centers to assist in decision making regarding public safety during emergencies • Site Re-entry procedure prepared and is under review;,. • Further Enhancement in Real time radiation monitoring system around CNPGS: One or two field measuring station will be added each year to existing set-up to increase the number from existing 06 stations to 12.
Exploration of alternate communication links at MCR and ECC at C-1 /C-2	30-06-12	Completed	Alternate communication equipment is being provided at C-1 and C-2 MCRs and also at ECC.
Reassessment of EPZ	31-12-13	In Progress	Impact of simultaneous accident at both units on EPZ is in progress.
Assessment & development of possible additional access routes to the site	31-12-15	In Progress	New access path is in basic design stage. Arrangements are however, in place to remove obstructions on access roads.
Up-gradation of personnel de-contamination facility in local hospital	30-06-12	Completed	Personnel de-contamination facility in local hospital has been upgraded to handle increased number of contaminated personnel along with the relevant training of personnel involved.
Development of Public Awareness Program	31-12-13	In Progress	Draft Program is in review process.

Topic 6 : International Cooperation			
Task	**Target**	**Activity Status**	**Current status Results**
WANO Peer Review at C-1	April 2012	Completed	Work initiated in response to various recommendations made by WANO mission (Please see Section 2.1.4)
IRRS Mission at PNRA	April 2014	In progress	IRRS Preparatory mission carried out in March 2013.
WANO Special Peer Review Follow-up at KANUPP	April 2013	Completed	Implemented Corrective Actions in response to various WANO mission recommendations (Please see Section 2.1.3)

2.3 Technical Issues identified at Second Extraordinary meeting

Following is an overview of the implementation of various "Technical Issues" identified during the Second Extraordinary Meeting of the Contracting Parties of CNS, held in August, 2012:

S.No	Issue	Information
1.	For existing nuclear power plants, the results of reassessments of external events, of periodic safety assessments and of any peer reviews, and any follow-up actions taken or planned, including upgrading measures.	• Results of reassessments of external events- Please see Section 2.2 Topic 1 • Results of periodic safety assessments- Please see Section 1.4, 12.2, 14.1, 14.2.1, 14.2.2, 18.2, 19.2 and 19.3.Please also refer to Annexure VII of Pakistan's Fifth National report on CNS • Results of peer reviews, and follow-up actions taken or planned, including upgrading measures.- Please see Sections 2.1.3, 2.1.4, 2.1.5, 10.3.3, 16.5 and Annexure XIII "International Peer Reviews"
2.	For existing nuclear power plants, any actions taken or planned to cope with natural hazards more severe than those considered in the design basis.	Please see Section 2.2 Topic 1
3.	For new nuclear power plants, improved safety features and additional improvements, if any, to address external hazards and to prevent accidents and, should an accident occur, to mitigate its effects and avoid off-site contamination.	Please see Section 2.2 Topic 1, Topic 2 and Topic 3 Safety features improved at existing NPPs to address external hazards will also be incorporated in C-3/C-4 wherever applicable.
4.	Upgrading of accident management measures for extreme natural events.	Please see Sections 2.2 Topic 2 and Topic 5
5.	Measures taken or planned to ensure the effective independence of the regulatory body from undue influence, including, where appropriate, information on the hosting of IRRS missions.	• Independence of regulatory body – Please see Section 8.2 • IRRS Mission -Please see Section 2.2 Topic 6 and Section 8.9.3.5
6.	Enhancements of emergency preparedness and response measures.	• Updates to Emergency Plans- Please see Section 2.2 Topic 5 , Section • Planning Emergency exercises –Please see Sections 16.3, 16.5 • Enhancement in Radiation Monitoring and communication capability- Please see Section 2.2 Topic 5 , Section 16.5, • Recovery phase aspects- Please see Section

		2.2 Topic 1, Section 16.3 • Adequacy of Emergency response "Headquarters" and Sheltering Centers - Please see Section 16.3
7.	Information on how IAEA safety standards are taken into account.	Please see Section 7.1.2:
8.	Information on activities undertaken to enhance openness and transparency for all stakeholders.	Please see Section 2.1.7
9.	Activities to improve safety culture based on lessons learnt from the Fukushima accident.	• Safety Culture at Nuclear Installations – Please see section 10.3, 10.3.1, 10.3.2, 10.3.3, 12.3, 13.2.2, 14.4. • Safety Culture at PNRA- Please see Section 8.8, 10.4.

2.4 Progress on Challenges identified during the Fifth Review Meeting 2011.

The following challenges were identified for Pakistan during the Fifth Review Meeting:

i. Access to the technology for the development of safe and sustainable nuclear power infrastructure;
ii. Improve the existing capability to design, construct and operate nuclear power plants safely;
iii. Develop indigenous capability to manufacture nuclear power plant components; and
iv. Develop the capability to assess and address the ageing of principal components of nuclear installations.

The Pakistan Government is committed to continually update its nuclear power infrastructure to incorporate the latest technological developments to ensure the safety of its nuclear power plants. Pakistan under the umbrella of various IAEA technical projects is involved in the acquisition of technical information and technology. Pakistan supported the proposals by C.Ps at the second Extraordinary meeting regarding changes in the CNS supporting documents (INFCIRC/572) to conducting of safety assessments at NPPs according to modern standards and best international practices.

Pakistan has encountered problems in acquisition of safety related equipment on several occasions. The Government of Pakistan is taking up the issue of equitable access to safety related nuclear technology at various levels. Nevertheless, various R&D institutions of PAEC are involved in research projects for the development of safe and sustainable nuclear power infrastructure in the country.

PAEC is committed to upholding of the latest safety standards in the operation and construction of its NPPs. Under the IAEA TC projects, PAEC personnel are undergoing intensive training to enhance their capabilities to design, construct and operate nuclear power plants.

Pakistan is developing infrastructure for manufacturing components of nuclear installations including safety class components for NPPs. The equipment includes tanks, vessels, process equipment, precision mechanical components, heavy steel structures, etc.

Two project proposals have been submitted to IAEA under technical cooperation program for 2013-14 to develop and enhance the capability to address the ageing of NPP equipment.

Part III

3 Future Challenges

Development of Public Awareness Program

Both PNRA and PAEC have started a limited scope public awareness programs targeting specific groups of population. The PAEC is focusing towards the population around nuclear installations as part of offsite emergency planning and preparedness. In this regard lectures/talks are being arranged in the educational institutes, hospitals, community centers and in district government departments around nuclear installations. All these activities have helped in educating the institutions to play their role in the emergencies however, efforts are being made to develop and implement comprehensive public awareness program with broader scope and complexities.

PNRA has also initiated efforts with the perspective of public involvement in the regulatory decision making process. In this regard various activities are being accomplished which mainly includes public education towards safety aspects of nuclear installations and radiation facilities and the role of a national regulatory body. Lectures, seminars and workshops are being organized at the licensee's premises and educational institutions to educate general public and the radiation workers about the radiation hazards, functional domains of nuclear regulatory body and the process of giving input in the regulatory functions. Furthermore, during the process to formulate regulations, the draft regulations are also placed on the PNRA website for seeking comments from all the stakeholders including general public before finalization. Although limited input is being received from the public in terms of comments on the draft regulations, however, further efforts are needed to stimulate effective response. The other aspects which need further efforts include public involvement in the regulatory decision making process.

Risk Informed Regulatory Approach

At present, PNRA is following prescriptive approach in the regulatory decision making process with some limited application of risk informed approach. However, it is anticipated that with increase in number of nuclear installations, the regulatory activities need to be optimized with the application of risk informed decision making. In this regard, PNRA is in the process of development of PSA Regulator's Model under IAEA technical cooperation program. The project is going with good pace and planned to be completed in early next year followed by its use in the regulatory decision making process such as review of design modifications, development of risk informed oversight program for operating NPPs. Further, development of capability for level-2 and level-3 PSA is also part of the long term development activities of PNRA for which technical assistance from international community would have catalytic effect.

Enhancement and up-gradation of PNRA Emergency Response Capabilities

The accident at Fukushima Dai-ichi highlighted the importance of emergency response capabilities as an ultimate action for protection of public, workers and the environment. Accordingly, PNRA is in the process of enhancing its emergency response capabilities and up-gradation of its infrastructure to respond to any emergency at nuclear installations in the country. The challenge ahead is to up-grade the Nuclear Radiological Emergency Coordination Centre (NRECC) into a state of the art coordination center as a focal point for regulatory response in case of such emergency in Pakistan or abroad. The mechanism of information exchange has to be improved by establishing a country wide online integrated system of coordination with centralized on-line display of important plant parameters, meteorological data and other information. Strong coordination with relevant organizations for reliable information exchange both in normal and emergency situations will be a step forward to move towards

achieving this goal. Improving liaison with organizations working in the domain of nuclear and radiological emergencies and disaster management is to be worked out and to formulate a tangible and reliable mechanism of coordination. Infrastructure for training of emergency response workers from off-site organizations needs to be strengthened.

Part IV

Article 4 – Implementing Measures

"Each Contracting Party shall take, within the framework of its national law, the legislation, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention".

4 Implementing Measures

This report presents legislative, regulatory and administrative measures and steps that Pakistan has taken, within the framework of its national law, which are necessary for the fulfillment of its obligations under this Convention. These measures have been described in earlier five national reports. The main legislative instruments have been enacted and essential national regulations are in place. An approach of continuous and gradual fulfillment of the safety obligations is adopted by Pakistan and priority is given to the most safety significant issues.

Pakistan has, therefore, met the obligations of Article 4 of the Convention.

Article 5 – Reporting

"Each Contracting Party shall submit for review, prior to each meeting related to in Article 20, a report on the measures it has taken to implement each of the obligations of this Convention"

5 Reporting

After signing the Convention on Nuclear Safety, five national reports were submitted by Pakistan and were reviewed by the contracting parties in the respective review meetings. A special National report was also submitted by Pakistan to the IAEA in response to the Fukushima Dai-ichi accident and underwent peer review by the Contracting parties during the Second Extraordinary meeting in August 2012. This is the sixth national report by Pakistan in compliance with Article 5 of the Convention.

Pakistan has, therefore, met the obligations of Article 5 of the Convention.

Article 6 – Existing Nuclear Installations

"Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shut-down may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact."

6 Existing Nuclear Installations

Three nuclear power plants are operating in Pakistan whereas, two plants are under construction. The existing nuclear installations are listed in Annexure–I. Following paragraphs briefly provide information about existing nuclear power plants whereas, Post Fukushima assessments and implementation of activities related to each nuclear installation are presented in Section 2.2.

6.1 Karachi Nuclear Power Plant

Karachi Nuclear Power Plant (KANUPP) continued safe operation since its licensing beyond design life. In the previous report, details of some of the relicensing requirements and their fulfillment by KANUPP were described. KANUPP underwent long maintenance outage that started from December 2010 and continued till May 2011. During this period, KANUPP completed all the major activities as required by PNRA including assessment of main equipment such as steam generators and fuel channels. The activities performed by KANUPP were thoroughly assessed by PNRA to verify compliance with the regulatory requirements and to ensure that the plant can operate safely. Based on the review and assessment and observations made during regulatory inspections, KANUPP was conditionally allowed to make the reactor critical and subsequent power operation in June 2011. KANUPP was further asked to submit detailed reports that would form the basis for any further extension in operating licence of KANUPP. On October 19, 2011, while the plant was in shutdown state, the incident of heavy water leakage occurred as a result of development of a crack on south end inlet feeder of fuel channel S-11. PNRA directed KANUPP to submit detailed report of the incident and not to start the plant unless approval from PNRA is obtained. The incident was reported to Nuclear Event Web-based System (NEWS) of IAEA as level- 1 on INES. KANUPP applied for plant startup permission on December 12, 2011 along with submissions of the required documents and detailed report on the event. Based on assessment of these reports, PNRA granted permission for plant startup till April 2012. Any further operation required detailed assessment and evaluation of remaining useful life of steam generators and integrity of fuel channels.

KANUPP operating licence was extended till December 31, 2016 on April 30, 2012. The extension is a result of thorough assessment of remaining useful life of steam generator and integrity of fuel channel and determination that further operation is safe.

6.2 Chashma Nuclear Power Plant Unit–1

Chashma Nuclear Power Plant Unit–1 (C-1) is operating safely since award of Operating Licence in 2000. The plant has undergone eight refueling outages. The plant operated within the approved operating envelope during the reporting period. Its radioactive releases to the environment and doses to workers and public remained well below the authorized/regulatory limits.

The operating licence of C-1 expired in December 2010 and as part of ten yearly licence renewal requirements of PNRA Regulations PAK/909, C-1 conducted Periodic Safety Review (PSR) covering areas like plant design, condition of Structures, Systems and Components (SSC), safety analyses (both deterministic and probabilistic), operating experience feedback, management and environmental impact assessment. C-1 submitted one-hundred and ninety-three (193) reports with the application to extend its operating licence for another 10 years, i.e., until 2020. Based on the review of PSR reports and satisfaction that no safety issue remained unresolved and appropriate corrective actions have been identified, the operating licence of C-1 was revalidated up to December 2020.

In August 2011, C-1 completed its seventh operating cycle and the plant was shut down for refueling outage-7 (RFO-7). During RFO-7, C-1 replaced the locally developed indigenized LPMS with LPMS procured from Greece. In addition, various other jobs such as maintenance, testing, surveillance, in-service inspection, refueling, etc., were performed during the RFO. Upon completion of RFO-7 activities, C-1 applied for permission of making reactor critical along with the documents required under PNRA regulations PAK/913. Upon completion of review of these documents and confirming that the licensee has completed all actions required under the directives issued by PNRA, C-1 was allowed to make the reactor critical on September 28, 2011. RFO-8 was completed in February 2013 followed by permission to restart by PNRA. Major activities included Refueling Containment Structural Integrity Test (SIT), Containment Integrated Leak Test (ILRT), Eddy Current Testing for both Steam Generators, overhauling of one Reactor Coolant Pump motor, Steam Generator Manhole Studs modification, Main Generator maintenance, Overhauling of Auxiliary Transformer and maintenance of 220 KV and 132 KV GIS etc.

C-1 applied for the construction of Surveillance Capsule Assembly Testing Facility and Extended Storage Facility for Low Level Radioactive Waste. Based on the review and assessment of C-1 applications, PNRA allowed construction of these facilities. PNRA extended time specific licence condition regarding Storage of Radioactive Waste up to 2014 on the request of C-1 after analysis and verification through review and assessment and inspections that enough space is available in the existing storage building.

6.3 Chashma Nuclear Power Plant Unit – 2

Review of regulatory submissions, including Final Safety Analysis Report of Chashma Nuclear Power Plant Unit-2 (C-2) was conducted and Fuel Load Permit was issued to PAEC at the end of December 2010.

C-2 achieved its first criticality on 22 February 2011 and grid connection was made on 15 March 2011. Requisite tests were conducted at low power, power ascension and full power to verify plant performance and response as per design intent.

As per requirement of Regulation for Licensing of Nuclear Installation(s) in Pakistan (PAK/909), C-2 was required to submit application for Operating Licence within six months after first fuel load. In compliance, C-2 submitted its application along with submissions required under the regulations. Assessment of these submissions and verification of the fulfillment of commitments made by the licensee in response to review and assessment and inspections were undertaken by PNRA. The Operating Licence has been awarded to C-2 till 31st December, 2021.

During first RFO, Main Feed Water Control Valves were replaced with new valves. As a result, it was possible to attain maximum power (340MWe) which had remained limited to 325 MWe during initial cycle. ISI of selected portion of RPV, Structural Integrity Test of Containment and Integrated Leakage Rate Test of containment were also carried out.

6.4 Chashma Nuclear Power Plant Units-3 & 4

Detailed review of SER for units 3 & 4 (C-3 and C-4) was completed in the first quarter of 2011 and the site was registered by PNRA on February 07, 2011 for the construction of C-3. As per licensing procedure, the design and safety criteria for C-3 and C-4 were finalized and agreed by PNRA. Afterwards, PAEC submitted an application for issuance of Construction Licence for the Units along with a Preliminary Safety Analysis Report and other documents as per requirement of PNRA regulations PAK/909.

Review of the construction licence application including necessary licensing submissions i.e., Preliminary Safety Analysis Report (PSAR), Probabilistic Safety Analysis (PSA) Report and Overall Quality Assurance Program (OQAP) for C-3 and C-4 was completed in 2011. After satisfactory resolution of all the relevant issues, construction licence was awarded to C-3 on May 28, 2011. The process of site registration of C-4 was prolonged till the end of year 2011 due to the issue of C-4 exclusion area boundary outside PAEC land. However, after resolution of this issue, C-4 site was registered on December 08, 2011, whereas, construction licence was issued on December 14, 2011. The civil work of C-4 has started with first concrete pouring on December 18, 2011.

Civil work for the construction and installation of C-3 and C-4 is in progress. Construction milestone of dome placement for C-3 reactor building was accomplished in March 2013. Civil construction and equipment manufacturing of C-4 is progressing according to project schedule and the dome placement of containment is expected in April 2014.

Design Parameters of C-3/C-4 are given in Annexure II.

Pakistan has, therefore, met the obligations of Article 6 of the Convention.

Article 7 – Legislative and Regulatory Framework

"1.Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.

2. The legislative and regulatory framework shall provide for:

(i) the establishment of applicable national safety requirements and regulations;

(ii) a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence;

(iii) a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and terms of licences;

(iv) *the enforcement of applicable regulations and of the terms of licences, including suspension, modification or revocation."*

7 Legislative and regulatory Framework

PNRA was established as an independent nuclear regulatory authority to regulate, oversee and formulate the requirements for nuclear safety & radiation protection. Through licensing, review and assessment, and inspections processes, PNRA carries out its regulatory oversight responsibilities to assure that the nuclear and radiation facilities throughout Pakistan are safe and secure. Presently, Pakistan is party to the following conventions related to nuclear safety:

S/N	Convention	Date of Accession
1.	Convention on early notification of a nuclear accident	12 October 1989
2.	Convention on assistance in the case of a nuclear accident or radiological emergency	12 October 1989
3.	Convention on nuclear safety	29 December 1997

7.1 Regulatory Framework

PNRA Ordinance, together with the PNRA Regulations and Regulatory Guides forms the basis for a nuclear legislative and regulatory framework. Ordinance and Regulations are of mandatory nature while guides are non-mandatory. These guides provide methods on meeting requirements specified in the regulations. Methods, other than those specified in these guides can be adopted provided it can be demonstrated to the Authority that the same or higher level of safety and quality can be achieved.

7.1.1 Pakistan Nuclear Regulatory Authority Ordinance 2001

The Ordinance provides the statutory basis for the Authority. PNRA ordinance authorizes PNRA to devise, adopt, make and enforce Regulations to protect worker public and environment from harmful effects of ionizing radiations.

The Ordinance empowers PNRA to:

i. make regulations and rules in accordance with the provisions of the Ordinance;

ii. issue licence,

iii. inspect all nuclear installations, radiation facilities and waste facilities, nuclear substances or radioactive materials to ensure compliance of regulations, and

iv. take enforcement actions against non-compliance of the regulations.

7.1.2 PNRA Regulations

Section 56 of the ordinance empowers PNRA to issue Regulations. Up till now, 15 different Regulations related to different areas of nuclear safety and radiation protection have been promulgated.

The PNRA regulatory framework is mainly based on the IAEA Safety Standards.

List of gazette notified Regulations is given in Annexure-IV .The Regulations have been placed on the website http://www.pnra.org for easy access.

PAK/909 describes the licensing system for nuclear installations whereas PAK/908 describes the licensing system for radiation facilities other than nuclear installations.

7.1.3 Regulations Published Since the Last Report

Since publication of last report, the following new Regulations have been promulgated:

i. Pakistan Nuclear Regulatory Authority Enforcement Regulations – (PAK/950)

ii. Regulations on Transaction of Business of Pakistan Nuclear Regulatory Authority- (PAK/901)

iii. Regulations on the Safety of Nuclear Research Reactor(s) Operation – (PAK/923)

7.1.3.1 Pakistan Nuclear Regulatory Authority Enforcement Regulations – (PAK/950)

This regulation gives all the enforcement actions that may be taken against the licensees who are found to contravene any provision of the PNRA Ordinance or rules and regulations made there under or terms and conditions of the authorization or licence and the non-licensees under section 44 of the Ordinance.

PNRA Enforcement Procedure (WP-PNRA-003(Rev.0)) has also been issued. This procedure describes step by step approach for initiating enforcement actions against licensee and non licensee for the implementation of PAK/950.

7.1.3.2 Regulations on Transaction of Business of Pakistan Nuclear Regulatory Authority-(PAK/901)

These Regulations define transaction of business of the Authority in a manner consistent with the Ordinance. The regulation presents establishment of the secretariat and designation of the authority, defines time frame, methods to call the meeting; notification agenda and quorum of the meeting, and how the decision can be made. .

7.1.3.3 Regulations on the Safety of Nuclear Research Reactor(s) Operation – (PAK/923)

These regulations are based on IAEA Safety Standards NSR-4. The main objective of these regulations is to establish requirements on aspects relating to regulatory control, management of safety and basis for safety assessment for operation of research reactors. These regulations establish requirements for the safety of research reactors, with particular emphasis on requirements for operation.

7.1.4 Revision of regulations

The PNRA Regulations are revised normally after 05 years or on need basis due to any of the following:

- Obligations of PNRA Ordinance
- Feedback of licensing and licensee Experience
- International Practice and Experience

The Regulations for Licensing of Nuclear Installations in Pakistan-PAK/909 (Rev.1) were revised during the reporting period. Scope of PAK/909 was broadened by including the licensing requirements of other nuclear facilities such as spent fuel storage facilities, waste storage and disposal facilities etc. Some new requirements were incorporated in the draft related to the following:

a. Permission prior to Commissioning.
b. Revalidation of Operating Licence.
c. Requirements for removal from regulatory control/decommissioning and licence amendment.
d. Transport of nuclear/radioactive material to/from a nuclear facility.
e. Transfer of licence.
f. Separate licence for establishment of spent fuel storage or a predisposal radioactive waste management facility in case the facility is not covered under licence of any operating NPPs or RRs.
g. In case the licensee is unable to start construction of the nuclear facility within a period of five (05) years after the issuance of Construction Licence, the same shall be deemed to have been cancelled. In such a case, the applicant shall have to re-submit the case for issuance of construction licence.

7.1.5 Amendment in Regulations

Regulations on Radiation Protection (PAK/904) were amended and criteria for radiation protection officer were added in the regulations as Annex VII.

7.1.6 New Regulations under preparation

The following new regulations are being formulated:

- Regulations on Decommissioning of Facilities Using Radioactive Material (PAK/930).
- Regulations on Physical Protection of Nuclear Installations and Nuclear Material (PAK/925).

7.1.7 Regulations currently under revision

The following regulations are being revised:

- Revision of Regulations for Licensing of Nuclear Safety Class Equipment and Component Manufacturers (PAK/907).
- Revision of Regulations on Radioactive Waste Management (PAK/915).
- Regulations for the Licensing of Radiation Facility(ies) other than Nuclear Installation(s) (PAK/908).
- Regulation on the Safety of Nuclear Power Plant Design (PAK/911).

7.1.8 Regulatory guides

The following regulatory guides have been issued in the reporting period:

- Format and Contents of Application for Modifications in Technical Specifications and Operating Policies and Principles of NPP.
- Probabilistic safety assessment of nuclear power plants level-1.

7.1.9 Guides under preparation

The following regulatory guides are under preparation:

- Radiation Safety in Industrial Radiography.
- Protection of Patients in Diagnostic Radiology.
- Format & Contents of Radiation Protection Program of Radiation Facilities/Practices.
- Format and Content of Emergency Plans for radiation facilities and Activities.
- Guidance for Evaluation of Radiation Safety Requirements at Radiation Practices.
- Guidelines for Medical Professionals on Transport, Diagnosis and Management of Over Exposed and Contaminated Individuals in Radiation Emergency.
- Radiation Protection and Safety in Radiotherapy.
- Regulatory guide on format and contents of applications for design modification /change approvals for NPPs.

7.1.10 Use of International Regulatory Guides and Industrial Standards

Under the provisions of regulations PAK/909, PNRA delineates that the guidance from regulatory guides of USNRC or IAEA is acceptable. Since the USNRC regulatory guides specify internationally used industrial standards such as ASME, IEEE, etc., therefore, these standards can also be used by the licensees. In addition, the industrial standards of the exporting countries such as RCC-M of France or GB of China can also be employed. If necessary, international standards such as ISO, IEC, etc. can also be referred.

Pakistan has, therefore, met the obligations of Article 7 of the Convention.

Article 8 – Regulatory Body

> *"1. Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfill its assigned responsibilities.*
>
> *2. Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organization concerned with the promotion or utilization of nuclear energy."*

8 Regulatory Body

Ordinance No.III of 2001 was promulgated by the Government of Pakistan for the establishment of the Pakistan Nuclear Regulatory Authority. PNRA is empowered to formulate and implement regulatory framework and has sufficient authority and funding to carryout day to day affairs.

8.1 Vision and Mission of PNRA

The vision of PNRA is to become a world class regulatory body with highly trained, competent and dedicated personnel working in unison with zeal to foster a positive safety culture in its licensed facilities. It should regulate nuclear installations to protect the public, workers and the environment from the harmful effects of radiation in a manner that wins the confidence of all the stakeholders such as the public, the Government and the Licensee.

The mission of PNRA will be fulfilled by formulating and implementing effective regulations, building a relationship of trust with the licensees and maintaining transparency in its actions and decisions

8.2 Legal Basis of PNRA

PNRA Ordinance No. III of 2001 of Government of Pakistan provides the legal basis for an independent nuclear regulatory body. It describes the constitution of the Authority, tenure and eligibility of its Chairman and the Members, interface with Government of Pakistan, etc. The Chairman is the chief executive officer of the Authority and is responsible for the day to- day administration of the affairs of the Authority and ensuring nuclear safety in Pakistan.

PNRA is the sole national regulator responsible for the nuclear safety and radiation protection. Environmental Protection Agency of the Government of Pakistan separately regulates all aspects of environment protection except for those having radiological impact, which are regulated by PNRA.

8.3 Organization of PNRA

The organizational setup of PNRA is continually under review and is revised as and when found necessary. As provided for in the Ordinance, PNRA comprises a Chairman, two fulltime and seven part-time Members. The Federal Government appoints the Chairman and the Members. Chairman is the chief executive of the Authority and reports to the Prime minister of Pakistan on all matters related to nuclear safety and radiation protection. Annexure–V shows the organizational structure of PNRA.

PNRA is organized on the basis of executive and corporate wings; headed by Member (Executive) and the Member (Corporate) respectively. The executive wing is responsible for core functions of the Authority, whereas, the corporate wing is responsible to drive the Authority as an organization and also provides technical support to the executive wing through its Technical Support Organization (TSO). The Secretary of the Authority, the Advisory Committees and the Director General of the Chairman Secretariat, report directly to the Chairman. The latter assists Chairman in planning future activities of PNRA.

There are two Director Generals under the authority of Member (Executive); DG (Technical) and DG (Inspection & Enforcement). The former looks after the three Technical Directorates {Directorate of Nuclear Safety (NSD), Directorate of Radiation Safety (RSD) and Directorate of Transport and Waste Safety (WSD)}, Whereas the latter looks after three regional directorates and activities of National Radiation Emergency Coordination Centre (NRECC) which is responsible for coordinating the response to nuclear accidents or radiological emergencies.

Two Director Generals are working under the authority of Member Corporate; namely DG (Corporate) and DG (Capacity Building). DG (Corporate) is responsible for the activities of corporate wing and DG (Capacity building) looks after the progress of projects of national importance undertaken by the PNRA.

The following projects are being supervised by the DG capacity building

- National Dosimetery and Protection Level Calibration Laboratory. (NDCL)
- National Environmental Radiological Surveillance Program. (NERSP)
- Safety Analysis Centre. (SAC)
- National Nuclear Security Action Plan. (NSAP)
- PNRA School for Nuclear and Radiation Safety. (SNRS)

Main functions of the different directorates are summarized as follows:

Directorate of Nuclear Safety (NSD) – NSD is responsible for matters related to the safety of nuclear installations. It establishes and maintains regulatory framework for nuclear safety. Licensing of nuclear installations including approval of modifications, periodic safety reviews and relicensing are also in the domain of this Directorate.

Directorate of Radiation Safety (RSD) – RSD is responsible for regulation and supervision of matters related to radiation protection. It ensures that harmful effects of radiation on human health and the environment arising from licensed activities are As Low As Reasonably Achievable (ALARA). RSD operates the National Radiation Emergency Coordination Centre (NRECC). It is the national and international focal point for notifying nuclear or radiological emergencies.

Directorate of Transport and Waste Safety (WSD) – WSD is responsible for regulating matters related to radioactive waste management, control of radioactive discharges to the

environment, safety and security of radioactive sources and decommissioning of nuclear installations. It establishes and maintains regulatory framework in these areas and ensures compliance with regulatory requirements through joint regulatory inspections with regional directorates.

Regional Nuclear Safety Directorates (RNSDs) – The regional directorates are responsible for inspections and enforcement within their areas of jurisdiction and monitor activities at the plants affecting safety. RNSD conducts routine and special regulatory inspections to provide a high level of assurance that all activities performed at the installations during all stages of licensing process and all phases of the life cycle of a nuclear installation are carried out according to regulations and conditions of licence. The areas covered by inspection programs are radiation protection, operations, maintenance, testing and surveillance, quality assurance, emergency preparedness, industrial safety, fire protection, etc.

Directorate of Information Services (ISD) – ISD maintains computer networks, PNRA official website, PNRA internal network site, PNRA library, conducts media campaigns for public education and awareness, issuance of press releases on important matters and interaction with the media.

Directorate of International Coordination (ICD) – ICD interacts with IAEA and other international bodies for visits/trainings/workshops. International cooperation with other organizations such as NNSA, NSC, CNPO, USNRC, VUJE, etc. is also accomplished through ICD. In addition to other activities, ICD also facilitates security clearance/visa of foreign experts to PNRA and departure formalities for PNRA officials while proceeding on visits or training abroad.

Directorate of Policies and Procedures (PPD) – PPD is the custodian of the development and maintenance of all regulatory documents such as PNRA Regulations and Regulatory Guides as well as internal documents including PNRA policies, programs, criteria and procedures for internal working.PPD maintains a central registry of all these documents including record of different phases of development and revision. PPD is responsible for coordinating, within PNRA, the review of draft IAEA Safety Standards and communication of comments at different stages of development of the Standards.

Directorate of Regulatory Affairs (RAD) – RAD is responsible for performing technical audit of directorates, preparing plans and annual performance reports for submission to the Government of Pakistan and for the general public. It coordinates with the government, autonomous and semi-autonomous organizations having a stake in PNRA activities. It performs self assessment of regulatory effectiveness and develops performance indicators and programs for improving performance. It is also responsible for development of quality policy, quality management manual and lower tier procedures.

Centre for Nuclear Safety– The scientists and engineers of the Centre for Nuclear Safety have been trained in different areas of regulatory aspects and nuclear power plant design and operation through in-house training programs as well as local and foreign trainings and workshops. During the reporting period, the TSO provided valuable technical support in different licensing activities pertaining to nuclear power plants C-1, C-2, KANUPP and research reactors

PARR-I and PARR-II. Currently, Centre for Nuclear Safety conducted the review and assessment of the C-3/4 Preliminary Safety Analysis Report (PSAR).

Following is a brief introduction of the PSDP projects being implemented by PNRA:

National Dosimetery and Protection Level Calibration Laboratory (NDCL) - One of the main objectives of PNRA is to ensure the protection of radiation workers and general public from the harmful effects of ionizing radiations. PNRA has developed Radiation Protection Regulations and Annual Radiation Dose Limits for occupational workers as well as for general public so that the risk of adverse radiation effects to the human body could be reduced. Assessment of radiation exposure is a fundamental mechanism to ensure the radiation safety of occupational personnel working at the licensed facilities. In this regard, PNRA is implementing a Project for establishment of National Dosimetry and Protection Level Calibration Laboratory (NDCL) since 2007 with the objective to provide Internal and External Radiation Dosimetry Services to the licensed radiation facilities.

National Environmental Radiological Surveillance Program (NERSP)- PNRA has the responsibility to ensure that the public is protected from any buildup of environmental radioactivity in the country. The National Environmental Radioactivity Surveillance Program (NERSP) is aimed at enhancing PNRA's capabilities for monitoring environmental radioactivity, evaluating any buildups of radiation, assessing the doses being received by the public, and verifying the environmental data provided by NPPs. The Program is being implemented by PNRA and entails systematic measurement of radioactivity in soil, air, water, flora and fauna throughout the country.

Safety Analysis Centre - Safety Analysis Centre is a Technical Support Organization (TSO) to provide technical support in safety analyses for NPPs to both regulators and operators without compromising regulatory independence.

SAC performed analysis on a number of important issues including Coupled Field Analysis of Upper Closure Head of C-2 RPV under Operating Conditions, Design Familiarization using MATLAB and Radiological Consequence Analysis.

National Nuclear Security Action Plan (NSAP) -The objective of NSAP project is "to develop a national sustainable system in nuclear security with the established response and recovery capabilities, integrated with national laws, regulations and procedures".

In the year 2012, the NSAP project was extended to the next FY 2012-2013 to complete some outstanding physical targets. The Project continued its activities in the areas of nuclear security to enhance and strengthen the nuclear security culture within the country.

The functions of the NSAP are summarized as:

- Ensure that appropriate measures for physical protection of nuclear and other radioactive materials and facilities are taken,
- Ensure that corrective actions are taken when a radioactive source is in an unsafe and unsecured condition,
- To request other authorized bodies to monitor at appropriate checkpoints for the purpose of detecting orphan sources;

- Ensure that adequate arrangements are in place for the appropriate training of the staff of regulatory body, its stake holders, law enforcement agencies, response organizations etc,
- Promote awareness among industry, health professionals, the public, and government bodies about the security hazards associated with radioactive sources,
- Prepare, or establish provisions, to recover and restore appropriate control over orphan sources, and to deal with radiological emergencies and to ensure appropriate response plans and measures are in place.

PNRA School for Nuclear and Radiation Safety (SNRS) - PNRA has established the School for Nuclear and Radiation Safety (SNRS) which imparts knowledge and skills to newly recruited officers as well as conducts refresher courses for existing staff since maintaining a sufficient number of highly skilled professionals, with appropriate academic qualifications and adequate experience, for regulatory supervision is one of the key future issues for PNRA. This project was aimed at developing the indigenous work force required for nuclear regulation. This Project has been completed in June 2012 and PC-IV of the Project has been submitted to the Planning Commission for evaluation and approval.

SNRS boasts a number of laboratories which are equipped with the necessary tools, a soft-panel training simulator, physical models of nuclear power plant equipment, and various computer software. A non-destructive testing (NDT) laboratory has been established where PNRA inspectors can learn about welding and NDT activities at NPPs and manufacturing facilities.

Advisory Committee for Improving Utility Regulatory Interface (ACIURI) - ACIURI was initially established in 2005 and was reconstituted during the year 2009 due to retirement of some of its members. The members of the committee represent all the stakeholders (public, Government of Pakistan, universities, PAEC and PNRA) concerned with nuclear safety issues. Functions of ACIURI include giving recommendations on the PNRA regulations while maintaining a national tolerable level of risk and standard of safety, giving recommendations on the acceptability of impairments in the plants resulting from difficulties being faced by the utility and nuclear power plant suppliers and giving advice to facilitate smooth implementation of future nuclear energy generation programs.

PNRA Legal Cell - PNRA has also established a legal cell to provide advice on enforcement actions. The Legal cell operates under the authority of DG (I&E).The functions and responsibilities of the Legal Cell are as under:

- Performing all legal actions pertaining to the implementation of PNRA Enforcement Procedure,
- Make arrangements for the hearings by DG (I&E) and maintain the smooth running of the proceedings,
- Audio, video or both types of recoding of the proceedings of the hearing for further usage in the Court of Law,
- Register and Record the Offence Reports,

- Examine the Offence Reports and verify the facts,
- Serve legal Notice to the accused person,
- File complaint in the Court of Law for prosecution of the accused person,
- Follow-up litigation cases in the Judicial Forums.

8.4 PNRA Management System

Please see Section 13.5

8.5 Human Resources

The existing workforce at PNRA stands at two hundred and twenty five (225) technical professionals and by 2020 the manpower strength would be increased to around four hundred, through direct recruitments and fellowship schemes, to cater for expanding nuclear power generation capacity. PNRA awards fellowships to deserving candidates for Masters in Nuclear Engineering in Pakistan Institute of Engineering and Applied Sciences (PIEAS) and KANUPP Institute of Power Engineering (KINPOE) and these fellows join PNRA after successful completion of studies. Each year, 15 fellows are inducted in masters program at PIEAS. 4 fellows are studying in KINPOE one of them will join PNRA in 2013 and others three in 2014.

A leadership development Program was initiated at PNRA in collaboration with Lahore University of Management Sciences (LUMS) in 2008. The Program remained in progress during the reporting period and a new batch of future leaders were identified which are now undergoing mentoring and coaching from the previous batch of leaders.

The manpower requirements of each Directorate are assessed regularly and manpower distribution is made according to the workload of the Directorate and nature of its activities.

Special teams comprising professionals drawn from all Directorates are formed in the case of specialized tasks such as review of SER, SAR, etc.

8.6 Financial Resources

Funds provided to PNRA consist of grants from the federal government, income from the licence fees, and through PSDP funded projects for capacity building. These funds are adequate enough to meet the current financial requirements of PNRA. PNRA is financially independent of the organizations it is regulating.

8.7 Separation between Regulatory and Promotional Functions

No function or responsibility assigned by the Ordinance to PNRA is related with the promotion of nuclear energy, and none of its functions and responsibilities conflict with its responsibility for regulating nuclear safety and radiation protection. PAEC or any other organization, responsible for promotion or utilization of nuclear energy or ionizing radiation, does not have any regulatory function. Moreover, Chairman PNRA reports to the Prime Minister of Pakistan who is the head of the Government. This feature, among others, ensures the independence of PNRA.

8.8 Monitoring and Evaluation

Monitoring and Evaluation is an integral part of the management systems of the PNRA. The monitoring of the regulatory performance of the PNRA is based on 12 strategic performances. These indicators are shown in Annexure–VII. The submission of annual report of the activities of PNRA to the Government of Pakistan and the general public is a regular feature of PNRA. This submission enables PNRA to keep the public, the Government and other stakeholders informed about its efforts for ensuring safety of the public, the workers and the environment from ionizing radiation. As part of its self assessment program, PNRA has conducted an internal audit of activities of all its directorates to identify areas for improvement in order to enhance regulatory effectiveness.

A pilot study on assessment of Safety Culture has recently been initiated at PNRA in collaboration with the IAEA. Data for the assessment will be collected through observations, interviews of employees, focus group discussions, surveys and documents review.

8.9 Use of External Technical Support

PNRA has adequate arrangements for obtaining technical or other expert professional advice or services in support of its regulatory functions and retains full responsibility for its decision-making on safety matters. PNRA has adequate resources and competence to carry out most of its core and support functions. However, room of improvement exists. PNRA seeks technical advice from several external sources whenever needed, but this advice is never binding and PNRA's remains independent in its decision making.

PNRA has established strong bilateral relationships with National Nuclear Safety Administration (NNSA), Nuclear Power Operation Technology Corporation (CNPO) and Nuclear Safety Centre (NSC) of China. The bilateral agreements with these organizations provide a forum for free exchange of information on matters related to nuclear safety. These prestigious Chinese institutes are assisting PNRA in the review and assessment as well as inspections of Chashma nuclear power projects.

Besides Chinese organizations, PNRA has made bilateral agreements with VUJE, of Slovak Republic. VUJE is an engineering, design and research organization specializing in nuclear power plant technology, safety and environmental issues. It provides assistance in training of PNRA personnel in nuclear safety, specifically in safety review and inspection of pressurized water reactors components. PNRA is also interacting with United States Nuclear Regulatory Commission (USNRC) for institutional strengthening and capacity building in order to face the current challenges and issues related to nuclear safety.

8.10 Cooperation with National Organizations

PNRA keeps liaison with other governmental organizations for maintaining nuclear and radiation safety in Pakistan. In addition to close interaction with the Pakistan Atomic Energy Commission (PAEC), PNRA also liaises with other National regulators such as Oil and Gas Regulatory Authority (OGRA), the Pakistan Telecommunications Authority (PTA), Public Procurement Regulatory Authority (PPRA), Civil Aviation Authority (CAA), and the National Electric Power Regulatory Authority (NEPRA). In addition, liaisons are maintained with national universities and

academic institutes of national repute to keep abreast with latest national and international research and developmental activities.

PNRA professionals delivered lectures at leading national universities under the program of public awareness program to spread awareness about the radiation protection, nuclear power plants safety etc. Special lectures were arranged at various universities after the Fukushima Dai-ichi accident.

PNRA professionals are members of the committee for decisions regarding adoption of IEC standards for the Pakistan Standard and Quality Control Authority (PSQCA).

8.11 International Cooperation

PNRA has been actively participating and contributing in the international efforts to promote nuclear safety and security. These efforts include fulfillment of international obligations /implementation of international legal instruments i.e. Conventions, Treaties, and Codes & Standards and exchange of technical information & expertise with international community under IAEA umbrella through participation in Technical Cooperation & Regional Asia Projects, technical meetings and exchange of expert missions etc. Representatives from PNRA participated and contributed in international events organized by IAEA and other international organizations and shared their experience and knowledge in the field of nuclear safety and regulatory affairs. These events include, Technical Meetings, Training Courses, Fellowships & Higher Studies Programs, Conferences, Scientific & Consultancy Missions, Inspections and contract placement.

8.11.1 International Conventions and Treaties/ Participation in International Conventions

Pakistan is a party to all important international nuclear safety and security Conventions such as Convention on Nuclear Safety, Convention on Early Notification of a nuclear accident, Convention on Assistance in Case of Nuclear Accident or a radiological emergency and Convention on Physical Protection of Nuclear material and Code of conduct on safety and security of radiation sources.

During 2012, the IAEA convened Second Extraordinary Meeting of the Convention on Nuclear Safety in which representatives from sixty (60) countries participated to analyze the lessons learned from Fukushima Dai-ichi Accident, to discuss future nuclear safety challenges and plan measures to enhance the effectiveness of the Convention. The delegation of Pakistan, led by Chairman PNRA, participated in the meeting and submitted the national report highlighting the reassessment of national nuclear framework after Fukushima Dai-ichi accident and measures taken to enhance nuclear safety on the basis of lesson learned from Fukushima Dai-ichi accident in the areas of External Events, Design Issues, Severe Accident Management and Recovery, National Organizations, Emergency Preparedness & Response and Post Accident Management and International Cooperation.

8.11.2 Bilateral and Multilateral Cooperation

PNRA acknowledges the importance of bilateral and multilateral cooperation and understands their significance in the enhancement of regulatory effectiveness and human resource

development in the field of nuclear safety. The PNRA Ordinance also empowers the Authority to enter into bilateral cooperation agreements with other national regulators and international organizations in peaceful uses of nuclear technology.

Presently, PNRA has bilateral agreements with National Nuclear safety Administration (NNSA) of China and its allied institutes and technical support centres. In addition, our TSO, CNS also has a cooperation agreement with VUJE of Slovakia.

PNRA is also interacting with United States Nuclear Regulatory Commission (USNRC) for the institutional strengthening and capacity building related to nuclear safety. Two officers from PNRA have completed on the job training at USNRC and joined back their duties at PNRA.

Pakistan is also trying to develop bilateral relations with the other national regulators such as National Safety and Security Commission of South Korea, NNR of South Africa, JNRC of Jordan and TEAK of Turkey.

8.11.3 Pakistan - IAEA Collaboration/Cooperation

The role of IAEA is crucial in strengthening regulatory infrastructure in Pakistan and capacity building of scientists and engineers of PNRA in the field of nuclear & radiation safety and security. Officers from PNRA regularly participate and contribute in the activities of IAEA committees, and networks. PNRA is also a beneficiary of IAEA's Technical Cooperation and Regional Asia Projects. The detail is as under:

8.11.3.1 IAEA Committees, Forums and Networks

PNRA is contributing to various IAEA committees as an active Member State including the Nuclear Safety Standards Committee (NUSSC), Transport Safety Standards Committee (TRANSSC), Waste Safety Standards Committee (WASSC), Radiation Safety Standards Committee (RASSC), Advisory committee on Nuclear Security (AdSec) and Commission on Safety Standards (CSS).

PNRA also participated as the national coordinator in the activities of the International Event Scale (INES), Incident Reporting System (IRS) forums of IAEA, IAEA Response Assistance Network (RANET) and Radiation Safety Management System (RASIM), etc.

Pakistan had been participating in the activities of United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) since 2008 as an observer. However, during the year 2011, United Nations General Assembly also formally granted permanent Membership of UNSCEAR to Pakistan. Pakistan is fully committed to positively contribute to the objectives of this committee. During the reported year, Pakistan shared environmental monitoring data at this forum to conduct its assessment on levels and effects of radiation exposure due to the nuclear accident after the 2011 great east-Japan earthquake and tsunami and subsequently Fukushima Dai-ichi accident.

Chairman PNRA was a part of the delegation on IAEA Ministerial Conference on Nuclear Safety from 14-17 December 2012. He led the delegation for the 6th Steering Committee Meeting between PNRA and National Nuclear Safety Administration, China. He also participated in the

IAEA technical meetings regarding developing and maintaining capacity building in Member States and capacity building and human resources development for new and expanding nuclear power program respectively.

PNRA also participated in the activities of IAEA Regional Cooperation Forum (RCF) that is formed to help developing regulatory infrastructure in new countries embarking on nuclear power program by sharing nuclear knowledge and training of personnel in core functions of regulatory body. The purposes of the meeting are to address the Regulatory Cooperation Forum action plans for Jordan and Vietnam in collaboration with the European Commission (EC) Instrument for Nuclear Safety Cooperation (INSC) program and engage with non RCF member countries embarking on nuclear power to realize the benefits of the RCF for improved international cooperation and collaboration.

8.11.3.2 IAEA Technical Cooperation Projects

PNRA is participating in two IAEA Technical Cooperation Projects, “Enhancing Nuclear Safety Infrastructure and regulatory Framework (PAK/9/035)” and “Strengthening Infrastructure for Radiation, Transport and Waste Safety (PAK/9/037)”. The IAEA has approved both these projects till year 2015 due to impressive implementation of the planned activities under both the projects.

8.11.3.3 IAEA Regional Asia Projects (RAS Projects)

Besides Technical cooperation projects, PNRA is also participating in eleven (11) IAEA Regional Asia (RAS) Projects for the cycle 2011-13 mainly related to strengthening regional nuclear regulatory authorities and safety culture, promoting and maintaining regulatory infrastructure for control of radiation sources.

Strengthening the transfer of experience related to occupational radiation protection of the nuclear industry and other application involving ionization radiation, strengthening radiation protection of patient in medical exposure, strengthening education and training infrastructure and building competence in radiation safety, strengthening and harmonization of national capabilities for response to nuclear and radiological emergencies, etc. Under these projects, personnel from PNRA participated in various activities such as training courses/workshops organized by IAEA.

8.11.3.4 IAEA and Pakistan’s Nuclear Security Cooperation Program

PNRA-IAEA Nuclear Security Cooperation Program is in progress and a number of activities such as training courses, establishment of laboratories; procurements of equipment related to physical protection, etc. are underway under this project.

8.11.3.5 Expert Missions

PNRA is sharing knowledge and expertise with international community through participation in IAEA activities as experts and lecturers. Experts from PNRA participated in different IAEA missions such as Integrated Regulatory Review Service (IRRS), Emergency Preparedness Review (EPREV) and Regulatory Authority Information System (RAIS).

Moreover, experts from PNRA also delivered lectures during IAEA training courses held in Vienna and other international venues in the areas of regulatory importance and nuclear safety & security such as formulation of nuclear regulations, development of regulatory infrastructure, review and inspection, emergency preparedness and response, physical protection and capacity building etc.

During 2012, PNRA experts contributed in a number of areas of regulatory importance at international levels as consultants; Nuclear Forensics, International Reporting System of NPP Operating Experience (IRS); IAEA Coordinated Research Project (CRP) on Risk Assessment ; State Management of Nuclear Security Regime; Physical Protection Inspection; Peer Review of Operational Safety Performance Experience (PROSPER) and to Produce PROSPER Guidelines; Regulatory Cooperation Forum (RCF) Support Mission to Vietnam on the Importance of an Independent Regulatory Body and basic training course on Nuclear Reactor Instrumentation and Operation, etc.

Moreover, experts from IAEA also visited PNRA for participation in different events such as, trainings, Courses/workshops on Security of Radioactive Sources; Nuclear Security Culture, Detection Techniques and Coordination (FLO-MEST); Training of Trainers on Radiation Detection Techniques for Front Line Officers for Pakistan's Officials; Performing Installation and Training related to the Whole Body Counter System; Commissioning of Physical Protection Interior Labs (PPIL); Training and Installation/Commissioning of TLD Reader Systematic.

During the reported period Mr. Kwaku Aning, Deputy Director General (DDG), Mr. Alexander Bychkov (DDG), Nuclear Energy IAEA, Technical Cooperation (TC) and Mr. Oscar E. Acuna, Section Head, TC Asia and Pacific Section, IAEA visited PNRA and discussed about progress and implementation of various TC projects and explore the possibilities for further cooperation in various fields and to support various Member States in their capacity building through the placement of fellows. Similarly, Dr. Daud Mohammad, DDG Nuclear Science and Application, IAEA also visited PNRA and discussed the matters to strengthen cooperation in the field of nuclear science and applications.

On the request of PNRA, IAEA planned Integrated Regulatory Review Services (IRRS) Mission preparatory meeting during the last quarter of 2012 at PNRA, however, due to some unavoidable circumstances, the proposed meeting was held during March 2013. IRRS Mission is now planned for April, 2014.

Pakistan has, therefore, met the obligations of Article 8 of the Convention.

Article 9 – Responsibility of the Licence Holder

"Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility."

9 Responsibility of the Licence Holder

Pakistan has ensured that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence. Appropriate steps are taken to ensure that the licence holder fulfills this responsibility.

9.1 Regulatory Requirements

PAEC is the owner and operator of the nuclear installations. It functions under the Pakistan Atomic Energy Ordinance 1965. This Ordinance requires that the Commission shall do all acts and things, including research work, necessary for the promotion of peaceful uses of atomic energy in the fields of agriculture, medicine and industry and for the execution of development projects including nuclear installations and generation of electric power.

National regulations that regulate various aspects of nuclear installations such as licensing, design, quality assurance and operation explicitly state that the licence holder is responsible for the safety of nuclear installations. The national regulation for licensing, PAK/909, states that the licensee is directly responsible for the safety of the nuclear installation. It is also mentioned in regulations on design, PAK/911 clause 3.1; that the licensee has the overall responsibility for safety. Similarly, according to the quality assurance regulations, PAK/912; it is a requirement that the licensee shall retain the responsibility for the effectiveness of the quality assurance program, likewise, regulations on operation of nuclear installations, PAK/913 section 5 clause (1); also delineates that the licensee shall have the responsibility for safe operation.

All authorizations by PNRA to the licensee explicitly state that the licensee shall retain prime responsibility for safety but it may delegate authority to the respective management of nuclear installation for operation according to the applicable regulations. The management of the installation is also responsible for providing clear and adequate guidance to its contractors to ensure that safety is integrated into all the activities and any other activity such as production shall not have priority to the responsibility for safety. PAEC being the licensee of nuclear installations has overall responsibility for the fulfillment of safety requirements for its nuclear installations and provides necessary resources and support to the respective management for safe operation in accordance with regulatory requirements.

9.2 Responsibilities of PAEC

The responsibilities of PAEC Headquarters and nuclear installations are described below.

9.2.1 PAEC Headquarters

According to the licence of the nuclear installations, issued by PNRA, PAEC is the licensee on record for the nuclear installations in Pakistan. Whereas, PAEC has delegated its responsibilities related to the safe operation of the plant to the respective plant management, PAEC is providing necessary financial and human resources to meet the requirements for:

a. safe and continued operation of nuclear installations during the operating life.
b. safety upgrades/modifications needed for safe operation.
c. safe design, construction and operation of new nuclear installations.

PAEC has established safety and quality infrastructure at the corporate and nuclear installation levels. At the corporate level, the Directorate of Nuclear Safety (DNS) and Directorate of Quality Assurance (DQA) are established to advise the corporate management on safety and quality issues. At corporate level, Corporate Safety Review Committees (CSRC) have been established to review problems in nuclear power plants operation, scientific and engineering issues important to safety, radiation protection arrangements, physical protection plan, emergency plans, quality assurance procedures, administrative control and training.

At the nuclear installation level, Divisions having required authority and independence are in place, which are responsible for nuclear safety, licensing and quality assurance related activities. In addition, safety committees advise the management on safety and quality related issues. Representatives of Directorate of Nuclear Safety (DNS) at Chashma site conducts external audit of plant divisions such as health physics, QA, maintenance, etc. on sampling basis.

In addition, various directorates at corporate level are providing design and engineering support to nuclear installations. This indigenous capability in design and engineering has a positive impact in enhancing the operational safety of nuclear installations as well as in review and implementation safety upgrades, as and when required. PAEC organizational chart showing the corporate directorates is shown in Annexure–VI.

PAEC interacts with PNRA both at the corporate level and at the nuclear installation level. At the corporate level interaction is through Chairman and Members of PAEC to their corresponding counterparts in PNRA. The interaction between the regulatory body and the nuclear installations is through the technical directorates and regional directorates.

9.2.2 Karachi Nuclear Power Plant (KANUPP)

The station vision and mission has clearly been defined and communicated to all workers so that they put in all efforts in the right direction for continued safe and reliable operation of the plant to ensure safety of public, workers and environment. The vision of KANUPP is to maintain and operate plant safely throughout the extended period beyond its design life. The mission of KANUPP is to achieve excellence in safe and reliable operation of the plant by effective implementation of safety, quality and configuration control requirement and optimum use of operating experience in all work activities of operations, maintenance and engineering support for continual improvement.

KANUPP Safety Committee (KSC) exists at the plant level which meets regularly to discuss safety issues and gives recommendations to the Director General, KANUPP. The committee, amongst other things, review safety related design modifications, changes to the operating policies & principles, new safety issues, reportable events, implementation of radiological emergency response plans etc. Nuclear Safety and Licensing Division (NSLD) reports directly to the Director General, KANUPP. This Division also interfaces with PNRA and provides oversight

of safety matters within the plant.

9.2.3 Chashma Nuclear Power Generating Station

Chashma site organization has been restructured considering the requirements of multiunit site. Currently, Chashma Nuclear Power Generating Station (CNPGS) headed by Director General consists of two operating units (C-1 and C-2), a common directorate of technical support and a common training centre.

The mission of CNPGS is to generate electricity in a demonstrably safe, reliable and cost effective manner over the long term, for the benefit of our society and stake holders, as well as to consolidate the basis for development of the nuclear power program in Pakistan. The vision is to establish a modern, effective and efficient management system within the organization, to enhance the standard of management so that the safety and economic performance of the plant is in the top quartile in the world nuclear power industry. CNPGS is earnestly working to achieve its mission and vision.

Technical divisions of C-1 and C-2 are responsible for system performance evaluation of structure, system and components related to safety, safety surveillance during operation and outage, review of safety and technical specification modifications etc. Nuclear safety and operating experience section of technical division is responsible for interface with the regulatory authority and performs the function of operating experience feedback within C-1&C-2 and manages Corrective Action Program. Technical division also coordinates the follow-up actions of C-1 PSR corrective action plan.

Each plant has a high level safety committee, namely Operational Safety Review Committee (OSRC) which is headed by the respective Plant Manager. Other members include the Deputy Plant Manager, manager operation, manager health physics, manager quality assurance and manager technical. This committee, among other functions, reviews and assesses changes in approved technical specifications, safety related equipment/systems, tests, new safety issues, violations of approved technical specifications, reportable events, deficiencies in design or operation that may affect safety, radiological emergency response plan, physical protection plan etc.

9.2.4 Chashma Nuclear Power Project Unit -3 (C-3) and Unit-4 (C-4)

The Safety and Licensing Division of C-3/C-4 is responsible for addressing safety related issues. This Division is also responsible for coordinating the safety review, implementing Configuration Management Plan during installation. A Quality Assurance Division ensures quality through the implementation of the Quality Assurance Program. It performs audit of the activities of designer, contractor and sub-contractors and performs QA surveillance during installation at site. Technical Coordination Division reviews basic and detailed design and design modifications in coordination with other design establishments of PAEC. The review performed by the Technical Coordination Division is independent of the review performed by the designer.

The licensee abides by the provisions of the PNRA Ordinance, rules and regulations made under the Ordinance, licence conditions and directives of PNRA issued from time to time. The licence holder submits the required safety reports and documentation as laid down in the

regulations or required by PNRA in support of safety case. In addition, the licence holder agrees to regulatory inspections, during all phases of the plant life, which are carried out by PNRA to verify that the requirements of the regulations and conditions of the licence are met.

9.2.5 Technical Support to Operating units

KANUPP management ensures effective technical support activities are provided as necessary for safe and reliable operation of the plant. The major activities of technical support are performed by Technical Division, Design and Development Division, Control Instrumentation Application Laboratory and Computer Design & Development Division. Roles, responsibilities and programs for each Technical Support Divisions of KANUPP are clearly defined and understood by station personnel.

Directorate of Technical Support (DTS) of CNPGS is composed of eight divisions. Radioactive waste management division assists operating units in radioactive waste management activities. Technical coordination division assists in performing engineering and safety analysis, preparing design modifications, fuel management and core management activities and RFO planning activities. Information system division establishes and maintains information for the plants. Equipment management division develops and manages the PSI, ISI and ageing management programs. Structure & services division provides supporting activities related to construction and surveillance of structure/ buildings. In addition, three maintenance support divisions related to mechanical, I & C and electrical, maintenance assist the plants in major maintenance activities. Directorate of CHASCENT provides training and re-training to operating personnel of C-1 and C-2. Compliance of the work done by DTS and CHASCENT, to the safety requirements in the operating licence and PNRA regulations, is ensured by the plant organizations.

Corporate technical support is also provided to monitor and prepare for different plant operational as well as improvement activities. PAEC HQ sends various technical support teams from time to time to evaluate and assess different activities of operating plants. Besides, resources and engineering support are provided for plant life extension plans at KANUPP.

Pakistan has, therefore, met the obligations of Article 9 of the Convention.

Article 10 – Priority to Safety

"Each Contracting Party shall take the appropriate steps to ensure that all organizations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety."

10 Priority to Safety

Pakistan has taken appropriate steps to ensure that all organizations engaged in activities directly related to nuclear installations have established policies that give due priority to nuclear safety.

10.1 Regulatory Requirements

PNRA Regulations PAK/909 require that 'safety first' shall be the guiding principle in the Siting, Design, Construction, Commissioning, Operation and Decommissioning of nuclear installations. Regulations PAK/913 requires that special emphasis is placed on safety in operation. The operator is to establish an effective organizational structure for making and implementing policies for nuclear safety and quality, allocating adequate resources, enforcing requirements like fitness for duty, etc. PNRA Regulations PAK/913 further require that a policy on safety shall be developed by the licensee and applied by all site personnel. This policy shall give the utmost priority to the safety at the installation, overriding if necessary the demands of production and project schedules. The policy should include a commitment to excellent performance in all the activities important to safety and shall encourage an inquisitive attitude. All activities that may affect safety and which can be planned in advance shall be conducted in accordance with established procedures and shall be performed by suitably qualified and experienced individuals. Furthermore, regulations require that regular reviews of the operational safety of the plant are conducted, with the aim to ensure that an appropriate safety consciousness and safety culture prevails, the provisions set forth for enhancing safety are observed, documentation is up-to-date and there are no indications of overconfidence or complacency.

10.2 Nuclear Safety Policy of PAEC

Pakistan Atomic Energy Commission is the owner and operator of nuclear installations and has overall responsibility for safety. PAEC has formally prepared and implemented a Nuclear Safety Policy from which specific safety rules, procedures and other requirements are derived. Complete text of Nuclear Safety Policy of Pakistan Atomic Energy Commission is available at PAEC website: http://www.paec.gov.pk

10.3 Priority to Safety in Nuclear Installations

The licensee of nuclear installations in Pakistan is committed to give priority to nuclear safety. After Fukushima Dai-ichi accident, PAEC Corporate management formed a Taskforce for safety assessments of nuclear installations in the light of lessons learnt from the Fukushima Dai-ichi accident and the IAEA Nuclear Safety Action Plan. Areas were identified for improvement in terms of availability of safety functions in case of severe accidents and extreme natural hazards such as Mobile Emergency Power Sources, Hydrogen Control & Mitigation Systems, Off-site Emergency Planning and Preparedness etc. PAEC also provided financial resources for the implementation of the FRAP on priority basis.

Systems of event reporting, corrective action program, equipment health monitoring, a system of reporting near misses and operational experience feedback (within plant, other plants operating in the country, plants operating worldwide through IRS, WANO and other reporting systems) was further strengthened. WANO peer reviews have been carried out at C-1 and KANUPP in the reporting period. Such activities have added to the improvement of safety at nuclear installations in Pakistan.

10.3.1 Priority to Safety at KANUPP

At KANUPP, Station Vision, Mission, Goals and Objectives have been clearly outlined so that every plant personnel is well aware of their responsibility in ensuring safe and reliable operation of the plant.

In addition, Station instructions for Corrective Action Program (CAP), Self Assessment Program (SAP), and Safety Performance Indicators (SPI) are implemented. Event reporting has been made easy so that any worker can directly report an event to the CAP Group. After evaluation and/or investigation, wherever required, necessary corrective measures are taken and feedback is provided to the reporting person. An in-house database of CAP has been developed and made easily accessible to all the plant personnel through Local Area Network (LAN). Open training sessions / lectures are carried out on CAP and SAP to enhance awareness and acceptance of these programs amongst plant personnel. To further improve safety culture and event reporting attitudes, every year a shield is awarded to the Division having best reporting record and Certificates are awarded to one officer and one staff member for best safety suggestion. Focused Self Assessment (FSA) is carried out on monthly basis to assess the areas in which deficiencies in soft issues are highlighted by the CAP. Necessary actions are developed and tracked to further improve these areas.

10.3.2 Priority to Safety at C-1

The safety policy of C-1 is being implemented. Management of C-1 bears full responsibility for the safety of the plant according to the Safety policy. Plant Manager holds daily work plan meetings to discuss safety issues and ways of their resolution. Safety and quality takes precedence over production objectives. Event reporting is encouraged and any worker of the plant can report events and near misses through a user friendly reporting system. After evaluation and/or investigation, wherever required, necessary corrective measures are taken and feedback is provided to the reporting person. An in-house database of low level events, near misses and corresponding corrective actions is accessible to all the plant personnel through Local Area Network. CNPGS has implemented safety performance indicators program to monitor trends of operational safety of the plants in various domains.

10.3.3 Priority to Safety at C-2

After successful commissioning, C-2 started its commercial operation in May 2011. Operating licence was issued to C-2 after review of Final Safety Analysis report and commissioning results. Safety and quality takes priority over production objectives. Event reporting is encouraged and any worker of the plant can directly report events and near misses through a user friendly reporting system. After evaluation and/or investigation, wherever required, necessary corrective measures are taken and feedback is provided to the reporting personnel.

An in-house database of event reports and corresponding corrective actions has been developed and made easily accessible to all the plant personnel through Local Area Network. C-2 has also developed safety performance indicators to monitor operational safety of the plant. All plant personal are encouraged to report abnormal events and any “near misses” relevant to the safety and availability of the plant.

Operating experience is carefully examined to detect any precursor signs of possible tendencies adverse to safety and availability, so that corrective actions could be taken before any serious condition happen. Regular reviews of the operation of the nuclear power plant are arranged by C-2 to ensure that safety consciousness exists and provisions set forth for enhancing safety are observed. Plant Manager holds daily work plan meetings to discuss safety issues and ways of their resolution. Safety and quality takes precedence over production objectives. An operation safety review committee (OSRC) is in place which performs assessment and reviews for safety evaluations of procedures, change in procedures, equipment, system or facilities etc. and investigating any violations of the technical specifications. Periodic safety review of plant will be performed on regular time intervals of ten years in order to ensure plant's safety in light of operating experience and significant new safety information/issues. PEER review is also in consideration of management and in this regard international agencies like IAEA, WANO may be requested, if required.

In order to increase safety and reliability, technical support organizations are established which provide the technical support required for operations and maintenance activities of the plants.

10.3.4 Priority to safety at C-3 and C-4

Priority to safety at C-3 / C-4 is considered as the most important in safety policy/objectives. Safety has been ensured in different phases of Siting, Design and Construction in compliance to national regulations and international standards through reviews and assessments. An Overall Quality Assurance Program (OQAP) for C-3/C-4 is developed in accordance with PNRA’s “Regulations on the safety of nuclear power plants quality assurance “PAK/912, Rev.1, IAEA Code on “Quality assurance for safety in nuclear power plants and other nuclear installations” 50-C/SG-Q. This OQAP is applicable to all the safety related structures, systems and components as well as important non-nuclear safety structures, systems and components.

C-3/C-4 project organization is established to plan, monitor and control the design and construction activities to meet the safety objectives. Trained manpower has been made available to carry out all activities important to safety. At design stage, probabilistic safety assessment is performed in addition to the deterministic safety analysis.

10.4 Verification of Safety by PNRA

To effectively influence, monitor, and provide oversight of operators’ safety culture, PNRA has initiated a pilot project on the assessment of own safety culture in collaboration with the IAEA. Data for the assessment will be collected through observations, interviews of employees, focus group discussions, surveys and documents review.

PNRA regulatory oversight program covers verification of all activities having bearing on safety. PNRA promotes safety culture in nuclear installations by ensuring that it is on the agenda of the

licensee at the highest organizational level. PNRA inspection program for nuclear installations cover safety culture inspections in addition to other safety significant areas.

In safety culture inspections, PNRA relies primarily on the notes and reports of inspectors collected during plant tours, reviews of documentation, and interviews with plant personnel, etc. It is supplemented through reviews of event and near misses reports, post event inspections and licensees' self assessments, etc.

The policy of priority to safety issues is closely followed by PNRA as top-down approach for handling nuclear safety related issues.

Pakistan has, therefore, met the obligations of Article 10 of the Convention.

Article 11 – Financial and Human Resources

"1. Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.

2. Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life."

11 Financial and Human Resources

Pakistan has taken appropriate steps to ensure that adequate financial resources are available to support the safety of nuclear installations and that sufficient number of qualified staff with appropriate education, training and retraining are available for all safety related activities at each nuclear installation throughout its life. The adequacy of the resources was re-assessed after Fukushima Dai-ichi accident and augmented wherever found necessary.

11.1 National Requirements for Financial Resources

The licensee is required to ensure that adequate resources, services and facilities are provided for the safety of the nuclear installation during siting, design, construction, installation, commissioning, operation and decommissioning.

11.2 Financial Resources at Nuclear Installations

Nuclear installations are owned by the PAEC (Government sector organization) with a clear commitment to provide financial resources required throughout their lifetime. National Electrical Power Regulatory Authority (NEPRA) is the electricity tariff determining body. While fixing the unit (kilowatt-hour) price to be paid by the distribution companies to PAEC, it takes into consideration the specific issues related to nuclear installations such as operation and maintenance, refueling outages, decommissioning costs, storage and disposal of radioactive waste, periodic safety reviews and upgrades, etc.

11.3 National Requirements for Human Resources

PNRA Regulations PAK/911, PAK/912, and PAK/913 require that the nuclear installations are staffed with competent managers and qualified personnel having proper awareness of the technical and administrative requirements for safety. The regulations specify the requirements for academic qualifications, experience at nuclear and other installations, training and retraining, examination procedures, etc. The regulations also specify the requirements for qualification, training and experience required for issuance of licence to operating personnel, validity, revalidation and conditions to be satisfied for renewal of the licence, conditions for revoking or cancellation of licence.

11.4 Human Resources, Training and Retraining for Nuclear Installations

At the national level, PAEC has established a number of institutions for the development of human resources needed for operation of its nuclear installations. The Pakistan Institute of Engineering and Applied Sciences (PIEAS) at Islamabad imparts education at the post graduate level in several disciplines including Nuclear Engineering and Systems Engineering. Karachi Institute of Power Engineering (KINPOE) at Karachi is also conducting post graduate level degree courses. In-Plant Training Center (IPTC) at KANUPP trains mainly the operating personnel for licensing examinations. CHASNUPP Center of Nuclear Training (CHASCENT) at Chashma provides training to plant personnel according to plant requirements including training in radiation protection and industrial safety. CHASCENT also runs a one year post graduate training program (PGTP).

Specialized training courses are offered by National Centre for Non-Destructive Testing (NCNDT) and Pakistan Welding Institute (PWI) in the fields of non-destructive testing and welding technology respectively. PAEC has a sizeable pool of specialists working in various fields to support the design and engineering activities in nuclear installations. Support from the original plant designers and vendors/suppliers is also available under various agreements to supplement the PAEC expertise. PNRA and PAEC organize symposia, workshops, training courses, etc. in collaboration with IAEA in the areas related to nuclear safety. The scientists and engineers of PNRA and PAEC also received training in various area of nuclear safety in other countries through the support of IAEA.

PAEC inducts fresh engineers, scientists and technicians every year so that the age profile of the organization remains balanced. Trainings and re-trainings are provided to the operation and maintenance crews of the plants. PAEC employs engineers and scientists possessing high academic qualifications such as Master of Science/Engineering in relevant disciplines or other post graduate degrees. Many engineers and scientists have received comprehensive training in relevant fields both in Pakistan and abroad. The plant technicians possess three years diploma after their Secondary School Certificate examination from various institutes in the country or have B.Sc. degrees from recognized universities. They are given one year Post Diploma Training (PDT) at CHASCENT. KINPOE also conducts Post Diploma Training for technicians.

The organization of the power plants is such that all the managerial and supervisory positions are held by graduate engineers with a minimum of 6 to 10 years experience in respective fields. The qualification requirement for shift supervisors and shift engineers is graduate engineering degree before obtaining necessary licences.

Qualification and training of operating personnel follow the regulatory requirements of PAK/913 and training program of the plant. PNRA conducts oral and operating examination for award of licences to operating personnel. Main Control Room (MCR) engineers of CNPGS undergo mandatory training on a Full Scope Training Simulator (FSTS) for shift personnel licence. The licenced operation engineers receive retraining on FSTS twice every year. The licenced personnel are re-examined internally every year. The field operators also undergo two months retraining every year.

While considering issuance of Fuel Load Permit or allowing commissioning, the availability of appropriate manpower is verified by PNRA. MCR operators including the shift supervisors are

required to obtain licences from PNRA prior to first fuel loading. The shift complement is also verified by PNRA resident inspectors during operation. It is ensured that the nuclear installations maintain a sufficient number of qualified and skilled manpower in all areas necessary for safe operation.

Since Government of Pakistan plans to increase the nuclear power generation capacity to 8800 MWe by 2030, PAEC is enhancing the capacity of its training institutes such as PIEAS, KINPOE, CHASCENT, etc.

11.5 Resources for Decommissioning and Waste Management

PAEC is committed to carrying out decommissioning of its nuclear facilities in a safe manner when it becomes necessary.

PAEC is also committed to safe and secure management of radioactive waste generated from activities in its nuclear facilities according to National Policy on Radioactive Waste Management. PAEC has also ensured provision of adequate financial resources for decommissioning and waste management at important nuclear facilities.

National Policy on Control and Safe Management of Radioactive Waste requires that the generator of radioactive waste shall be responsible for safe and secure management of radioactive waste and shall pay for its safe disposal.

11.6 Human Resources, Training and Retraining at PNRA

Competency development of the regulatory staff is a top priority of PNRA. Therefore, right from its inception, it has focused on the transfer of knowledge and skills of the experienced nuclear professionals to the younger generation. A number of steps were taken over the last few years to strengthen professional capabilities of PNRA staff. These included in-house professional trainings, courses in local training institutes, foreign regulatory bodies and technical organizations. PNRA also arranged participation of its manpower in international workshops and fellowship programs in specialized fields, provided on-the-job training, and scientific visits to enhance the technical competencies for the regulation of nuclear power plants and radiation facilities in Pakistan

11.6.1 Human Resource Development at PNRA

Initially, PNRA established an Education and Training unit with the responsibility for inducting new technical staff and to arrange training for them. Later, the unit was transformed into a full fledged Human Resource Development Directorate (HRD). PNRA adopted two pronged approach for recruitment of technical officers:

a. Fast track direct recruitment drive, and

b. Recruitment through fellowship scheme.

PNRA has attached four (04) of its engineers with C-2 operation group for a period of four years. These engineers are receiving plant operation training to obtain licence for operating the plant. After that they will work with C-2 operation group in MCR for at least one year before rejoining PNRA. These engineers will assist PNRA in review and assessment, regulatory inspections and conducting the licensing examinations of plant operating personnel.

The total manpower strength of technical professionals at present is around 225. However, in view of the Government's plan for increasing nuclear power production to 8800 MWe by the year 2030, regulatory responsibilities of PNRA are also expected to increase.

PNRA has adopted following processes for the competency development of its staff:

i. In-house training programs and

ii. Trainings arranged in external organizations.

PNRA initiated its first ever in-house professional training program in 2003 by adopting the syllabi of the IAEA basic professional training courses, since training material of these courses was easily available. The focus was on three areas namely, nuclear safety, radiation protection and regulatory control.

The biggest challenge for PNRA was to arrange these training courses in a systematic and consistent manner for its staff.

In this perspective, Government of Pakistan approved PNRA proposal for the establishment of a full-fledged School for Nuclear and Radiation Safety (SNRS) for Competency development of newly inducted professionals as well as the existing staff of PNRA to enable them to discharge their regulatory responsibilities in an efficient and effective manner.

The SNRS faculty has gained enough teaching experience over the last eight years, and is now capable of imparting knowledge at the international level. The School has generated a number of training manuals for various courses and possesses well equipped classrooms, computers and multimedia systems. Other facilities at the training centre include PWR simulator, physical models of plant equipment, radiation protection laboratory and various computer codes. The School has capability to assist the international community in enhancing the competency of regulatory professionals. Faculty members of the SNRS conducted training lectures during the Master Program (Nuclear Engineering & Nuclear Science) of Nigerian Atomic Energy Commission (NAEC) in 2012. This Master Program was initiated by NAEC with the help of IAEA under TC Project.

Faculty members from SNRS are also involved in the development of training material for the "Workshop on Human Resource Management of Regulatory Body" for IAEA.

11.6.1.1 Trainings Arranged at External Organizations

During the reporting period, PNRA has arranged education and training of PNRA employees at various national and international training institutes and continued to maintain training profiles of PNRA employees. HRD arranged training courses at local training institutes like Pakistan Institute of Management (PIM), Pakistan Welding Institute (PWI), National Center for Non Destructive Testing (NCNDT), Pakistan Atomic Energy Commission (PAEC), National University of Modern Languages (NUML), Pakistan Standards & Quality Control Authority (PSQCA), Research Society of International Law (RSIL), Secretariat Training Institute (STI), and Pakistan Manpower Institute (PMI).

PNRA also arranged a number of training courses and training fellowship schemes at international institutes as detailed below.

a) Training in Pakistan through expert missions from IAEA, NSC, VUJE, etc.

b) Fellowships at IAEA and other countries through TC projects

c) Placement at China Nuclear Power Operation (CNPO) Ltd., NNSA and NSC China

11.6.2 Research and Development

Research and development activities remained in progress at PNRA in collaboration with national academic and research institutions like Pakistan Institute of Engineering and Applied Sciences (PIEAS), Nuclear Institute of Agriculture and Biology (NIAB), and Pakistan Institute of Nuclear Science and Technology (PINSTECH) in the areas of nuclear and radiation safety. Moreover, PNRA maintains bilateral relationships with some international research institutions like Nuclear Safety Centre Beijing (NSC), China Nuclear Power Operation Technology Corporation (CNPO) and the IAEA for research and exchange of safety related information.

Pakistan has, therefore, met the obligations of Article 11 of the Convention.

Article 12 – Human Factors

“Each contracting party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation."

12 Human Factors

Pakistan has taken appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation. PNRA and PAEC recognize that human performance plays an important role in ensuring the safety of a nuclear installation during all phases, i.e. Siting, Design, Construction, Commissioning, Operation and Decommissioning. Accordingly, PNRA has set regulatory requirements for establishing management systems and procedures for human factors to ensure safe operation. Subsequently, PAEC has established management systems and procedures for analyzing events involving human factors and to improve human performance for ensuring safe operation.

12.1 Regulatory Requirements

PNRA Regulations PAK/911 require due consideration of human factors at the design stage. The design is required to be ‘’operator friendly’’ aiming at minimizing human errors and their effects. Systematic consideration of human factors and the man-machine interface must be included in design process at an early stage and should continue throughout the entire life. This would ensure an appropriate and clear distinction between the functions of operating personnel and those of automatic systems.

The aim of the design is to promote the success of operator actions with due regard to the time available for action, the physical environment to be expected and the psychological demands to be made on the operator. The need for intervention by the operator on a short time scale must be kept to a minimum. The necessity for such intervention is only acceptable when it can be demonstrated that the operator has sufficient time to make a decision and to act. The information necessary for the operator to make the decision to act should be simple and unambiguous. In addition, following an event, the physical environment in the control room or in the supplementary control room and on the access route to that supplementary control room should be acceptable.

PAK/913 requires that the licensee defines the qualifications and experience necessary for personnel performing duties that may affect safety. Suitably qualified personnel are selected and given necessary training and instruction to enable them to perform their duties correctly for different operational states of the plant and in the event of an accident, in accordance with the appropriate procedures.

A high level of health and fitness is required for the personnel of nuclear installations. Accordingly, PAK/913 requires that all personnel of the licensee whose duty may affect safety shall be medically examined on their appointment and at subsequent intervals to ensure their fitness for duty and responsibilities assigned to them. Psychological examination is also required for licenced control room operating personnel. In addition, PAK/904 elaborates requirements for health surveillance program of radiation workers.

PNRA evaluates all human factors elements of Human Factors Engineering (HFE) planning and analysis. HFE program management, operating experienced review, function requirement analysis and function allocation, task analysis, staffing and qualification and human reliability analysis, human system interface design, procedure development, training program development, verification and validation , implementation and operation are reviewed as per requirements of PAK/911, PAK/913, USNRC NUREG-0800, NUREG-0700, and NUREG-0711.

PNRA also applies the NUREG-1764 to review licence amendment requests that credit the use of manual actions.

12.2 Steps Taken by PAEC to Ensure Consideration of Human Factors

KANUPP has made several design improvements to enhance human performance.

In addition to actions reported in the previous report against Human Factors, the implementation of SPDS was completed during long shutdown in 2010-11 and all of its eight critical safety functions have now been successfully implemented. This facility is available both in MCR and Emergency Control Centre (ECC) so that the operator can monitor the plant status under accident and transient conditions more easily and can take corrective actions when required to bring the plant to a safe state. Emergency Operating Procedures (EOPs) were revised in the light of Fukushima Dai-ichi event and training was imparted accordingly to operating shift crews. Draft Severe Accident Management Guidelines (SAMGs) are being revised as a result of modifications at the plant in response to Fukushima Dai-ichi accident.

During the first PSR of C-1, one of the safety factors to be reviewed was 'Human Factors' and the objective was to confirm the human factors that may affect the safe operation of C-1 are adequately addressed. The review included aspects related to plant personnel capabilities for continued safe operation of the plant and effective Human-Machine Interface (HMI).

The review of the human factors related to staffing, training and qualification, competency, fitness for duty and operating experience feedback system for human errors was carried out. Surveys and interviews of plant personnel were carried out on matters of training and qualification. The adequacy of corrective actions as suggested in Periodic Inspection Reports (PIRs), Operation Inspection Reports (OIRs) issued by PNRA along with Audits and Deficiency Reports issued by PAEC QA Division were also assessed. Event reports pertaining to human errors were identified and analyzed to assess effectiveness of OE program to minimize human errors. For review of Human Machine Interface (HMI), design of Main Control Room (MCR) and other work stations was analyzed. Compliance with the latest codes and standards was verified, walk-downs of MCR and other work stations including Full Scope Training Simulator (FSTS) was carried out. In addition modifications and events reported during last 10 years due to HMI were studied and feedback from plant operators was analyzed. Furthermore, the work load of MCR crew was also assessed by conducting interviews. Review of Human Reliability Analysis (HRA) and PSA reports to find linkages with HMI was also conducted. Based on the review result following corrective actions were identified:

- Development of comprehensive certification program.
- Self Assessment in the area of training and qualification.

- Inclusion of competency level training and qualification procedure.
- Development of need based /performance based training adopting SAT methodology.
- Marking of direction of movement of actuation control switches on panel in MCR.
- FSTS updating in line with modifications in MCR.
- Replacement of paper recorders with digital recorders for significant parameters.
- Formation of a dedicated Work Control group to take care of MCR work authorization process.
- Marking of controllers in accordance with the process result i.e. write Open/close on the respective sides of the controller.

The design of the main control room (MCR) at C-1 is based on a comprehensive and systematic Task Analysis and follows good human factors practices to facilitate the operators. It is compatible with human psychological and physical characteristics and enables the required tasks to be performed reliably and efficiently. In order to overcome human errors related to alarms, Alarm Response Procedures (ARP) are being developed.

In original design of C-1 MCR, a number of alarms were lit undesirably thus causing undue burden on MCR operators. C-1 accordingly initiated an Undesired Alarm Reduction Program to reduce all such alarms by changing the alarm logic. For this a number of alarms were identified both in conventional and nuclear systems. The reduction of undesired alarms on conventional side system is complete, whereas, for nuclear systems, work is in progress.

At C-2, Human Factor Engineering has been applied from the conceptual design phase to final detailed design. All elements of Human Factors were considered in the control room design in accordance with international practice. PSA was conducted at design stage and Human Reliability Analysis was performed for Human Factor Engineering (HFE). The design of the Main Control Room of C-2 was improved with respect to human factors by using operating experience feedback from C-1. In design of C-2, it is ensured that sufficient information associated with individual plant systems and equipment is available to operators. HFE is also considered for the design of Emergency Control Room. Human performance monitoring program is also being established.

On the basis of HFE requirements, Bypass Inoperable Safety System Indication System (CBI) has been included in the MCR of C-2. Several improvements have been performed on the basis of requirements of HFE design standards and operating experience of C-1, in human system interface design of main control room, local control rooms, MCR alarm system and training programs of plant specific full scope training simulator.

At C-1, Event-based Emergency Operating Procedures were provided by the vendor and the Symptom-based Emergency Operating Procedures (SEOP) have now been developed. Validation of these procedures at Simulator has been completed. For C-2, SEOPs will be completely implemented by Aug 2014. C-2 has developed SAMGs based on generic SAMGs which are being made plant specific.

Specific full scope simulator is used in the training and qualification examination of operators. All activities at nuclear installations are carried out in accordance with approved procedures. The licensee ensures that technical content of the instructions is correct, and that the design and presentation of instructions enable users to follow them accurately and reliably. This reduces the chances of human error. The procedures and instructions are subject to a process of verification and validation to ensure that they accurately represent operational requirements and are compatible with the design of plant and equipment. Suitable arrangements are made to implement these procedures and instructions. Nuclear installations have performed PSA including human factor events and their importance for different stages of the plant life. Through Human Reliability Analysis (HRA), human error probabilities are calculated for the errors that may be due to procedural lapses or operator errors. These inputs are used to improve procedures and operator training on simulator to minimize human errors.

KANUPP revised its full power PSA with internal fire event. On the basis of Fire PSA results, design improvements are being analyzed to enhance plant safety. C-1 has performed PSA Level-1 (full power internal initiating event excluding internal fire and flood). C-1 is working on incorporation of IPSART recommendations. C-1 is performing an internal fire and flood PSA as well as low power and shutdown PSA.

The Human Reliability Analysis has also been carried out and a number of improvements have been suggested which will be implemented accordingly.

In case of C-2, HRA was performed in PSA to assess contribution towards initiating events. Based on this analysis, improvements were suggested in the design and also in procedure writing.

C-1 is implementing operating experience feedback program to collect, categorize, investigate and implement corrective actions plan related to plant events. If human performance related issues are found, it is subject of further investigation to identify the corrective actions to prevent the recurrence.

In C-3/C-4 Human Factor Engineering has been applied from the conceptual design phase to final detailed design. All elements of Human Factors are considered in the control room design in accordance with international practice and experience feedback from C-1 and C-2.

12.3 Verification of Human Factors Considerations by PNRA

PNRA verifies that the human factors are considered throughout the life of a nuclear installation. Firstly, at the design stage, it is ensured that human factors are considered in the probabilistic safety assessment, design of main control room, emergency control room, local control room, safety parameter display system, safety system bypassed and inoperable status indication system, post accident monitoring system, alarm system, full scope training simulator, communication system, procedure development, training program development, technical support center and emergency control center. Secondly, during operation stage, regulatory inspections include various elements like checking of work conditions such as lighting, labeling, environmental and habitability issues, housekeeping, fitness for duty, etc.

PNRA Inspectors witness simulator exercises during training/re-training. They also carry out inspections of operation shift crews to verify compliance with procedures and to assess whether

the operator actions are in accordance with the procedures and design intent. Human performance evaluation is also an essential element of safety culture. Inspections and reviews of unusual occurrence reports determine the contribution of human factors in initiation and progression of the event.

While reviewing PSA of all nuclear installations, it is verified that human factors have been adequately considered and all operator actions are modeled in accordance with actual design. Improvements are suggested in procedures and training material to minimize operator errors during normal operation, anticipated operational occurrences and design basis accidents.

Pakistan has, therefore, met the obligations of Article 12 of the Convention.

Article 13 – Quality Assurance

> *"Each contracting party shall take the appropriate steps to ensure that quality assurance programs are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation."*

13 Quality Assurance

Pakistan has taken appropriate steps to ensure that quality assurance programs are established and implemented with a view to providing confidence that specified requirements for activities important to nuclear safety are satisfied throughout the life of a nuclear installation.

13.1 Regulatory Requirements

The regulatory requirements for the submission of quality assurance programs (QAP) at the time of applying for site registration, for applying construction licence and subsequently at the time of applying for first fuel load permit have been stipulated in PNRA Regulations PAK/909. The PNRA Regulations PAK/912 provides basic requirements for establishing and implementing quality assurance programs related to the safety of nuclear power plants. These basic requirements apply to overall quality assurance program of licensee/management, as well as to other separate quality assurance programs in each stage of the life of a nuclear installation. The licensee has to ensure safety in Siting, Design, Construction, Commissioning, Operation and Decommissioning of the nuclear installation. The regulations recognize that all work processes are planned, performed, assessed and improved. These basic requirements apply to all individuals and organizations, including designers, suppliers, constructors, manufacturers and operators of nuclear power plants.

The QAP is required to provide an interdisciplinary approach involving many organizational components and is not regarded as the sole domain of any single group. The QAP is to demonstrate the integration of following components:

a. Managers providing planning, resources and support to achieve the organization's objectives;
b. Staff performing the work to achieve quality; and
c. Management (at all levels) performing assessments to evaluate the effectiveness of management processes and work performance.

13.2 Quality Assurance Activities at Nuclear Installations

PAEC has established QAP at nuclear power plants to achieve its safety objectives. QAP includes quality policy statement, vision, mission, organizational structure with defined responsibilities, functions, interfaces, work process & performance, monitoring & evaluation and process control procedures.

13.2.1 Quality Assurance at Corporate Level

A Directorate of Quality Assurance (DQA) is in place at corporate level at the PAEC HQ to coordinate QA activities in various PAEC establishments, and to have corporate oversight for QA matters. The Directorate conducts QA audit of plants, provides guidance to the plant and the

corporate management on quality issues and recommends actions for improvements. PAEC has formally issued its Nuclear Safety Policy which encompasses the quality assurance elements such as management's commitment for giving priority to safety over production objectives, compliance with safety regulations and industrial standards for achieving excellent performance in all activities through highly professional and qualified manpower by utilizing all necessary financial and material resources. PAEC issued its quality policy which is considered as guiding principle for developing plant quality policies focusing on consideration of quality assurance principles in management, operation, maintenance and all related working spheres.

13.2.2 Quality Assurance at Nuclear Installations

KANUPP, C-1 and C-2 have established and implemented QAP in accordance with PAK/912 for operation phase to ensure quality in their safety related activities. KANUPP updated its operational QAP to address specific issues related to operation beyond design life. The OQAP of C-3 & C-4 for design and construction phases was approved by PNRA. The nuclear installations have established Quality Assurance Divisions (QADs) staffed with appropriately qualified personnel reporting directly to the highest level of the plant management. The QA personnel have been entrusted with necessary authority to ensure the implementation of QAP through inspections and audits. Among other things, QAD has the authority to stop any work not meeting the QA requirements. Assessment of QAP is carried out through self and independent assessments. This is done by performing internal and external audits, peer reviews, technical reviews, etc. The purpose of such assessments is to highlight the strengths and weaknesses of the management systems and to identify areas for improvement.

At KANUPP, Quality Assurance Division (QAD) conducts QA audits of Operation, Engineering Support, Chemistry Control, Health Physics, Maintenance, Procurement, Material Management and Training. All field activities related to areas mentioned in QA manual are routinely inspected following weekly work plans prepared by section in-charge of each area. As per QA manual, QA audits of different plant areas were carried out during the reporting period. Necessary improvements are made on the basis of QA findings.

The work undertaken by the work groups is reviewed from QA point of view before it is started. The work is observed during the execution and reviewed again after completion to verify that QA requirements have been fulfilled. QA verification of important plant documents such as operation and maintenance procedures, station instructions, change approvals, etc., is also carried out. The non-conformance control system is an essential part of QA which identifies non-conformances and corresponding corrective measures.

The QAD verifies that the work groups clearly understand management expectations to establish and maintain safety culture at KANUPP. Training and retraining of QA personnel including auditors is a continuous activity to maintain and enhance their qualifications and skills.

QAP of C-1 & C-2 encompasses all items and activities important to safety and availability of the plant. The Quality Assurance Divisions (QAD) is staffed with adequately qualified manpower and reports directly to respective Plant Managers. In all its activities, QAD emphasizes the safety and quality culture. Through planned QA surveillance and audit programs, the QAD verifies compliance with the established requirements of QAP. Planned as well as general surveillances are carried out in all plant areas within the scope of QAP. Internal and external

audits are performed according to the audit plans and applicable procedures. Follow-up of audit findings is continued till the implementation of required corrective actions.

QAD also performs inspections during fuel manufacturing and transportation and controls the activities of contractors of C-1 and C-2 through audits and surveillance. QAD provides support to the plant management during management reviews and assessments. Detailed working procedures related to safety and quality undergoes a thorough QA review by QAD before approval.

C-3 & C-4 has established an "Overall Quality Assurance Program (OQAP) for Design, Procurement, Construction and Commissioning of Chashma Unit-3 & 4" in accordance with the requirements of national regulations. The OQAP was reviewed and approved by PNRA. The OQAP covers all activities related to design, construction and commissioning including management, performance and assessment. Non-conformances are dealt according to the severity and safety implications as per procedure. Disposition actions are approved at different levels of the overall QA and regulatory system, depending upon the severity and implications. C-3 & C-4 have a Quality Assurance Department which assists the Director General on QA matters. The QAP of project contractors and sub-contractors are required to be in line with the OQAP. C-3 & C-4 perform QA audits of its contractors and sub-contractors to verify compliance with the OQAP.

Corporate level QA audit is also carried out by the Directorate of Quality Assurance (DQA) audit team. During DQA audit conducted in 2012, recommendations were made in various areas such as audit of local suppliers, revision of Aging Management program and Documentation control.

13.3 Quality Assurance Activities of Equipment Manufacturing Facilities

"Regulations for Licensing of Nuclear Safety Class Equipment and Components Manufacturers" – PAK/907 (Rev. 0) explain the licensing process for obtaining licence to manufacturers of Nuclear Safety Class Equipment and Components. The licensee is required to submit quality assurance manuals, process flow diagrams (production technology) and manufacturing schedules so that control points for inspections may be selected. The manufacturing activities are performed according to quality plans which describe the processes, testing, examination, reviews and checks in sequential order. Processes are required to be qualified according to the requirements of applicable codes and standards. Mock-ups are also required to be prepared to qualify the processes. Manpower involved in manufacturing and testing is qualified according to the requirements of relevant regulations, codes and standards.

PNRA performed numerous control point inspections of safety class equipment manufacturers during the equipments manufacturing of C-3/C-4 projects to verify the compliance with the requirements of national regulations and to assess the implementation and effectiveness of QAP in compliance with the applicable codes and standards.

13.4 Regulatory Surveillance of QA Activities

PNRA periodically performs regulatory surveillance of overall QA activities of its licensees. During routine and non-routine inspection activities, surveillance of relevant aspects of QAP/QAM is observed. Comprehensive inspections of specific areas of QA are performed as and when required in addition to the QA administrative inspections of licensees, contractors and

subcontractors performing safety related activities. During these inspections, PNRA verifies compliance with the requirements of national regulations and the licence conditions. The inspections at the sites of nuclear installations are conducted by PNRA Regional Directorates at Karachi and Chashma, while the inspections at the manufacturing facilities are controlled by PNRA Headquarter at Islamabad.

QA administrative inspection of licensee, main contractor and subcontractor of C-3&C-4 project performing safety related activities has been carried out by PNRA. During these inspections; PNRA verified the OQAP of licensee, QAP of main contractor and sub-contractor for the fulfillment of its delegated responsibilities as per requirement of PAK/912 and IAEA Code 50-C/SG-Q.

PNRA is also participating in control point inspections during equipment manufacturing of C-3/C-4 projects to verify the implementation and effectiveness of QAP in compliance with the applicable codes and standards.

13.5 PNRA Integrated Management System

PNRA has established and implemented an integrated management system to carry out its activities since 2010 in order to continuously improve its regulatory effectiveness. Management system of PNRA is in line with the requirements of the IAEA safety standard GS-R-3. In this regard, PNRA management system manual has been documented which describes the establishment, implementation, assessment and continuous improvement of management systems at PNRA. The manual contains Policy statements, Vision, Mission, Core values, Objectives, Organizational structure, Responsibilities & Authorities, Core and Support functions, Work process, Monitoring & evaluation processes, Assessment and improvement practices, etc. The Management System processes of PNRA are being regularly assessed through planning, control and effective supervision of its regulatory activities.

An internal audit of all PNRA directorates was conducted in 2011 to verify the compliance with requirements and recommendations of internationally accepted norms and standards. A self assessment of existing management system, based on IAEA self assessment methodology and tool (SARIS–Self-Assessment of Regulatory Infrastructure for Safety) is being carried out in the areas of legislative and governmental responsibilities, organization of the regulatory body, authorization process, regulatory body review & assessment, inspection & enforcement, development of regulations & guides and management system for the regulatory body to identify weak areas for further improvement in regulatory framework.

Pakistan has, therefore, met the obligations of Article 13 of the Convention.

Article 14 –Assessment and Verification of Safety

"Each contracting party shall take the appropriate steps to ensure that:

(i) Comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of the operating experience and significant new safety information, and reviewed under the authority of the regulatory body;

(ii) Verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions."

14 Assessment and Verification of Safety

Pakistan has taken appropriate steps to ensure that comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments are well documented and subsequently updated in the light of operating experience and significant new safety information. Such assessments are reviewed by PNRA. Verification by analysis, surveillance, testing and inspections is carried out to ensure that the physical state and operation of a nuclear installation continue to be in accordance with its design objectives, and operational limits & conditions.

14.1 Regulatory Requirements

A detailed regulatory framework exists which ensures comprehensive safety assessment and verification before the commencement of operation. PNRA Regulations PAK/909 delineate a detailed procedure for licensing of nuclear installations in three stages, namely, Site registration, construction licence and operating licence. Regulation PAK/910 prescribes detailed site assessment requirements for site registration (for details refer to section 17.1).PAK/911 requires that at the design stage of a nuclear installation, a comprehensive safety analysis shall be carried out to identify all sources of exposure and to evaluate radiation doses that could be received by workers at the installation and by the public, as well as potential effects on the environment. The safety analysis shall take into consideration:

i. All planned normal operation modes of the plant.

ii. Plant performance in anticipated operational occurrences.

iii. Design Basis Accidents.

iv. Event sequences that may lead to a severe accident.

On the basis of this analysis, the robustness of the engineering design for withstanding postulated initiating events and accidents can be established, the effectiveness of safety systems and safety related items or systems shall be demonstrated, and requirements for emergency response shall be established. Measures shall be taken to ensure that radiological consequences are mitigated. Such measures include: engineered safety features; onsite accident management procedures established by the operating organization; and possibly off-site intervention measures established by governmental agencies in order to mitigate radiation exposure if an accident occurs. A safety analysis of the plant shall be conducted in which methods of both deterministic and probabilistic analyses shall be applied. On the basis of this

analysis, the design basis for items important to safety shall be established and confirmed. It shall also be demonstrated that the plant as designed is capable of meeting prescribed limits for radioactive releases and acceptable limits for potential radiation doses for each category of plant states. The basis of the safety assessment shall be the results derived from the safety analysis, previous operational experience, results of supporting research and proven engineering practices. The licensee shall ensure that an independent verification of the safety assessment is performed before the design is submitted to the regulatory body. PNRA Regulations PAK/913 require the licensee to perform a systematic safety re-assessment of the plant for its entire operational lifetime. In such a reassessment, operating experience and significant new safety information from all relevant sources will also be taken into account. The Regulations also include the assessment and verification requirements during operation phase, in particular the assessment and verification of design modifications. It is emphasized that modifications involving plant configuration and the operational limits and conditions, shall conform to the requirements set in the Regulations PAK/911. In particular, the capability of performing all safety functions adequately shall not be degraded. The requirements for safe management of radioactive waste in the country have been specified in Regulations PAK/915. The licensee has to carry out safety assessments and the activities needed for Siting, Design, Construction, Operation and Closure, as well as the measures needed in the post-Closure phase of radioactive waste disposal facility. Additional requirements of Periodic Safety Review (PSR) for revalidation of Operating Licence and assessment for licensing beyond design life have also been stipulated in the Regulations.

14.2 Assessment and Verification of Safety by Nuclear Installations

The safety of the plant is continuously assessed and verified during all phases of the plant life. This includes self assessments, reviews of plant safety performance by plant safety committee, quality assurance division, engineering department, health physics division and relevant operation and maintenance departments. Independent reviews and assessments by corporate safety body and international reviews such as WANO peer review, OSART mission, etc. are conducted. Nuclear installations have established effective systems for recording deficiencies identified during the assessment and verification activities, event analysis, corrective actions and maintaining records for authorization and control of temporary changes to the equipment, procedures, etc. In-Service Inspection (ISI) programs are implemented to assess and verify the condition of plant structures, systems and components important to safety at appropriate intervals. All these systems of safety verification take into account the requirements of applicable regulations, codes, standards and international practices.

In addition, all nuclear power plants underwent rigorous self assessments after Pakistan adopted the IAEA Action Plan on Nuclear Safety to incorporate lessons learned from the Fukushima Dai-ichi accident. (For details, please see Section 2.2)

14.2.1 Assessment and Verification of Safety at KANUPP

Safety of KANUPP is being assessed and verified through periodic safety reviews, ageing management, in-service inspections, surveillance, and quality assurance programs. KANUPP is now operating under licence by PNRA beyond its design life. Ageing Management program is based on the international practices in line with national regulatory requirements.

KANUPP remained under shut down for long outage from December 2010 to May 2011 to conduct necessary evaluations, maintenance, surveillance and modifications so that an assessment for further operation life of the plant can be made. During this period, KANUPP completed all the major activities as required by PNRA including assessment of main equipment such as steam generators and fuel channels. The activities performed by KANUPP were thoroughly assessed by PNRA to verify compliance with the regulatory requirements and to ensure that the plant can operate safely. Based on the conclusion of review and assessment and observations made during regulatory inspections, KANUPP was conditionally allowed to make the reactor critical and subsequent power operation in June, 2011. KANUPP was further required to submit detailed reports to justify continued safe operation of KANUPP. KANUPP Operating Licence was extended till December 31, 2016 based on thorough Assessment of remaining life of Steam Generators and integrity of Fuel Channel. Steam Generators Assessment was performed by B&W, Canada whereas; the Fuel Channel Integrity Assessment (FCIA) was performed by the Candu Energy Inc., Canada. As per licensing condition, KANUPP would have to complete the 2nd Periodic Safety Review (PSR) by the year 2014 on which the work has already started. Revision of KANUPP Fire PSA was completed under the guidance of IAEA experts. Application of Fire PSA has been initiated.

14.2.2 Assessment and Verification of Safety at C-1

C-1 performs assessment and verification of safety under its Quality Assurance Program for Operation. The support from the designer and vendor is also sought when required. The plant has an Operational Safety Review Committee which performs review and assessment of the safety evaluation, modifications, events reports, plant operations, etc. Independent assessments are carried out in the form of audits, surveillance and peer reviews. At C-1, a comprehensive program is established for design modification control, which defines roles and responsibilities of the work units involved in the plant modification process. A set of procedures cover all aspects of design modifications, from the initial request, prioritization, safety screening, preparation of the design package, review and preparation of installation package to the evaluation of impact, testing/commissioning requirements, documentation revision and modification handover, etc. Control of temporary modifications is done through a specific procedure which requires safety screening and evaluation similar to the one for permanent modifications. The activities related to verification of safety are stipulated by the Technical Specifications which include the surveillance program, periodic testing, In-Service Inspection (ISI) Program, etc. to determine qualitative guidelines for maintaining high availability and reliability of components. Peer reviews are conducted by organizations such as IAEA and WANO. A WANO Peer Review Mission was conducted at C-1 in April 2012.

A dedicated group for ageing management is in place and C-1 has agreement with external organizations for support on Ageing Management activities. C-1 conducted PSR in 2010 and following are the significant corrective actions:

- Severe Accident analysis.
- Development of SAMGs.
- Development of Need based training program of Emergency Response personnel.
- Development of equipment Qualification Program.

- Development of Aging Management Program.
- Containment aircraft crash analysis.
- Updating of FSAR.
- Updating of deterministic safety analysis.
- Updating of probabilistic safety analysis.

14.2.3 Assessment and Verification of Safety at C-2

The design of C-2 was assessed at various levels for verification of safety. The designer (SNERDI) performed detailed assessment at the first level and it was verified independently by the personnel who were not directly involved in the design. At the second level the design was verified by C-2 as owner. Modifications in the design followed the same course for approval as for the original design as required by the national regulations. PNRA has carried out inspections during installation and commissioning of C-2 components and systems. After successful completion of commissioning tests (stage A), review of Final Safety Analysis Report and other documents as stipulated by PAK/909, demonstration of implementation of emergency preparedness plan and completion of physical protection measures fuel load permit was issued to C-2 on December 21, 2010 and C-2 completed its all other commissioning test successfully and started its commercial operation in May 2011. C-2 has the modification process as that of C-1 and all safety cases for modification are approved in Operational Safety Review Committee of the licensee and then the safety case is submitted to PNRA for approval.

The activities related to verification of safety are stipulated by the Technical Specifications which include the surveillance requirements, periodic testing and In-Service Test Program, etc.

14.2.4 Assessment and Verification of Safety at C-3/C-4

The list of applicable codes and standards for Chashma Nuclear Power Plant Units 3 & 4 (C-3 and C-4) plants were finalized and accepted by PNRA well before the submission of Site Evaluation Report (SER). Detailed review of SER for C-3 and C-4 was completed in the first quarter of 2011. After completion of the review and acceptance of C-3 SER, the site was registered. Review of the construction licence application including necessary licensing submissions i.e., Preliminary Safety Analysis Report (PSAR), Probabilistic Safety Analysis (PSA) Report and Overall Quality Assurance Program (OQAP) for C-3 and C-4 was completed in 2011. After satisfactory resolution of all relevant issues, construction licence was awarded to C-3 on May 28, 2011.

The process of site registration of C-4 prolonged till the end of year 2011 due to the issue of C-4 exclusion area boundary outside licensee's control. However, after resolution of this issue, C-4 site was registered on December 08, 2011, whereas, construction licence was issued on December 14, 2011. The civil work of C-4 has started with first concrete pouring on December 18, 2011.

A separate Quality Assurance Division (QAD) is established in C-3/C-4 for outlining the QA requirements during design, construction, installation and commissioning. The QAD conducted audit of the contractors and subcontractors, performed QA surveillance, issued non-conformance notices in non-compliance situations and verified corrective actions accordingly.

Safety and Licensing Division (SLD) is also established in C-3/C-4 with the responsibility for addressing all safety related issues during design, construction, installation and commissioning stages. PNRA has developed its inspection program for manufacturing and construction activities. PNRA had also performed the QA inspections of licensee, manufacturers, contractors and subcontractors.

14.2.5 Performance Indicators Program of Nuclear Installations

KANUPP has developed and implemented safety performance indicators (SPI) program to monitor the performance trends and to take appropriate actions for performance improvement. All identified SPIs (89) have been established in three phases. KANUPP also participates in the WANO Performance Indicators program.

CNPGS has adopted WANO performance indicators program and shares its performance indicators data elements with WANO on quarterly basis. The existing program consists of collecting, trending, exchanging, and disseminating performance data for complete set of WANO performance indicators, covering critical safety and operational aspects of the plant.

CNPGS has also developed safety performance indicators (SPIs) program to monitor operational safety of station. The SPIs program is based on the guidelines of IAEA-TECDOC-1141, 'Operational Safety Performance Indicators for Nuclear Power Plants'. It may be mentioned that some of the previously developed SPIs have been merged and some additional SPIs have been included in the current program. Safety performance indicators trends are reported in Technical Reports of the plant.

14.3 Regulatory Review Process

According to the procedure for licensing of nuclear installations in Pakistan, PNRA performs regulatory review of various licensee submittals such as Site Evaluation Report (SER), Preliminary Safety Analysis Report (PSAR), Final Safety Analysis Report (FSAR), Commissioning Program, Periodic Safety Review (PSR) Report, PSA Report, etc., during various licensing stages. Earlier, the safety review was performed by PNRA staff with the help of consultants; however, PNRA has now established Centre for Nuclear Safety as its technical support organization to indigenously perform safety reviews and assessments for the licensing process of nuclear installations. Safety reviews are carried out in accordance with national regulatory requirements for Siting, Design, Construction, Commissioning, Operation and Decommissioning of nuclear installations as referred in the Regulations PAK/909. In those areas where PNRA regulations and regulatory guides do not provide the necessary guidance, the relevant latest US Nuclear Regulatory Commission regulations/guides or IAEA Safety Standards and Requirements along with relevant safety guides may be used. Review meetings are held between the licensee and regulatory staff to address the queries raised during the review process. After completion of the regulatory review, safety evaluation report is issued that highlights all the major findings of the review and provides a comprehensive assessment of licensee's compliance with the regulatory requirements. This report also indicates non-compliant situations which may form the licensing conditions attached with the regulatory authorizations issued at various stages of licensing process. Any change in the plant configuration or its operations that may have an effect on the licensing basis requires PNRA approval prior to implementation. In this regard a formal request for approving the change is submitted which

needs approval of PNRA before implementation. Accordingly, PNRA reviews and approves the modifications. The design modification review process emphasizes that modifications, involving plant configuration and the operational limits and conditions, conform to the design requirements. The licensees have been asked to submit PSA submissions along with FSAR and PSAR at the construction stages, fuel load permit and PSR at licence revalidation stages.

PNRA reviewed the C-2 FSAR, C-3/C-4 SER, C-3/C-4 PSAR and C-1 PSR reports and KANUPP Residual Life Assessment reports to the satisfaction of national regulations in the reporting period.

14.4 Verification of Safety by PNRA

Verification of safety of nuclear installations is carried out through regulatory inspections, reviews, analyses and audit calculations. The verification of safety is carried out during all phases of Siting, Design, Construction, Installation, Commissioning, Operation and Decommissioning. Safety analysis, carried out by the licensee to support the design, is reviewed and audit calculations are conducted on sampling basis using applicable computer codes. The underlying assumptions, modeling techniques, accident sequence quantification, results and uncertainties are verified against the acceptance criteria. Comparison of results with already approved design, where applicable is also considered. The inspection program of each phase is prepared in line with project schedule under intimation to the licensee. The inspection programs are focused on ensuring that plant construction, equipment manufacturing, installation and commissioning are in conformity with the design intent, and that the operation is within the approved limits and conditions. In addition to planned inspections, reactive/special inspections are also performed in situations requiring special attention or regulatory intervention. PNRA has included safety culture in its inspection program and has performed safety culture inspections at KANUPP and C-1 and the follow-ups. All activities of KANUPP, C-1 and C-2 , related to safe operation and maintenance of the plant, including engineering support, health physics, emergency preparedness, quality assurance, event analysis, operating experience feedback, radiological environmental surveillance, etc., are overseen by the regulatory inspectors to verify compliance with the regulatory requirements.

C-3 and C-4 is at the construction stage and PNRA verifies selected construction and manufacturing activities through its control point inspection programs. The inspection program is being executed in three types of inspections i.e. Hold “H”, Witness “W” and Record “R” point inspections according to the schedule agreed with the licensee.

14.5 Safety Reviews and Assessment through External Organizations

PAEC understands the importance of international evaluations and their benefits for enhancing safety and operational performance of the plant. This is done through benchmarking with plants having excellent performance in safety and availability.

Taking in view the above, CNPGS invited following external mission during recent period.

a) Pre-Start Up WANO Peer Review of Chashma Unit-2. (July 2010)

b) Follow up of Pre-Start up WANO Peer Review of Chashma Unit-2. (November 2010)

c) Pre-visit of WANO Peer Review Mission to Chashma Unit-1. (March 2012)

d) Peer Review Mission to Chashma Unit-1. (April 2012)

KANUPP also invited WANO Special Peer Review Follow up mission in April 2013. Following major improvements have been made as a result:

i. Distraction conditions in the MCR have been minimized.

ii. Procurement process for essential spare parts has been expedited.

iii. Plant performance indicator of emergency AC showing improvement.

iv. Changes of multiple to single access control helped in reduction of personal contamination control.

Furthermore, the WANO team appreciated the efforts of plant management in response to lessons learned from Fukushima Dai-ichi accident apart from evaluating the status of corrective actions against previous AFIS.

Pakistan has, therefore, met the obligations of Article 14 of the Convention.

Article 15 - Radiation Protection

> *"Each Contracting Party shall take the appropriate steps to ensure that in all operational steps the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed the prescribed national dose limits."*

15 Radiation Protection

Pakistan has taken appropriate measures to ensure that during all steps of nuclear installations such as Operation, Maintenance, Refueling, Implementation of design modifications, etc., the exposure to plant personnel, public and environment is kept as low as reasonably achievable and that no individual is exposed to radiation which exceeds the prescribed dose limits.

15.1 Regulatory Requirements

Pakistan Nuclear Regulatory Authority (PNRA) is responsible for controlling, regulating and supervising all matters related to radiation protection. PAK/909 requires submission of a radiation protection program, radioactive waste management program and radiological environmental monitoring program as part of the pre-requisites for issuance of operating licence.

The radiation protection objective described in regulations PAK/911 states that, it is to be ensured that in all operational states, radiation exposure within the installation or due to any planned release of radioactive material from the installation is kept below prescribed limits and as low as reasonably achievable (ALARA), and to ensure mitigation of the radiological consequences. The safety objectives for design of nuclear installations require that nuclear installations shall be designed and operated so as to keep all sources of radiation exposure under strict technical and administrative control.

PAK/913 requires that the licensee shall establish and implement a radiation protection program to meet the objective of PAK/911. The regulation also require that implementation of the radiation protection program shall be ensured by the appointment of qualified manager health physics who advises the plant management and shall have authority to participate in establishing and enforcing of safety procedures. The qualification of Manager Heath Physics is also defined in the regulations. The dose limits for radiation workers and public during normal operation are given in PAK/904 and are reproduced in Annexure–VIII.

15.2 Radiation Protection at Nuclear Installations

PAEC is committed to take all appropriate steps so that occupational radiation exposure to personnel working in its nuclear facilities is maintained as low as reasonably achievable (ALARA). Moreover, PAEC is committed to take all reasonably practical steps to achieve the following two safety objectives:

- The risk of prompt fatality to an average individual in the vicinity of a PAEC nuclear facility, as a result of an accident in the facility, should not exceed 0.1 % of the sum of prompt fatalities due to other accidents to which the members of the public are generally exposed.

- The risk of cancer fatalities to population in the area of a PAEC nuclear facility that might result from the operation of the facility should not exceed 0.1 % of the sum of all cancer fatalities.

The nuclear installations have developed policies and procedures, for the protection of workers, public and environment from the harmful effects of radiation, in conformance with the national regulatory requirements. It is ensured that in all operational states radiation exposure within the installation or due to any planned release of radioactive material from the installation is kept below prescribed limits and as low as reasonably achievable (ALARA), and that the measures to mitigate the radiological consequences arising from any design basis accidents are in place.

At nuclear installations, monitoring and surveillance of doses to radiation workers is conducted and records maintained. For environmental monitoring, continuous air sampling and ambient dose level monitoring are performed. Environmental samples of air, water, soil, vegetables, fruits, milk, meat etc., are collected and analyzed for estimation of radionuclide content at frequencies prescribed in the radiological environmental monitoring programs. On-Site and Off-Site environmental monitoring points are selected at different locations. Environmental TLD dosimetery is also performed to record the cumulative dose level on quarterly basis. PNRA normally reviews the records of sampling and analysis of the licensees, however, independent verification of plant monitoring samples may also be conducted. PNRA has also established its own environmental monitoring laboratory.

At nuclear installations, radiological environmental monitoring is conducted during pre-operational phase, operational phase and emergency phase. The records are maintained and reports generated on quarterly and on annual basis. During three phases of plant operations, radiological environmental monitoring is performed for the followings:

- To determine ambient gamma radiation dose rate in pre-operational phase, operational phase and emergency phase and hence to assess the public doses contributed by NPPs operation.
- To determine level of activity in air, soil, water, vegetables, crops and milk etc. during the three phases and hence to assess the internal gamma doses to public attributed by NPPs operation.
- To meet the surveillance requirement of standard/codes and hence to consolidate the basis for enhancing public confidence in NPPs safe operation.

15.2.1 Radiation Protection at KANUPP

At KANUPP, radiation exposure is controlled by means of job planning, pre-job briefing, frequent radiation surveys, radioactive contamination control, and regular training to keep the doses well below the regulatory limits. In addition, a Radiation Control Officer (RCO) is designated for radiation intensive jobs with prime responsibility of taking part in each activity right from planning to execution. Internal radiation dose is controlled by providing suitable respiratory protection equipment, reducing the airborne contamination level. Internal uptake limits have been defined, which are followed strictly.

Radiation exposure to the public is kept as low as reasonably achievable by controlling the release of radioactive effluents from the plant. This is done by on-line monitoring of the releases, removing the Tritium contents from boiler room atmosphere, filtration of gaseous effluent before releasing to the environment, decay and dilution of liquid effluent before its release, collection, processing and safe storage of solid radioactive waste, etc. As a result, the gaseous and liquid effluent radioactive releases from the plant are well below the Derived Release Limits for KANUPP.

An environmental monitoring program is in place that includes regular radiation ambient dose rate monitoring at plant periphery and in different areas of Karachi city. This is done by placing TLDs and high volume air sampling system away from the plant. Environmental samples from the vicinity of plant are collected and analyzed. The records show no appreciable change in ambient background dose levels.

Annual collective doses to the workers during, 2010, 2011 & 2012 at KANUPP were 2.467 man-Sv, 4.007 man-Sv and 1.317 man-Sv respectively. Average individual dose for these years were, 2.80 mSv, 4.01mSv and 1.44 mSv respectively. The graphical representation of these doses is shown in Annexure– IX.

Gaseous radioactive effluents released during 2010, 2011 and 2012 were 86.66 TBq, 178.09 TBq and 88.34 TBq of Tritium respectively. Whereas, gaseous radioactive effluents released during 2010, 2011 and 2012 were 5.45 TBq, 3.68 TBq and 4.44 TBq of noble gases respectively. On the average, the cumulative gaseous releases remained less than 1% of annual release limits.

The liquid effluents released to sea during 2010, 2011 and 2012 contained, 62.61 TBq, 60.32 TBq and 123.10 TBq of Tritium respectively. Generally, these were less than 0.01 % of annual release limit for Tritium. Gross beta-gamma radioactivity released to sea during 2010, 2011 and 2012 was 0.018 TBq, 0.025 TBq and 0.014TBq respectively which are less than 1.0 % of annual derived release limit for gross beta-gamma radioactivity. The effluent releases of KANUPP are shown graphically in Annexure–X.

15.2.2 Radiation Protection at C-1 & C-2

In order to implement the radiation protection program, C-1 & C-2 has established the necessary organizational setup headed by Manager, Health Physics Division. Health Physicists working under him are responsible for implementing the radiation protection program for handling and monitoring radioactive materials, including sources and secondary source materials. This program conforms to national Regulations and includes

a. Conformance to working procedures for implementing the radiation protection program.
b. Survey of all incoming and outgoing shipments that may contain radioactive material.
c. Investigation and documentation of any radiological incident to minimize the potential for recurrence and for reporting these incidents to PNRA in accordance with the regulations.
d. Periodic surveys of radiation, contamination and airborne activity.
e. Record keeping of occupational radiation exposures and reporting to the PNRA.

f. Provision of personnel and other radiation monitoring equipments and their periodic calibration.

g. Establishment of access control points to separate potentially contaminated areas from uncontaminated areas and survey of tools and equipments before removal from a controlled area.

h. Issuance of radiation work permits (RWP) in accordance with the station radiation control procedures.

i. Bioassay program including whole body counting and / or a urinalysis sampling to measure the uptake of radioactive material.

j. An environmental radiological monitoring program to measure any effect of the installation on surrounding environment.

Annual collective dose for C-1 during 2010, 2011 and 2012 were 612.573 man-mSv, 511.038 man-mSv and 131.01 man-mSv respectively. Average individual dose for these years remained 0.392 mSv/man, 0.324 mSv/man and 0.10 mSv/man respectively. The graphical representation of these doses is shown in Annexure–IX.

Annual collective dose for C-2 during the year 2011and 2012 was 11.025 man-mSv and 4.856 man-mSv. However, annual average individual dose is 0.171 mSv/man and 0.006 mSv/man respectively.

At C-1 & C-2, all liquid and gaseous effluents are monitored before release to the environment. Liquid effluents are released from C-1 & C-2 into the discharge canal, which falls into the Indus River. Gaseous effluents released during 2010, 2011 and 2012 were 16.2 TBq, 0.1 TBq and 0.04 TBq respectively. On the average these releases remained less than 1% of annual release limit. Liquid effluent releases for the years 2010, 2011 and 2012 were, 2.42 TBq, 3.35 and 3.68 TBq respectively. These releases were less than 1% of annual release limit. C-1 effluent releases are shown graphically in Annexure–X.

Gaseous and liquid effluent releases from C-2 during 2011 were 0.0075 TBq and 9.21 TBq respectively. Gaseous and liquid effluent releases from C-2 during 2012 were 0.0011 TBq and 18.10 TBq respectively. The releases were less than 1% of annual release limits.

15.3 National Environmental Radioactivity Surveillance Program (NERSP)

The National Environmental Radioactivity Surveillance program (NERSP) of PNRA is also operational. The main aim of this program is to protect the public, environment and worker from harmful effects of ionizing radiation. The program would generally cover measurement of radioactivity in sand/soil, air, water, flora/fauna in the whole country. This program also assesses the radiation survey and analysis of NORM related activities at National level. NERSP has also analyzed samples around NPPs and verified environmental data provided by the licensees. Under NERSP, establishment of three Environmental Monitoring (EM) labs are in progress at Islamabad, Chashma & Karachi. The environmental monitoring lab at Karachi is fully established for radiometric analysis. At Islamabad, a temporary lab has been established for radiation analysis of samples whereas; construction of Chashma lab has been completed.

15.4 National Dosimetry & Protection Level Calibration Laboratory (NDCL)

In order to facilitate and verify the implementation of radiation protection at Nuclear and radiation facilities at Pakistan, PNRA has established Internal and External Dosimetry Laboratories. The Internal Dosimetry laboratories have been established at Islamabad, Karachi and Chashma. Each centre is equipped with a Whole Body Counter to assess internal contamination of radiation workers of licenced facilities. The Islamabad centre is also equipped with a Bed Type Counter using High Purity Germanium detector. Therefore this system provides detailed analysis of the quantity of each radionuclide present inside the body of the radiation worker. The External Dosimetry Laboratory of PNRA consists of new state-of-the-art Thermo luminescent dosimeter reader systems and three TLD Readers have been installed so far. The External Dosimetry Lab is providing the services of whole body dosimetry and extremity dosimetry to various centers.

15.5 Classification of Areas and Radiation Zones

According to the requirements of PAK/904, the radiation areas are classified into two parts i.e. Supervised and Controlled areas for the purpose of controlling the occupational exposure. At KANUPP, Controlled area is divided into 4 zones. Zone 1 contains no radioactive equipment and is kept free of contamination at all times. Zone 2 contains no radioactive equipment and should not become contaminated. However, some contamination may get into this area with the movement of personnel from Zone 3 which includes service area for active equipment and materials that are potential sources of contamination. Zone 4 contains sources of Contamination.

C-1 & C-2 Radiation controlled Area (RCA) is classified into 5 radiation Zones.

15.6 Dose Constraint

For KANUPP, dose constraint limit is set as 0.3 mSv/yr. C-1 and C-2 have established dose constraint limit of 0.26 mSv/yr.

15.7 Verification of Implementation of Radiation Protection Program

Performance of the nuclear installations is continuously monitored to verify compliance with radiation protection requirements. In this regard, PNRA performs regulatory inspections and reviews reports of the licensees to verify compliance with radiation protection and radiological environmental monitoring programs. Such inspections are an essential part of annual inspection plan of PNRA Regional Directorates for nuclear installations. During these regulatory activities, various aspects of implementation of radiation protection program are considered. These include development and implementation of ALARA plans for activities involving radiation exposures, compliance with the procedures, provision of personal protective gear to workers, availability and accuracy of personal and area monitoring equipment, radiation dose records for radiation workers and records of radioactive releases from nuclear installations. It has been observed that the doses to radiation workers remain well below the radiation dose limits and the average dose received by an individual remains less than a fraction of the annual dose limit. Similarly, in the entire operating history of nuclear installations in Pakistan the gaseous and liquid effluent releases have been well below the derived release limits. The licensees report the ambient dose levels at nuclear installations to PNRA quarterly and annually. PNRA has

observed that the ambient dose levels at the boundary of KANUPP and C-1 are generally close to the level of natural background. The ambient dose levels for KANUPP for the years 2010, 2011 & 2012 are 107, 111 and 103 nGy/hr respectively. The ambient dose levels at Chashma site during the years 2010, 2011 & 2012 are 94, 96 and 92 nGy/hr respectively. The ambient dose levels at KANUPP and Chashma site are summarized in Annexure– XI.

Pakistan has, therefore, met the obligations of Article 15 of the Convention.

Article 16 - Emergency Preparedness

"1. Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency. For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.

2. Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.

3. Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency."

16 Emergency Preparedness

Pakistan has taken appropriate steps to ensure that there are on-site and off-site emergency plans for nuclear installations, which are routinely tested and cover all the activities to be carried out in the event of an emergency. For new nuclear installations, such plans are prepared and reviewed before the commencement of operation. In addition, appropriate steps have been taken to ensure that the surrounding population is provided with appropriate information for emergency planning and response.

16.1 Regulatory Requirements

The PNRA Regulations PAK/909 set the requirement for preparing an emergency preparedness plan prior to introduction of nuclear material into the system. PNRA Regulations PAK/913 requires the licensee to establish appropriate emergency arrangements from the time that nuclear fuel is brought to the site and to put in place emergency preparedness plans before the commencement of operation. Emergency preparedness plans are required to maintain the capability for managing accidents, mitigating their consequences if these do occur, protecting the site personnel, public and the environment. These plans are to be submitted to PNRA for approval and adhered to in the event of an emergency. In addition, an emergency plan is required to be tested in an exercise before the commencement of operation and at periodic intervals thereafter. Some of these exercises shall be integrated and shall include the participation of as many as possible of the organizations concerned. The plans shall be subject to review and updating in the light of experience gained from the exercises.

Further, the PNRA Regulations PAK/914 “Regulations on Management of a Nuclear or Radiological Emergency” require that licensee shall develop, test, and put in place an infrastructure according to the hazard category as defined in the Regulations. In addition, the licensee shall ensure a timely, managed, controlled, coordinated and effective response at the installation, in the emergency planning zones anticipated to be affected by the nuclear or

radiological emergencies. Implementation of these Regulations is aimed to minimize the radiological consequences for the public, property and the environment arising from such an emergency. In case of severe emergencies, the response at national level is also required by these Regulations.

16.2 National Emergency management Infrastructure

West Pakistan National Calamities (Prevention and Relief) Act of 1958 provides for the maintenance and restoration of order in areas affected by calamities, and relief against such calamities. The Calamities Act 1958 was mainly focused on organizing emergency response. Emergency Relief Cell (ERC) created within the Cabinet Division in 1971, is responsible for disaster relief at national level. It provides assistance in cash and supplements the resources of the Provincial Governments in event of major disaster. National Crisis Management Cell (NCMC) was established in July 1999 under the Ministry of Interior. NCMC is responsible for coordinating plans for emergency relief services in case of emergency situations and its main function is to collect information regarding various emergencies in the country, along with coordination with Provincial Crisis Management Cell and other relevant agencies.

The need for strong institutional and policy arrangements was fulfilled by promulgation of the National Disaster Management Ordinance 2007 (NDMO) in the aftermath of the 2005 earthquake. Under NDMO, Government of Pakistan established a National Disaster Management Commission (NDMC) headed by the Prime Minister. It also established a National Disaster Management Authority (NDMA) to serve as the focal point and coordinating body to facilitate implementation of disaster management. All stake-holders including government departments / agencies and armed forces work through and form a part of NDMA in all stages of Disaster Risk Management.

Provincial Disaster Management Authorities (PDMAs) and District Disaster Management Authorities (DDMAs) have been established at the provincial and district levels of the country. The National Disaster Management Authority has formulated a National Disaster Response Plan (NDRP) after extensive cross-sectored consultations. NDRP seeks to upgrade the country's ability to cope with all conceivable disasters. To achieve this purpose, complete range of disaster management activities from preparedness to response has been addressed. The formulation outlines a framework for emergency response at different levels of the government structure; identifies roles and responsibilities of various stakeholders, and lays down coordination mechanism for activities involving the United Nations, Non Governmental Organizations (NGOs), civil society organizations, public & private sector and media to harness the full national potential for efficient disaster management.

Details on functions and responsibilities of NDMA/PDMAs/DDMAs and other stake holders are given in the NDRP.

The emergency plans of the nuclear power plants are continuously evaluated and improved. Recently, with a view to ensure effective and efficient management of nuclear emergencies, the existing system has been provided an overarching arrangement under the concept of Nuclear Emergency Management System (NEMS). This concept has been built around the principles of centralized control, decentralized execution through tiered and graded approach and comprehensive involvement of operators and other organizations. Under this system a very

comprehensive view is taken of the communication arrangements, flow of information, pre-arrangement of required assistance from different organizations / agencies and designation of authority to orchestrate such emergencies. The sole objective of this arrangement is provision of timely response to all nuclear and radiological emergencies. NEMS seamlessly dovetails with NDMA plans in case the nuclear emergencies begin to have off-site effects.

16.3 Emergency Plans of Licensees

The operating nuclear installations (C-1, C-2 and KANUPP) have developed on-site and off-site emergency plans. These emergency plans describe on-site and off-site response organizational setups, classification of emergencies, assessment and declaration of emergencies, emergency facilities, on-site and off-site notification systems, emergency planning zones, intervention and derived intervention levels, environmental dose measurement and assessment facilities, application of protective measures, recovery operations and termination of emergency, public information, records and reports pertaining to exercises and drills, etc. Emergency plans also give brief details of plant systems, demography and regional climatology. The on-site and off-site emergency response organizations of all nuclear installations are described in the emergency plans covering the role of each responsible person during an emergency situation. Emergency facilities like emergency control centre, auxiliary emergency control centre, communication facilities, radiation monitoring system, post accident monitoring system, medical facilities, decontamination facilities, etc. are described in the emergency plans.

The effectiveness of emergency plan is demonstrated in an integrated exercise before the commencement of operation of the nuclear installation. During years 2010-2012, the emergency exercises at KANUPP, C-1 and C-2 have been conducted as per agreed schedule. The frequency of the exercises is given in Annexure–XII. Emergency exercises performed at KANUPP, C-1, C-2 and NRECC from January 2010 to Dec 2012 are also shown in Annexure–XII. PNRA inspectors and PAEC Corporate office witnessed the exercises and made recommendations to the licensee for further improvements. The plans are updated in the light of experience gained from the exercises and drills. In order to ensure an appropriate response, emergencies are classified according to the severity of an event or accident. Emergencies have been categorized into four classes in increasing order of severity as standby emergency, plant emergency, site emergency and general emergency. The details of the initiating conditions and actions to be taken during these emergencies are defined in the emergency plans. The initial assessment of the accidents and determination of associated emergency class is specified in relevant plant procedures to be exercised by the on duty Shift Supervisor (SS). After the situation comes under control and the plant is brought to a safer mode, SS terminates the emergency with the authorization of Site Emergency Director (SED). According to C-1/C-2 On-site Emergency Plan, 'CHASNUPP Emergency Response Organization' (CERO) is responsible for initiation and completion of recovery operation and is regarded as Recovery Organization while Technical Support Centre (TSC) is meant to provide technical support to the MCR crew in case of emergency. Both CERO and TSC are activated by SS in case of emergency.

C-1 and C-2 have separate onsite emergency plans and a common offsite emergency plan. Both units have developed a joint procedure for interface during radiological emergency to establish communication link between Emergency Control Centers (ECCs) and MCRs in case of emergency at C-1 and/or C-2. In case of emergency at any one unit, its MCR Shift Supervisor

will notify the other unit to declare the same emergency class. Consequently, both the units will perform actions in accordance with their respective emergency plans and procedures.

The offsite emergency plan includes role and responsibilities of all the response organizations. District Government (Headquarter) is designated as offsite ECC. If the consequences are beyond its control, the offsite ECC may request support of provincial and federal government. These arrangements are exercised on regular basis according to the requirements of plans and procedures.

Both CNPGS Emergency Plans (On-site and Off-site) have been revised recently in 2011 and 2012 respectively. CNPGS Off-site Emergency Plan is endorsed both by the district as well as provincial Governments.

In 2010, 2011 and 2012, CNPGS has conducted Integrated Emergency Exercise, Partial Emergency Exercises and to evaluate the effectiveness of approved emergency plan. In December 2012, CNPGS conducted 1st Off-site Partial Emergency Exercise (Tabletop) with full involvement of District Administration officers. During this exercise, detailed discussions were held among all district officers under supervision of DCO/DC and senior police officials for arrangement of resources needed to implement the public safety measures during emergency like evacuation, sheltering, re-habilitation etc., and was witnessed by PNRA.

EPZ for KANUPP was initially 3 km. After Fukushima Dai-ichi accident, the EPZ was revisited and set as 5 km where around 3000 people reside. Currently stock of 100,000 KI tablets is available. This inventory has been maintained conservatively keeping in view the population up till 16 Km around the plant. PDMA will provide necessary assistance as per KOFREP. SOPs for sheltering, KI tablets distribution and evacuation have already been prepared and approved.

EPZ at CNPGS were revised after the Fukushima Dai-ichi accident. Impact of simultaneous accident at both units on EPZ is being assessed. Reassessment of surveillance program for emergency equipment/ supplies expected from other off-site support organizations following extreme external hazards is being taken into consideration.

At KANUPP and CNPGS, a team of multi discipline reserve force (Operation, Maintenance, Health physics etc.) has been formed for assistance during severe accident.

Necessary competencies and qualifications for such a reserve force team have been identified. It was concluded that plant operations and maintenance staff is enough all the times, however more radiation protection and environment monitoring staff would be needed. A database for other organizations in country which have these capabilities has been compiled.

A cross training program is being developed to supplement the number of personnel required in case of emergency.

During 2012, PNRA has required the licensees to conduct emergency drills/exercises in different seasons and timings of the day to demonstrate implementability of emergency plans. In this regard, PNRA proposed a five year exercise calendar which has been agreed by the licensees.

16.4 Verification of Emergency Plans by PNRA

Verification of emergency plans is conducted through regulatory review and by witnessing periodic emergency drills and exercises conducted by the licensee in the fulfillment of the regulatory requirements. Emergency plan of the licensee is first reviewed to verify that it contains essential elements of emergency preparedness and response in line with the regulatory requirements for issuance of operating licence. Later through periodic inspections, it is verified that the implementing procedures are developed, on-site emergency response organizations are equipped with necessary means, and response personnel have adequate qualifications and training. Prior to the conduct of exercise, the licensee prepares and submits emergency exercise scenario for review and evaluation to PNRA. A team comprising observers from PNRA HQ and Regional Directorates witnesses the integrated exercises, whereas, PNRA resident inspectors and facility observers witness the emergency drills. PNRA also invites its liaison officers from the relevant Government Departments and Ministries to witness the emergency exercises. On the basis of the results of drills and exercises a report is prepared describing the actions to be taken for improvement of emergency plans and procedures. In order to verify the accuracy and continuous availability of designated emergency contacts of the licensee and regional offices, PNRA conducts Communication Test Exercises (COMTEX) thrice a year on regular basis. Any change in the emergency contact details is updated at the NRECC.

During the reporting period, PNRA conducted the review of revised C-1 Onsite Emergency Plans, C-2 Onsite Emergency Plan and CNPGS Offsite Emergency plan along with KANUPP Onsite and Recovery Plan.

16.5 National Radiation Emergency Coordination Centre

National Radiation Emergency Coordination Centre (NRECC) is established at PNRA Headquarters for coordination of response to nuclear accidents or radiological emergencies and remains functional round the clock. It is the focal point for regulatory response in case of an emergency (Abroad or Domestic) and also functions as the secretarial arm to Chairman PNRA, who is the National Competent Authority (NCA) for an emergency. NRECC is also the National Warning Point (NWP) of Pakistan for the Conventions on “Early Notification of a Nuclear Accident” and “Assistance in the Case of a Nuclear Accident or Radiological Emergency”. It is responsible for notifying National Competent Authority (Abroad and Domestic) and IAEA about a nuclear accident or radiological emergency. The main functions of NRECC are to:-

i. Receive a notification and information concerning the nature of the emergency, national as well as transnational, of potential consequences.
ii. Authenticate and verify notifications or information of a nuclear accident or radiological emergency.
iii. Inform forthwith, after being notified of an event, the NRECC Chain of Command about the received notification.
iv. Communicate received information (consistent with confidentiality limitations) promptly to licensee, public authorities or relevant international organizations.
v. Facilitate and/or co-ordinate the provision of assistance at the national/international level, if it is requested for.

vi. Assist NCA(A) or NCA(D) on recommendations to Government of Pakistan for protective actions like sheltering, evacuation or supply of prophylactics, etc.
vii. Use its best endeavors to promote, facilitate and support the cooperation and coordination between PNRA, licensees, public authorities and relevant international organizations.
viii. Ensure that there are timely, accurate and reliable releases of information to the media, as appropriate, through other relevant directorate of PNRA.

NRECC is adequately equipped with communication facilities. It is supported by two Mobile Radiological Monitoring Laboratory (MRML) vans and various types of radiation detection and personal protective equipment. MRMLs are stationed at PNRA HQ and can be activated after receipt of emergency notification within 20 to 30 minutes for dispatch to the affected site. Periodic emergency exercises are conducted in order to test the readiness and operation of MRMLs, and training of response personnel. In order to ensure a timely response to nuclear or radiation emergency, PNRA has also provided MRML to its Regional Nuclear Safety Directorates. In addition, PAEC has its own MRMLs at sites.

In 2010, PNRA registered for participation in an International Nuclear Emergency Exercise (INEX) conducted with the support of the Nuclear Energy Agency, Organization for Economic Cooperation and Development (OECD), France. The exercise was conducted during February 2011. NRECC participated in numerous ConvEx exercises conducted by Incident and Emergency Centre (IEC), IAEA. During the year 2011, the capabilities of NRECC were enhanced by equipping it with advanced radiation monitoring. NRECC remained activated round the clock after Fukushima Dai-ichi accident. NRECC also provides training on emergency preparedness and response to PNRA officials, licensees, response organizations through conduct of training courses, workshops, exercises and through participation in exhibition arranged by disaster management organizations.

During emergencies, the decision for implementation of protective measures is the responsibility of the licensee and is made on the basis of intervention levels, reference levels, etc., defined in the licensee emergency plans which are approved by PNRA. However, the licensee keeps NRECC informed about any protective measures taken. PNRA is consulted in case of any unforeseen situation. PNRA is also coordinating with the response and law enforcing agencies to familiarize them with their role during a nuclear accident or radiological emergency.

Pakistan requested IAEA for review of PNRA emergency preparedness and response arrangements for nuclear or radiological emergencies. An Emergency Preparedness and Review (EPREV) mission was conducted in May 2011 and a team comprised of international experts reviewed the PNRA arrangements. Most of the Mission recommendations were related to the development of National Radiation Emergency Plan, which are being addressed in the national Nuclear Emergency Management System.

16.6 Training of First Responder

In case of an emergency, the rescue person is always one of the first persons reaching at the scene of the accident. The trained rescuers can play an important role to avoid spreading of contamination and overexposure to the personnel. In order to train the first responders, PNRA has developed liaison with relevant public departments.

In 2011, PNRA in coordination with Rescue 1122, arranged eight training sessions at Rescue 1122 Rawalpindi Station and Police College, Sihala. More than 2,600 first responders participated in these training sessions.

In 2012, PNRA arranged four (04) training courses for first responders including rescue services, SPD, CDA, Defense Training Center- Quetta, Casualty Center and other relevant organizations. A total of 65 personnel were trained on various topics which mainly include concepts about radiation, radiation protection, potential causes of radiological emergency, and radiological emergency preparedness and response.

For the use and awareness of the first responders, PNRA has prepared pamphlets and booklets regarding nuclear and radiation emergencies which may be used in case of a nuclear or radiological emergency.

16.7 Training of Medical Professionals in Handling of Radiation Injuries

Overexposure to radiation or radioactive contamination may cause radiation injuries in case of a nuclear or radiological emergency. It is obvious that medical professionals would be among the first responders in such accidents. PNRA is working towards the development of national capability for the management and treatment of radiation injuries in collaboration with other national organizations and hospitals. PNRA pays special attention to the training of the medical personnel to ensure that adequate level of such capability exists among medical doctors and paramedical staff. In this regard, short courses have been arranged in different hospitals for medical doctors. These courses are based on basic medical techniques for treatment of overexposed and contaminated individuals at the site and in isolated rooms in hospitals in case of a nuclear or radiological emergency.

Ten seminars were conducted at different hospitals in Islamabad and Rawalpindi. In the second phase, similar activities were conducted at eight major hospitals in Lahore. During 2011, special seminars on the treatment and management of contaminated or overexposed individuals were conducted by PNRA at government and private hospitals in various cities of Pakistan.

16.8 Public Awareness

A two pronged strategy for implementation of public awareness program has been adopted. First, as part of implementation of offsite emergency plans, the licensees are implementing site specific public awareness programs in areas around nuclear installations. Assistance from other local organizations such as local governments, educational institutions, etc., is sought for providing awareness about emergencies and response of the public. PNRA is also developing public awareness program at national level to educate the public through electronic and print media and other communication means. Subject specific written material has been prepared in the form of leaflets, pamphlets and other literature in Urdu, English and local language for distribution in the public. The literature covers brief introduction of the plant and its safety aspects; need of emergency planning and preparedness; implementation of protective actions and public response during emergency.

16.9 International Cooperation

Pakistan is participating in a number of international projects sponsored by the IAEA in the area of emergency planning and preparedness. Pakistan participates in IAEA ConvEx3 exercises which are conducted to test the accuracy, availability and accessibility of contact points, adequacy of response time and capability to exchange information through ENAC35 website. These exercises, especially the large scale ones like ConvEx3, helped in testing the planning and preparedness. The evaluations of the exercises at IAEA have shown that in most cases the system worked as planned and intended. Corrective measures were introduced where the response varied from the expected one.

IAEA has three contact point entries for Pakistan. These are Permanent Mission of Pakistan to the IAEA, NRECC of PNRA (designated as the National Warning Point for Pakistan) and the Pakistan Nuclear Regulatory Authority {as the National Competent Authority for Domestic Emergencies NCA (D) and for Emergency from Abroad NCA (A)}.

As a Contracting Party to the Convention on Early Notification of a Nuclear Accident, and to the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, Pakistan will exchange information or consider provision of assistance in case of a nuclear accident or radiological emergency in line with the provisions of the Conventions.

16.8.1 Response and Assistance Network of the IAEA (RANET)

IAEA Response and Assistance Network (RANET) is an integrated system established under the International Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency and is designed to provide international assistance to Member States to minimize the radiological consequences of accidents. Being the State Party to the Convention, Pakistan has registered National Assistance Capabilities (NAC) in the RANET at IAEA. During the reporting period, PNRA has arranged few meetings of RANET team members comprising officials from PNRA, PAEC and other national organizations and hospitals to evaluate RANET member capabilities against the requirements set by the IAEA.

In 2011, the RANET scope and areas of assistance were revised by IAEA. The expertise and resources were re-evaluated at PNRA and PAEC in light of the revised RANET documents. During the year 2012, PNRA arranged a national workshop on technical arrangements of activating/deploying national assistance capabilities under RANET. PNRA participated in IAEA RANET related workshops/meetings to review the areas of RANET, preparation of RANET documentations and proposals for the inclusion of new areas of assistance in RANET pool after the Fukushima Dai-ichi Accident.

Pakistan also offered to provide assistance under RANET to Japan after the Fukushima Dai-ichi accident.

Three PNRA Officers participated as experts in a workshop at the RANET Capacity Building Center at Fukushima from May 27-31, 2013, which involved a field exercise in Fukushima Prefecture. The Centre forms part of the IAEA's work to further strengthen international emergency preparedness and response, as guided by the *IAEA Action Plan on Nuclear Safety.*

Pakistan has, therefore, met the obligations of Article 16 of the Convention.

Article 17 – Siting

"The Contracting Parties shall take the appropriate steps to ensure that appropriate procedures are established and implemented:

(i) for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;

(ii) for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;

(iii) for re-evaluating as necessary all relevant factors referred to in subparagraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;

(iv) for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties, in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation."

17 Siting

The general criteria adopted for Siting is that the site characteristics that may affect the safety of the nuclear installation shall be investigated and assessed. Characteristics of the natural environment in the region that may be affected by potential radiological impacts in operational states and accident conditions shall be investigated. All these characteristics shall be observed and monitored throughout the lifetime of the installation. Pakistan Nuclear Regulatory Authority Ordinance 2001 clearly stipulates "No person shall commence construction of any nuclear installation without first obtaining an authorization for the purpose from the authority as may be prescribed by regulations".

It is ensured that licensees have developed adequate procedures and implemented for evaluating all relevant site related factors likely to affect the safety of a nuclear installation for its projected lifetime, and for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment. The continued safety acceptability of the nuclear installations has been ensured by re-evaluating all relevant site related factors likely to affect the safety of a nuclear installation for its projected lifetime.

17.1 Regulatory Requirements

Requirements for the Siting of a nuclear power plant are provided in PNRA Regulations named "Regulations on the Safety of Nuclear Installations – Site Evaluation (PAK/910) (Rev. 1)" which was promulgated in 2008.

In the evaluation of the suitability of a site for a nuclear installation, the following aspects are considered i.e., external events (natural origin or human induced) occurring in the region of the particular site, the characteristics of the site and its environment that could influence the transfer to persons and the environment of radioactive material that has been released and the population density and population distribution and other characteristics of the external zone in

so far as they may affect the possibility of implementing emergency measures and the need to evaluate the risks to individuals and the population.

In addition, Regulations for Licensing of Nuclear Installation(s) in Pakistan – PAK/909 also require provision of “No Objection Certificates” from local, provincial and other federal agencies. Site Evaluation Report (SER) is required at the time of site registration to ensure that the plant complies with the national rules and regulations regarding environment protection, land and water use, etc.

The characteristics of the natural and human induced hazards as well as the demographic, meteorological and hydrological conditions of relevance to the nuclear installation are monitored over the lifetime of the nuclear installation. The site characteristics are assessed on the basis of historical evidences, recorded data, site surveys, detailed investigations and analyses in line with international practices and proven engineering techniques. Generally, site specific data (recorded data) are used. Where site specific data is not available, data derived from historical information and /or data of similar site is used. The site is evaluated against natural hazards as well as man-made hazards (storage, transportation, etc.).

These evaluations are used to establish design bases for nuclear installations. Seismic activities, ground water, meteorological conditions are continuously monitored and instruments are installed at proposed sites.

On the basis of experience feedback from the accident at Fukushima Dai-ichi nuclear power plants in Japan, PNRA initiated a review of National Regulations related to the safety of nuclear power plants. The preliminary review identified that modification needs to be made in the “Regulations on the Safety of Nuclear Installations-Site Evaluation”; PAK/910 regarding Periodic re-evaluation and re-assessment of all hazards (natural or man-made).

17.2 Environmental Monitoring Program

According to the PNRA Regulations on Licensing of Nuclear Installations PAK/909, licensee has to submit Environmental Monitoring Program duly approved by Pakistan Environmental Protection Agency (PEPA). The Environmental Protection Agency is responsible for the prevention and control of environmental issues. A Nuclear Power Plant is covered by Pakistan Environmental Protection Act. Under this Act, the proponent of the Plant is to submit an Impact Assessment Report to the concerned Environment Protection Agency. The Nuclear Power Plants are designed, installed and operated with such stringent standards that the adverse impacts are taken care of in an inherent way. While designing the Chashma Nuclear Power Plants, the environmental assessments were integrated with feasibility studies to avoid any major adverse impact on the environment. To fulfill the requirements of the environmental act, the information about the site, project development, plant features and operation has been provided in this report. The guidelines regarding air emissions, liquid effluents and solid wastes are followed.

17.3 Nuclear Installation Sites

Pakistan has two NPPs sites i.e. Karachi and Chashma. KANUPP is situated at Karachi Site. Chashma site has two operating nuclear power plants namely; C-1, C-2 and two nuclear power plants C-3 and C-4 are under construction. PAEC is also identifying additional sites for NPPs in

line with the Government of Pakistan Energy Security Plan to increase nuclear energy share up to 8800 MWe by the year 2030.

17.3.1 KANUPP Site

KANUPP is located along the coastline of the Arabian Sea, near Karachi. Karachi site was re-evaluated in 2012 to find any potential hazard including earthquake, Tsunami, flooding etc. Following the IAEA safety guide SSG-9, various structural elements present in the region were critically studied and PGA was estimated. Safety and safety related SSCs of KANUPP are assessed against 0.2g instead of the original design basis of 0.1g.

PNRA also directed the licensee to re-evaluate the seismic potential of Murray Ridge situated about 75 km from the site. Licensee submitted a report regarding seismic potential and Tsunami analysis of Murray Ridge and historic instrumental seismicity along with other geophysical and drilling data which indicates that no tsunami event occurred along Murray ridge in recent and distant past. It can be concluded that site is safe against earthquake or Tsunami hazard.

KANUPP has been enlisted with Tsunami Early Warning System (TEWS) of Pakistan Meteorological Department (PMD) for dissemination of Tsunami warnings. A fresh study to analyze the Seismic Hazard along with Tsunami potential, as per new IAEA guidelines, for KANUPP site has now been completed concluding results similar to those obtained from earlier studies conducted for earthquake and tsunami potential. PAEC has completed re-assessment of tsunami hazard for KANUPP. Since the KANUPP site is not close to any forest or fire source therefore possibility of external fire is ruled out.

17.3.2 Chashma Site

There are four nuclear power plants at Chashma site; two (C-1 and C-2) are in operation while the other two (C-3 and C-4) are under construction. The size of the exclusion area, low population zone and population center distance have been fulfilled with respect to each plant individually. Furthermore, the licensee is committed to demonstrate that the simultaneous operation of multiple reactors at site will not result in total radioactive effluent releases beyond the allowable limits of national regulations.

The impact of all relevant site related factors on plant and on individuals, society and the environment has been evaluated and reassessed.

The phenomena of surge & seiche flooding, and tsunami are not relevant for the Chashma site and were therefore, not considered. The floods due to other natural causes as well as those due to failure of upstream dams have been analyzed. As the Chashma site is not a coastal site, therefore there is no threat from tsunami, while the multi dam failure has been considered and the site has been evaluated as safe against peak flood.

17.3.2.1 Re-evaluation of C-1 Site related factors

The operating licence for a nuclear facility is granted for ten years. For the licence renewal Periodic Safety Review of the C-1 NPP site 2010, comprehensive re-assessments of safety, including the environmental safety of the nuclear facility and the effects of external events on the safety of the facility, was submitted by the licensee and reviewed by PNRA. The assessments covered meteorology, hydrology, geology, seismology, population and use of land.

A detailed re-evaluation of the site related factors was also carried out after Fukushima Dai-ichi disaster.

17.3.2.2 Site Evaluation of C-2

C-2 is the second PWR in Pakistan located adjacent to C-1. Most of the site data and studies pertaining to C-1 have been utilized in the evaluation of C-2 site. C-2 submitted updated site related studies in chapter 2 of final safety analysis report (FSAR) comprised of demography, nearby industrial transportation and military facilities, meteorology, hydrologic engineering and geology, seismology and geotechnical engineering. PNRA reviewed FSAR on the basis of national regulations and international standards. C-2 was awarded Operation licence in February 2012 and is now in operation.

17.3.2.3 Site Evaluation of C-3

As per requirement of National regulations, an application was submitted for registration of the C-3 site along with Site Evaluation Report (SER). The format and contents of the SER includes geology and demography, nearby industrial, military and transport facilities, meteorology, hydrologic engineering, seismology and geotechnical engineering. Comprehensive technical reports for all Siting factors were provided. Based on PNRA requirements, “g” value was determined using Next Generation attenuation (NGA) relationships. C-3 prepared and submitted the Site Evaluation report in which it has been demonstrated that design response spectra envelopes the response spectra generated from “g” value calculated by using NGA. C-3 site was registered in February 2011. Applicant has been asked to perform Probabilistic Seismic Hazard Analysis (PSHA) for Chashma Site.

17.3.2.4 Site Evaluation of C-4

C-4 is the fourth PWR in Pakistan and located adjacent to C-3. Applicant submitted SER along with other documents to meet the PNRA requirements for site registration. Factors, such as population distribution in the area, future growth and industrial development, have been given special attention, while the meteorological and seismological data have been updated to cover the past decade. The site registration of C-4 delayed till the end of year 2011 due to the issue of C-4 exclusion area boundary outside licensee’s control. However, after resolution of this issue, C-4 site was registered on December 08, 2011.

17.3.2.5 Issuance of Construction Licence for C-3 and C-4

Construction of a nuclear power plant on a registered site can only begin if the licensee is successful in availing the construction licence from PNRA. Concrete pouring in the foundation or the installation of any portion of the permanent facility on the site is deemed to be the beginning of the construction. In this regard, C-3 & C-4 submitted the PSAR for review, approval and issuance of construction licence. The PSAR was reviewed by PNRA in the light of National regulations, Standard Review Plan, IAEA guidelines, experience feedback and applicable codes & standards. Based on the review and assessment of PSAR, construction licence was granted to C-3 and C-4.

The construction of C-3 and C-4 is under regulatory oversight program of PNRA and resident inspectors of PNRA conduct inspections according to approved inspection plan to ensure

compliance with PSAR and to verify that quality of the work is according to applicable codes and standards.

17.4 Verification by PNRA

The details of site verifications of C-1, C-2 and KANUPP performed at the time of construction have been reported in the previous reports.

17.5 Trans-boundary Effects

Pakistan is signatory of the Convention on “Early Notification of a Nuclear Accident” and the Convention on “Assistance in the Case of a Nuclear Accident or Radiological Emergency”. In case of an accident, Pakistan will respond according to the obligations of these Conventions with international community.

17.6 Monitoring at Sites

Mechanisms of hazard monitoring are in place which includes seismic instrumentation and meteorological instrumentation station for monitoring of wind and temperature distribution. Furthermore, there is close interaction with the national authorities regarding information on tsunami, flooding and precipitation. The sites are declared as no fly zones and closed interaction exists with the concerned aviation authorities for implementation of such arrangements. Radiological environmental monitoring programs are also in place at all sites.

Pakistan has, therefore, met the obligations of Article 17 of the Convention.

Article 18 - Design and Construction

"Each Contracting Party shall take appropriate steps to ensure that:

(i) the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence-in-depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;

(ii) the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;

(iii) the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface."

18 Design and Construction

Pakistan has taken appropriate steps to ensure that the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence in-depth) against the release of radioactive materials, with a view to prevent the occurrence of accidents and mitigate their radiological consequences should they occur; and that the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis.

18.1 Regulatory Requirements

The Regulations PAK/911 relate to the design and construction of nuclear installations. In addition, PAK/904, PAK/910, PAK/912, PAK/913 and PAK/915 also cover various aspects of design and construction of nuclear installations including the obligations of Article 18.

18.2 Implementation of Defence-in-Depth Concept

In striving to realize the objectives of its Nuclear Safety Policy, PAEC is committed to design, construct, operate and decommission its nuclear facilities with appropriate barriers and engineered safety features to prevent or minimize potential radioactive releases. In order to ensure the safety of nuclear installations, a multi-barrier concept is applied based on the Defence-in-Depth (DID) principle in the design and operation of nuclear installations. All structures, systems and components of nuclear installations are designed in consideration of internal and external hazards.

During first PSR of C-1, re-evaluation of plant design in relation to application of defense in depth was carried out as per IAEA Safety Report Series 46 "Assessment of Defense in Depth for Nuclear Power Plants". Review of defense in depth identified non-availability of symptom based emergency operating procedures, non-existence of severe accidents analysis, non-existence of SAMGs, loose parts monitoring, and safety features for mitigation of severe accidents. The non-existence of safety features for mitigation of severe accidents included cavity flooding system, reactor coolant system fast de-pressurization valve, and passive hydrogen re-combiners. In this regard, following actions are completed:

- Development of symptom based emergency operating procedures.

- Installation of loose parts monitoring system.
- Provision of fuel assemblies with anti-debris filters.

The passive hydrogen re-combiners will be installed, whereas, compensatory measures are being looked into in lieu of cavity flooding system and reactor coolant system fast de-pressurization valve for mitigating severe accidents.

The design of C-2 has given due consideration to the DID principle including features for prevention and mitigation of severe accidents such as cavity flooding system, fast depressurization valve and passive hydrogen recombiners. Provision of these features in C-2 is primarily based on the severe accident analysis, PSA and international experience feedback.

18.2.1 Prevention and Mitigation of Accidents

Nuclear installations are adequately designed and constructed for preventing, controlling and mitigating the consequences of anticipated operational occurrences, faulted conditions and design & beyond design basis accidents. Following features have been considered:

a. The reactor coolant pressure boundary is designed to have an extremely low probability of abnormal leakage and gross rupture. If any leakage of the reactor coolant takes place, it is promptly detected to prevent a severe accident. It is also designed to permit periodic inspection and testing to assess the pressure boundary integrity and leak-tightness.

b. The reactor core is designed to assure that power oscillations, which can result in conditions exceeding specified acceptable design limits, are not possible or can be readily suppressed.

c. The emergency core cooling system is designed to provide abundant emergency core cooling following any loss of reactor coolant at a rate such that any fuel damage that could interfere with continued effective core cooling is prevented.

d. In case of loss of offsite power, there is provision of house load operation. Cooling through natural circulation up to certain level is also considered. Emergency power sources are also available to accomplish safety functions in case of loss of offsite power. Consideration of station black out (complete loss of power scenario) is also taken into account.

e. The reactor containment is designed so that if any accident occurs, the radioactive material released from the reactor coolant pressure boundary is confined and reduced over a long period. A system is installed in the containment to control the concentration of any combustible gas as it accumulates inside. The safety features including the containment spray system are considered to lower the pressure inside the reactor containment and to eliminate radioactivity.

f. The reactor protection system is installed to sense accident conditions and maintain the reactor in a safe state by automatically initiating the operation of the reactor shutdown system and the engineered safety features. The reactor protection system is designed with redundancy, diversity, and independence to assure that no single

failure of any equipment or channel of the system results in loss of the intended safety functions.

g. The Safety Parameter Display System (SPDS) is installed in the main control room so that challenge to major safety parameters/functions is promptly recognized. The main control room is designed so that even if any serious accident occurs, the operator can safely remain to take the necessary post-accident actions. It is also possible in the separate emergency control room to monitor the essential operating parameters, the radioactivity inside and outside the reactor containment, the radiation releasing passage, and the radioactivity around the nuclear installation in order to sense the accident conditions and to take appropriate actions.

h. Mitigating features for severe accidents such as cavity flooding system, passive hydrogen recombiners, fast depressurization of containment, large dry containment, thickened containment base-mat, etc, are provided.

i. Provision of alternate water and power sources for long term removal of decay heat for design extension conditions.

j. The Emergency Control Centers are established to assess, coordinate and respond to any radiological emergencies including release of radioactive material.

18.2.2 Application of Proven Technologies

For all nuclear installations, it is ensured that technologies incorporated in design are proven by experience or qualified by testing or analysis.

18.3 Improvement in Design of Nuclear Installations

As part of relicensing, plant life extension, Fukushima re-assessments, improvements were made in the design of KANUPP. These include:

i. Change of Power Supply for the loads of Class IE Inverters, Feed water & Primary Charging System Instrumentation from 120V AC to 220V AC UPS.

ii. Auxiliary Power Supply to Multiplication Relay of the SBO Diesel Generator.

iii. Installation of Ball Valve in Compressed Air Supply system for Manual operation of DE-DG3 Diesel Generator.

iv. Provision of additional power supply to Essential buses through Emergency Core Cooling Diesel Generators.

v. Provision of a CPU By-Pass for Reactor Protective Channel.

vi. Provision to inject water into the reactor core via gravity, diesel engine driven pumps, fire water ring and fire engine.

vii. Provision to inject water into boilers through gravity, diesel engine driven pumps, fire water ring and fire engine.

viii. Anchoring/seismic support of local electrical control panels and their respective cable trays of Emergency Diesel Generators.

ix. Reinforcement of block masonry wall above DE-DG3 Diesel Generator Bus bar.

x. Provision of quick connection facility for 300 kW Mobile Generator with Plant Essential Power System.

xi. Installation of a New Diesel Generator in Tank Area to provide alternate power supply to 220V AC UPS and 24V DC UPS.

xii. Provision of alternate power supply to Emergency Injection valves from 220 VAC UPS system.

xiii. Provision to inject water into Vault cooling and Dousing spray system via Diesel engine driven pumps, fire water ring and fire engine.

The designs of C-1 and C-2 are comparable to other PWRs operating elsewhere in the world and meet the current safety requirements. However, as a result of operating experience, following modifications were made in the design of C-1 during reporting period:

a) Installation of loose part monitoring system.

b) Spent resin solidification in existing liquid solidification system.

c) Establishment of hot workshop with chemical decontamination system (for RCP and other contaminated major equipment).

d) Installation of online dose monitoring and management system in hot workshop.

e) Replacement of control system of fuel manipulator crane.

Following modifications in C-2 design have been implemented/ planned to be implemented during the reporting period:

I. Provision of pumps motor bearings and winding temperature of Component Cooling Water System (SCW) on Plant Computer System (CPC).

II. Installation of fire detection and alarm system in LR building.

III. Provision of instrument air supply to SFP gates rather than currently supplied service air to improve reliability.

IV. Provision of power supply to tap changer of auxiliary transformer from security bus bar of Turbine Systems.

V. Alternate (redundant) cooling water for main compressors.

Further, Surveillance Capsule Assembly Testing Facility (SCATF) and an Extended Storage Facility for low level radioactive waste are under construction at Chashma site.

18.4 Construction of Nuclear Installations

The activities related to construction and installations of C-3/C-4 are described below.

18.4.1 Review of Preliminary Safety Analysis Report (PSAR) of C-3/C-4

The applicant (PAEC) submitted combined Preliminary Safety Analysis Report (PSAR) of C-3 and C-4 to PNRA in October 2010 which was reviewed for award of construction licence. C-3/C-4 PSAR also included Level-1 PSA report, Severe Accident Analysis and certain improvements over C-1 design as were committed in C-2 PSAR. The regulatory review was aimed at verifying compliance with licensee commitments as well as conformance to the requirements of national regulations and applicable standards. PNRA prepared PSAR review plan extending over a period of six months. The review of C-3/C-4 PSAR was completed in April 2011. After

confirmation for conformance to Regulations, agreed codes & standards, C-3/C-4 PSAR was approved by PNRA and Construction Licences for C-3 and C-4 were granted in May 2011 and December 2011 respectively.

18.4.2 Construction Activities at C-3/C-4 Site

Construction and installation activities are performed by the qualified sub-contractors under the supervision of main contractor in line with the quality assurance program of the licensees. PNRA has inspected the QA programs of licensee, contractors, and subcontractors during the QA administrative inspections to verify that the elements of the QA programs are in line with the regulatory requirements. Civil work for the construction and installation of C-3 and C-4 is in progress. Construction milestone of dome placement for C-3 reactor building was accomplished in March 2013. Civil construction and equipment manufacturing of C-4 is progressing according to project schedule and the dome placement of containment is expected in April 2014.

18.4.3 Manufacturing in Pakistan

Some of the Safety Class-2 and Safety Class-3 mechanical equipment is being manufactured in Pakistan. The manufacturing activities are performed according to quality plans which describe the processes, testing, examination, reviews and checks in sequential order. Processes are required to be qualified according to the requirements of applicable codes and standards, and the standards of the client. Mock-ups are also prepared to qualify the processes. Manpower involved in manufacturing and testing is qualified according to the requirements of relevant regulations, codes and standards.

Initially PNRA licenced the manufacturer for manufacturing of Nuclear Safety Class-2 and Safety Class-3 mechanical components which was later upgraded to allow manufacturing of Nuclear Safety Class 1 equipment also. During the reporting period, PNRA has conducted more than two hundred (200) regulatory inspections during equipment manufacturing.

18.4.4 Manufacturing in China

Most of the equipment for C-3/C-4 is being manufactured in China. Only a few components for C-3/C-4 are being manufactured in Pakistan. The manufacturers were selected by the main contractor according to the procurement control requirements of its QAP. The QAP of main contractor was developed on the basis of Overall Quality Assurance Program of C-3/C-4 approved by PNRA. C-3/C-4 and PNRA conducted inspections and audits of the manufacturing facilities selected by the main contractor. PNRA selected safety significant equipment and components for regulatory inspections. These inspections included QA inspections during manufacturing, testing and qualification of the equipment.

During regulatory inspections, PNRA mainly focuses on verification of compliance with the regulatory requirements of codes & standards.

During reporting period, the regulatory inspection for manufacturing of C-3 RPV was conducted to witness the qualification tests (Mechanical & Metallographic) of C-3 RPV shell course.

18.5 Design Consideration of Human Factors and Man-Machine Interface for Operation

Please see Article 12 for details related to human factor and man-machine interface.

Pakistan has, therefore, met the obligations of Article 18 of the Convention.

Article 19 - Operation

"Each Contracting Party shall take the appropriate steps to ensure that:

(i) the initial authorization to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning program demonstrating that the installation, as constructed, is consistent with design and safety requirements;

(ii) operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation;

(iii) operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;

(iv) procedures are established for responding to anticipated operational occurrences and to accidents;

(v) necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;

(vi) incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body;

(vii) programs to collect and analyze operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organizations and regulatory bodies;

(viii) the generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal."

19 Operation

Pakistan has taken appropriate steps to meet the entire intent of Article 19 of the Convention. Authorization for initial operation is issued based on appropriate safety analysis, commissioning program and other documents demonstrating that the plant construction, installation and commissioning is consistent with design and safety requirements. Operational limits and conditions are derived from safety analysis, commissioning tests and operational experience to identify safe boundary for operation, and are updated as necessary. All activities are performed according to approved procedures.

Technical assistance on safety matters remained available for KANUPP from Canada under the auspices of IAEA. Designer and vendor support is also available for C-1 and C-2. Engineering

and technical support is available at all the plants and from sister organizations within PAEC. Operating experience feedback process remained in place to collect and analyze operating experience and to take appropriate actions. Experience was also shared with the international community at various fora such as IAEA IRS, NEWS, WANO, COG, etc.

19.1 Regulatory Requirements

PNRA issues licences to nuclear installations according to Regulations PAK/909. The licensing process has three stages, namely, site registration, issuance of construction licence and operating licence. PAK/909 enlists the documents to be submitted for each licensing stage. As required by the regulations, a nuclear installation can be operated only after a licence is issued by PNRA. The issuance of licence is based upon an appropriate safety analysis and a commissioning program demonstrating that the installation, as constructed, is consistent with design and safety requirements.

The PNRA Regulations PAK/913 establishes regulatory requirements for safety of nuclear installations during operation. These include requirements such as organization & staffing, quality assurance, emergency preparedness, fire safety, physical protection, operating experience feedback, qualification & training of personnel, commissioning program, plant operation, licensee event reporting system, notification of emergency & non-emergency events to the regulatory authority, radiation protection & waste management, testing & surveillance program and criteria for appointment to significant posts, etc.

PNRA Regulations PAK/912 set the requirements for quality assurance during operation. The licensee is required to establish a comprehensive quality assurance system that covers safety related activities during operation.

19.2 Initial Authorization to Operate

Permission to operate a nuclear installation is granted by PNRA in steps. After construction and equipment installation, commissioning program is reviewed and approved on the basis that it encompasses a systematic and integrated testing of systems and components in line with the design and safety requirements. This allows the licensee to start cold commissioning. During this phase, Final Safety Analysis Report (FSAR) is submitted, which demonstrates that the plant conforms to the safety requirements and the design is according to safety standards. If the safety review of FSAR is also satisfactory and other requirements of PAK/909 are fulfilled, the licensee is allowed to load fuel, perform low power tests, raise power and perform other tests as specified in the commissioning program. Upon satisfactory completion of the commissioning program, trial operation after attaining full power and submission of updated FSAR and other documents, an operating licence is issued. The operating licence is valid for a period of ten years subject to certain conditions. For the case of relicensing, PAK/909 prescribes a procedure for operation beyond design life. The required documentation for the purpose is an updated version of last Periodic Safety Review report, revised FSAR, PSA (Level-1plus) report, decommissioning program, etc.

KANUPP achieved 40 years of commercial operation on November 28, 2012. KANUPP also surpassed its previous record of the highest annual gross generation (586 million KWhr) in 2012. KANUPP underwent a long maintenance outage that started from December 2010 and

continued till May 2011. During this period, KANUPP completed all the major activities required by PNRA including safety assessment of main equipment such as steam generators and fuel channels. The activities performed by KANUPP were thoroughly assessed by PNRA to verify compliance with the regulatory requirements and to ensure that the plant can operate safely. KANUPP operating licence was extended to operate the plant till December 31, 2016.

According to regulatory requirements for renewal of operating licence every ten years, C-1 submitted Periodic Safety Review (PSR) report to PNRA for review and approval in 2010. The PSR safety factors included Plant Design, Actual Condition of Structures Systems and Components (SSCs), Equipment Qualification, Ageing, Deterministic Safety Analysis, Probabilistic Safety Analysis, Hazard Analysis, Safety Performance, use of experience from other plants & research findings, Organization and Administration, Procedures, Human Factor Impact, Emergency Planning and Radiological Impact on the Environment. The licensee submittals have been reviewed and the Operating Licence of C-1 is further extended up to December 2021 after approval of PSR.

In August 2011, C-1 completed its seventh operating cycle and the plant was shut down for refueling outage- 7 (RFO-7). During RFO-7, C-1 replaced the locally developed indigenized LPMS with the environmentally qualified LPMS. The 8th Refueling Outage was completed in first quarter of 2013. C-2 achieved its first criticality on 22 February 2011 and grid connection was made on 15 March 2011. Requisite tests were conducted at low power, power ascension and full power to verify plant performance and response as per design intent. Some selected tests were also witnessed by PNRA. As per requirement of Regulation for Licensing of Nuclear Installation(s) in Pakistan (PAK/909), C-2 was required to submit application for Operating Licence within six months after completion of commissioning. In compliance, C-2 submitted its application along with submissions required under the regulations. After completion of the activities as per regulatory requirements, operating Licence was issued on February 25, 2012. C-2 has undergone its first refueling outage in the first quarter of 2013.

19.3 Operational Limits and Conditions

The operational limits and conditions are developed to ensure that plant is operated in accordance with design assumptions and intent. KANUPP has developed operating policies and principles (OPPs) based on Canadian practice, that set operational limits and conditions derived from the safety analyses, tests, and operational experience. C-1 and C-2 developed technical specifications based on Standard Technical Specifications i.e. NUREG-0452 and NUREG-1431 respectively.

The OPPs of KANUPP have been revised on the basis of design modifications carried out in response to re-licensing beyond design life. Furthermore, the OPP would be updated, if required, as a result of Fukushima re-assessments and PSR.

Technical specifications of C-1 and C-2 are classified as, safety limits; limits on safety system settings; limits and conditions for normal operation & transient operational states and surveillance requirements. The Technical Specifications are based on actual plant design, safety analysis as well as operational experience.

In the event, where the operation of the plant deviates from the established operational limits and conditions, the appropriate remedial actions are also defined with the timeline. The licensee is required to undertake review and evaluation of safety limit violations and notify to the Authority in accordance with the established event reporting system. These operational limits and conditions are revised as and when required, if the safety analysis and PNRA regulations are amended or design modifications are carried out. External operating experience feedback is also used for modification in TS.

19.4 Operating Plant Procedures

All operation, maintenance, inspection and testing activities at nuclear installations are carried out in accordance with written, validated and approved procedures. The revision and updating of plant procedures is a continuous process at KANUPP, C-1 and C-2, and any revisions of these documents is made known to the operating personnel and other relevant entities.

19.4.1 Procedures for Operation

Procedures for normal operation of the plant are kept updated to reflect as built conditions of the plants. These procedures ensure that the plant is operated within the design envelope. The procedures for C-2 were validated during the commissioning tests with the involvement of plant operating staff. Plant personnel engaged in operation are trained and re-trained in the use of these procedures. Mechanism for continuous improvement of procedures on the basis of operating experience feedback is in place.

19.4.2 Procedures for Maintenance and Inspections

Maintenance, testing, surveillance and inspection programs are in place since the commencement of operation. The procedures are developed in line with the programs taking into consideration the design data, equipment specifications, quality assurance requirements, human factors considerations and ALARA principle. The procedures are subject to revision within the time period specified in each document or as needed.

19.4.3 Procedures for Modification Management

Approved procedures are in place to manage and control modifications in the plants. Both permanent and temporary modifications are controlled through these procedures. All the plants have established administrative procedures for updating documents within the stipulated time after modification, installation and testing. Responsibilities for the revision of all documents such as drawings, procedures, safety analysis report, operational limits & conditions, system description, training material including simulator training, vendor equipment manuals and spare parts lists are clearly assigned to ensure that up to date procedures are used in operation, maintenance and testing of the equipment and systems.

19.4.4 Emergency Operating Procedures

At KANUPP, Emergency Operating Procedures (EOPs) have been reviewed and validated through Table Top and Walk Through exercises after Fukushima Dai-ichi accident and were revised accordingly. Background analyses for development of Severe Accident Management Guidelines (SAMGs) were conducted and SAMGs are being revised based on results of the analyses.

At C-1 and C-2, Emergency Operating Procedures (EOPs) are available to mitigate the consequences of failures and to limit the core damage and radiation dose to the plant personnel and the public. C-1 and C-2 initially received Event Based EOPs from the vendor. According to the licensing requirement and international practice, complete set of Symptom Based EOPs (SEOPs) to deal with DBAs and BDBAs has been developed at C-1, whereas, SEOPs for C-2 are to be implemented in 2014 as an Operating Licence Condition. C-2 has developed SAMGs based on generic SAMGs which are being made plant specific based on additional background analysis and set-point calculations. SAMGs for C-1 will be finalized by end of 2014.

19.5 Reporting of Emergencies and Events

Requirements for reporting emergency conditions and abnormal events to the regulatory body are specified in PNRA Regulations PAK/913 which requires immediate notification of emergencies and significant events. Detailed event report in a prescribed format is required to be submitted by the licensee within 60 days of the events. These reports are analyzed by the PNRA to identify any additional corrective action which needs to be taken by the licensee. Root Cause Analysis (RCA) is normally a part of the detailed event reports.

19.6 Engineering and Technical Support

Nuclear Installations have their own engineering departments for technical support, whereas, engineering support is also available from other organizations within PAEC. Efforts are also made at all installations to acquire necessary engineering and technical support from national and foreign organizations.

Technical assistance on safety matters remained available for KANUPP from Canada under the auspices of IAEA in certain areas. KANUPP steam generators (SGs) life assessment was performed by CANDU Energy (CE, formerly AECL) after water lancing campaign in 2010-11. Subsequent inspection and water lancing of SGs will be conducted on periodic basis. Ten fuel channels were examined using Nondestructive Examination and Dimensional Gauging in accordance with CSA Standard as part of follow-up of FCIA. These tasks were carried out through a contract with AECL, Canada under an IAEA technical cooperation project on “Ensuring Long Term Safe Operation of KANUPP (LTSK) Phase II”.

Engineering support of vendor and designer is available for C-1 and C-2 under lifetime support agreement. In addition, support from vendor country organizations for maintenance, in-service inspection, refueling operations, etc., are also available. CNPO has signed an agreement with CNPGS to provide technical support regarding development of an effective ageing management program and training of plant personnel. At Chashma site, Directorate of technical support has been established which supports all operating plants at site in the areas of engineering, maintenance, radioactive waste, procurement, etc. This Directorate will also provide support to all future plants at the site i.e.C-3 and C-4.

For indigenous development of review and assessment of licensees’ submittals, PNRA has established its own technical support organization with technical competencies in areas of review and assessment, probabilistic safety analysis (PSA), accident analysis, system & structural analysis, materials & plant systems etc. PNRA has also signed various Memorandum of Understanding (MOUs) and training agreements with various national and international

technical organizations such as PSQCA, NSC, NNSA, VUJE (Slovakia), CHASCENT, etc. for technical support and personnel training. In addition, a project namely Safety Analysis Centre (SAC), has been established with the objective to develop expertise in mathematical modeling and simulation. This has added to the existing safety analysis capability of the TSO.

19.7 Program to Collect and Analyze Operating Experience

KANUPP interacts with COG, WANO and IAEA networks to exchange Operating Experience (OPEX) Feedback information. Information received from these networks is screened for relevancy and applicability at KANUPP by OEF Section and disseminated to relevant Divisions/Sections for review and follow-up actions. If the information is found applicable, it is incorporated through changes in procedures, systems or equipment, etc., in order to prevent recurrence of event at KANUPP. A number of changes in plant systems and procedures have been carried out on the basis of operating experiences. In the areas, where it has experience and expertise, KANUPP responds to the queries raised by other NPPs.

C-1 and C-2 have a system of analyzing national and international operating experience feedback which includes analysis of events at national level and events reported through the IAEA, WANO, QNPC, SNERDI, CNPO, etc. on various safety related issues as well as best practices. In addition, plants have access to the IAEA Incident Reporting System (IRS) and NEWS. Technical divisions of the plants are responsible for collecting and analyzing the operating experience from within the installations while directorate of technical support (DTS) is responsible for OEF from other installations (including non-nuclear installations) operating in the country. DTS also utilizes international experience feedback to identify necessary actions. As a member of WANO, C-1 and C-2 share plant operating experiences with other members. C-1 is using PCR system (Plant Condition Reports) for collection of information about low level events. The information collected is screened and trended for identification of vulnerable areas of the plant. For significant events, “Event Notification and Reporting (ENR) system is in place which requires event analysis to find causes and formulate corrective actions to prevent recurrences. Under revised Internal Operating Experience Program (IOEP) PCR and ENR systems will be integrated.

Based on external operating experience, the design of fuel assemblies have been modified with the provision of anti-debris filters. Similarly, based on operating experience of C-1, C-2 has modified its Surveillance Requirement related to testing of ventilation system for fuel building.

The operating experience of management issues, unexpected degradation, design weaknesses, external hazards not considered earlier, etc., is shared through peer reviews conducted within and outside Pakistan under auspices of IAEA, WANO, COG, etc.

PNRA verifies the licensee’s programs to collect and analyze operating experience through reviews of licensee event reports and by inspections. PNRA is the contact point to the IAEA International Reporting System (IRS) on Operating Experience Feedback and NEWS and the licensee’s relevant personnel have access to these systems. PNRA encourages the licensee to benefit from relevant international operating experience at other nuclear installations to enhance safety and reliability.

19.8 Incident Reporting to INES and IRS

Safety significant reportable events occurring at nuclear installations are reported to INES and IRS.

An INES Level 1 rating event involving leakage of heavy water from inlet feeder of fuel channel at KANUPP occurred in 2011 which was reported to IRS. The detailed report has been submitted recently.

Further, four reports related to events at C-1 and C-2 were reported to the IAEA-IRS during the reporting period. The events are rated at INES Level 0.

19.9 Safety Performance Evaluation

KANUPP has implemented Safety Performance Indicators program to monitor operational safety and is also contributing to WANO Performance Indicator Program.

CNPGS has also developed safety performance indicators (SPIs) program to monitor operational safety of the Station. The SPIs program is based on the guidelines of IAEA-TECDOC-1141,"Operational Safety Performance Indicators for Nuclear Power Plants". It may be mentioned that some of the previously developed SPIs have been merged and some additional SPIs have been included in the current program. Safety performance indicators trends are reported in Technical Reports of the plant.

19.10 Radioactive Waste Management

According to PNRA Regulations PAK/915, licensee is required to keep the generation of both activity and volume of radioactive waste to the minimum practicable by suitable design, operation and decommissioning of its facilities.

Installations have developed their own radioactive waste management programs and the waste is managed accordingly. Waste generation at nuclear installations is kept to a minimum by appropriate classification, segregation, treatment, conditioning and reuse and recycling of material. Treatment and conditioning of radioactive waste is carried out in accordance with the waste acceptance criteria. Procedures are in place for processing of radioactive waste so that the resulting waste, packaged or unpackaged, can be safely stored and retrieved from the storage facility for disposal. Discharges to the environment and environmental monitoring are performed according to established monitoring program and procedures.

In the original design of C-1, spent resin was stored in holdup tanks which had capacity for 10 years resin generation. The process has been modified to solidify the stored resin resulting in enhancement of storage capacity of spent resin.

CNPGS is establishing modular extended storage building at Chashma site for Low Level Waste (LLW) storage within the plant boundary. This design envisages over packed LLW solidified drums in concrete containers with concrete grouting, which will then be stored in extended storage building. This form of waste can then be transferred to a final disposal facility. The storage buildings will cater storage needs of all plants at Chashma site.

The national policy on control and safe management of radioactive waste has been issued. The policy covers control and management of all radioactive wastes generated in the country

irrespective of its origin. The policy serves as national commitment to address country's radioactive waste control and management issues in a well coordinated manner.

19.11 Spent Fuel Storage

At present, spent fuel of KANUPP is stored in the spent fuel storage located inside the service building. The Spent fuel storage bay is designed to store spent fuel safely until it is removed for interim storage or final disposal. After 40 years of operational life, spent fuel storage bay is approaching its capacity limit. Due to good chemistry in spent fuel storage bay and low oxidation rates, no ageing is visible on the structural material used in stacking the fuel bundles and the spent fuel under water which appears to be in good physical condition. To handle the current storage problem, storage capacity of existing spent fuel storage bay is being increased via a seismically qualified High Density Tray Racking (HDTR) System to operate the plant till 2016. In anticipation that plant operation may continue beyond 2016, KANUPP has planned to construct spent fuel dry storage facility within the plant premises for which preliminary design has been submitted to PNRA for review and approval.

At C-1 and C-2, storage facility is designed to meet storage requirements of spent fuel for fourteen Refueling Outages (RFO's) plus one full core. Similar provision of spent fuel storage is included in design of C-3 and C-4. Additional facility for spent fuel storage for Chashma site will be constructed at appropriate time.

Pakistan has, therefore, met the obligations of Article 19 of the Convention.

Annexure–I: Existing Nuclear Installations

	KANUPP	C-1	C-2	C-3	C-4
Status	Operating	Operating	Operating	Under Construction	Under Construction
Location	Karachi, Sindh	Chashma, Punjab	Chashma, Punjab	Chashma, Punjab	Chashma, Punjab
Type	CANDU	PWR	PWR	PWR	PWR
Capacity (gross)	137 MWe	325 MWe	340 MWe	340 MWe	340 MWe
First fuel loading	July 1971	November 22, 1999	Feb, 2011	-	-
First criticality	August 1971	May 03, 2000	Feb, 2011	Dec, 2015 (expected)	Dec, 2015 (expected)
Date of operation	December 1972	September 25, 2000	May, 2011	2016 (expected)	2017 (expected)

Annexure–II: C-3/C-4 Design Parameters

Gross electrical output	340 MWe
Number of primary loops	2
Reactor type	PWR
Fuel	Enriched uranium
Containment building	1 meter thick pre-stressed concrete walled circular building capped with concrete dome
Containment building diameter	36 m (inner)
Containment Design pressure	0.26 MPa
Coolant Design Pressure	17.16 MPa
Design Temperature of Coolant	350 ^{o}C
Coolant flow rate (Best Estimate)	16800 x 2 m^3/h
Fuel assemblies	121
RPV material	SA508 Class 3
Height of RPV	10.366 m
Active core height	2.9 m
Coolant operating pressure	15.2 MPa
Control rod assemblies	37
Steam Generators	2
Reactor coolant pumps	2
Turbine type	Horizontal tandem machine

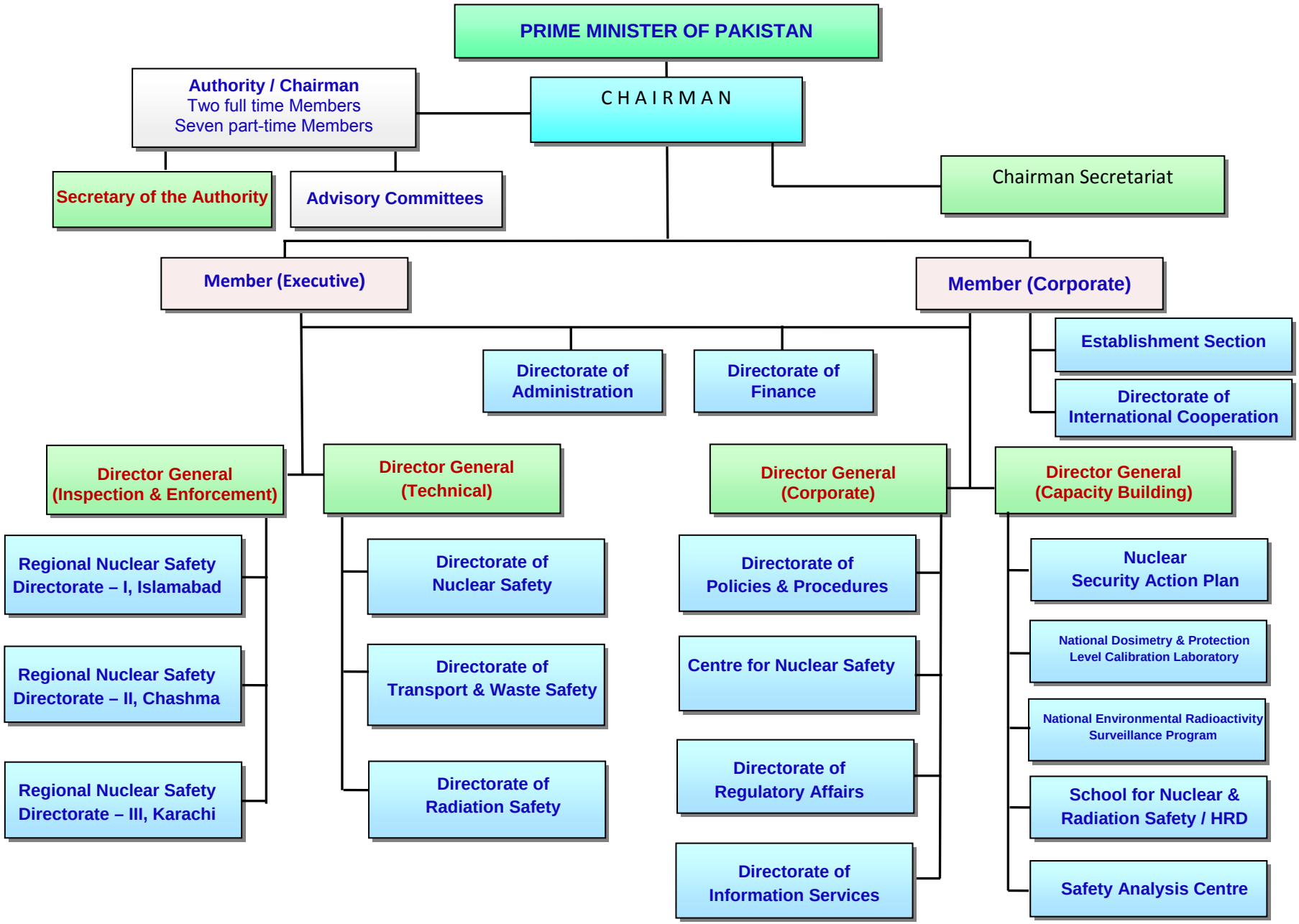
Annexure–III: Highlights of C-3/C-4 PSAR Review

Total Duration of the Review :	01-11-2010 to 29-04-2011
Total Number of Review Phases :	Two
➢ Review Phase 1 :	01-11-2010 to 15-11-2010
➢ Review Phase 2 :	22-11-2010 to 25-02-2011
PSAR Review Meeting :	25-04-2011 to 29-04-2011
➢ Total Number of Issues discussed	455
➢ Total Number of Issues Resolved	436
➢ Total Number of Issues Pending	19
Submission of Preliminary Safety Evaluation Report	25-05-2011
Issuance of Construction Licence	C-3 28-5-2011
	C-4 14-12-2011

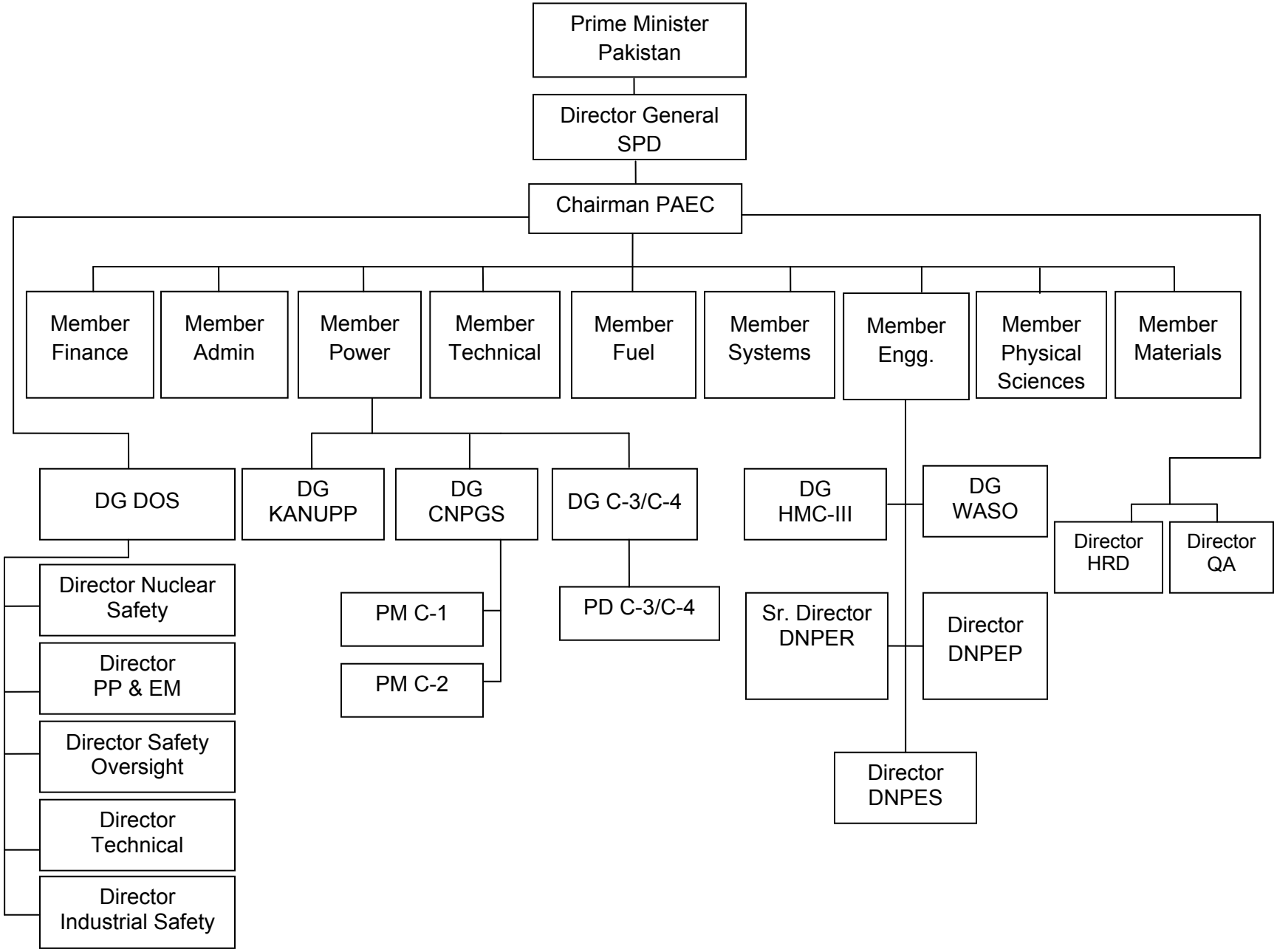
Annexure-IV: List of Issued Regulations

S. No	Title	S.R.O No.	Date of Publication
1.	Pakistan Nuclear Safety & Radiation Protection Regulations 1990 (Consolidated after incorporating all the amendments, replacements, additions and repeals till March 01, 2012)	S.R.O.957(I)/90	1990
2.	PNSRP (Treatment of food by ionizing Radiation) Regulations 1996.	S.R.O 166(I)/96	March 7, 1996
3.	Regulations on Licensing Fee by Pakistan Nuclear Regulatory Authority – (PAK/900)	S.R.O. 1150 (I) /2008	Nov 03, 2008
4.	Regulations on Transaction of Business of Pakistan Nuclear Regulatory Authority - (PAK/901)	S.R.O. 1116 (I) /2012	Aug 09, 2012
5.	Regulations on Radiation Protection (PAK/904) amended up to March 28, 2012	SRO 837(I)/2004	Oct 05, 2004
6.	Regulations for Licensing of Nuclear Safety Class Equipment and Components Manufacturers – (PAK/907)	S.R.O 910 (I)/2008	Sept 01, 2008
7.	Regulations for the Licensing of Radiation Facilities other than Nuclear Installations (PAK/908)	SRO 836(I)/2004	Oct 05, 2004
8.	Regulation for Licensing of Nuclear Installation(s) in Pakistan (PAK/909) revision 1	S.R.O. 798(I)/2012	June 29, 2012
9.	Regulations on the Safety of Nuclear Installations – Site Evaluation (PAK/910)	SRO 911 (I)/2008	Sept 01, 2008
10.	Regulation on the Safety of Nuclear Power Plant Design (PAK/911)	SRO 43(I)/2002	Jan 21, 2002
11.	Regulations on the Safety of Nuclear Power Plants-Quality Assurance (PAK/912)	SRO 900(I)/2003	Sept 11, 2003
12.	Regulations on Safety of Nuclear Power Plants-Operation (PAK/913) amended up to November 3, 2008	SRO 995(I)/2004	Dec 22, 2004
13.	Regulations on Management of a Nuclear or Radiological Emergency - (PAK/914)	S.R.O. 912 (I)/2008	Sept 01, 2008
14.	Regulations on Radioactive Waste Management (PAK/915) amended up to March 8, 2010	SRO 765(I)/2005	July 13 , 2005
15.	Regulations for the Safe Transport of Radioactive Material - (PAK/916)	S. R. O. 333 (I)/2007	April 20, 2007
16.	Regulations on the Safety of Nuclear Research Reactor(s) Operation (PAK/923)	S.R.O. 219(I)/2012	Feb 10 , 2012
17.	Pakistan Nuclear Regulatory Authority Enforcement Regulation (PAK/950)	S.R.O 1146 (1)/2010	Dec 23, 2010

Annexure–V: Organization Chart of Pakistan Nuclear Regulatory Authority



Annexure–VI: Organization Chart of Pakistan Atomic Energy Commission



Annexure–VII: PNRA Performance Indicators

Indicator 1. Acceptable level of safety being maintained by licensees

Indicator 2. Regulations and procedures in position and understood by licensees

Indicator 3. Continuous improvement of performance

Indicator 4. Appropriate actions taken to prevent degradation of safety and to promote safety improvements

Indicator 5. Human resource development, and competent and certified regulatory staff

Indicator 6. Legal provisions for enforcement, i.e., dealing with non-compliance or licence conditions violations

Indicator 7. Performance of functions in a timely and cost-effective manner

Indicator 8. Well established Quality Management System

Indicator 9. Availability of adequate resources for performing the functions

Indicator 10. Confidence of the operating organization

Indicator 11. Confidence of the general public

Indicator 12. Confidence of the Government.

Grading Scale for Performance Indicators

Green	Satisfactory
White	Minimally acceptable
Yellow	Needs improvement
Red	Unsatisfactory

Annexure– VIII: Dose Limits for Exposures Incurred From Practices

ANNUAL DOSE LIMITS FOR RADIATION WORKERS

Organ or Tissue	Dose Quantity	Dose Limit (mSv)
Whole body	Effective dose	20*
Lens of the eye	Equivalent dose	150
Extremities (hands and feet) or Skin (average dose over 1 cm^2 of the most highly irradiated area).	Equivalent dose	500

* In special circumstances, an effective dose of up to 50mSv in a single year provided that the average dose over five consecutive years does not exceed 20mSv/year.

ANNUAL DOSE LIMITS FOR APPRENTICES/STUDENTS (16 to 18 years of age)

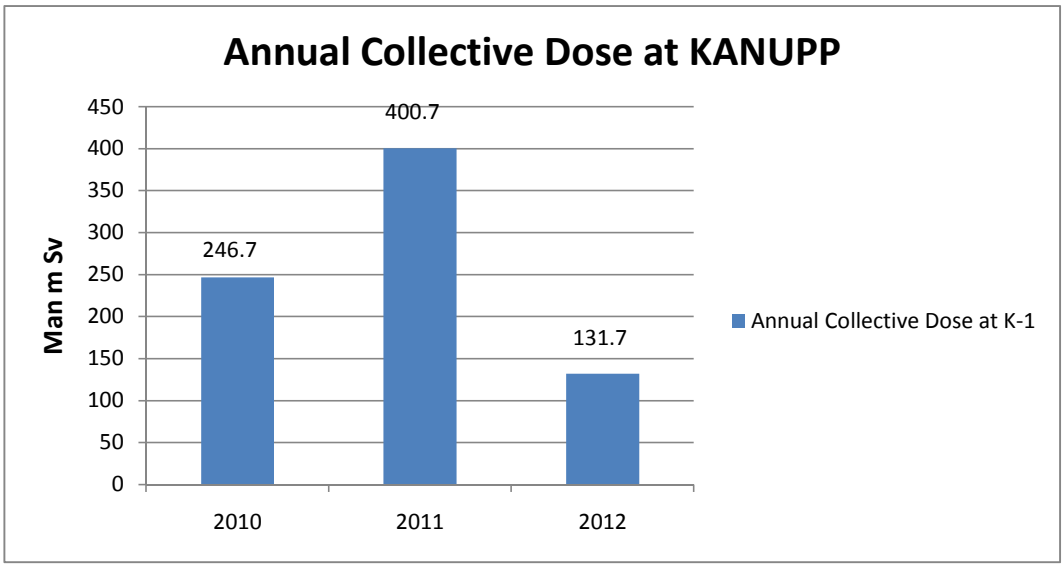
Organ or Tissue	Dose Quantity	Dose Limit (mSv)
Whole body	Effective dose	6
Lens of the eye	Equivalent dose	50
Extremities (hands and feet) or skin (average dose over 1 cm^2 of the most highly irradiated area).	Equivalent dose	150

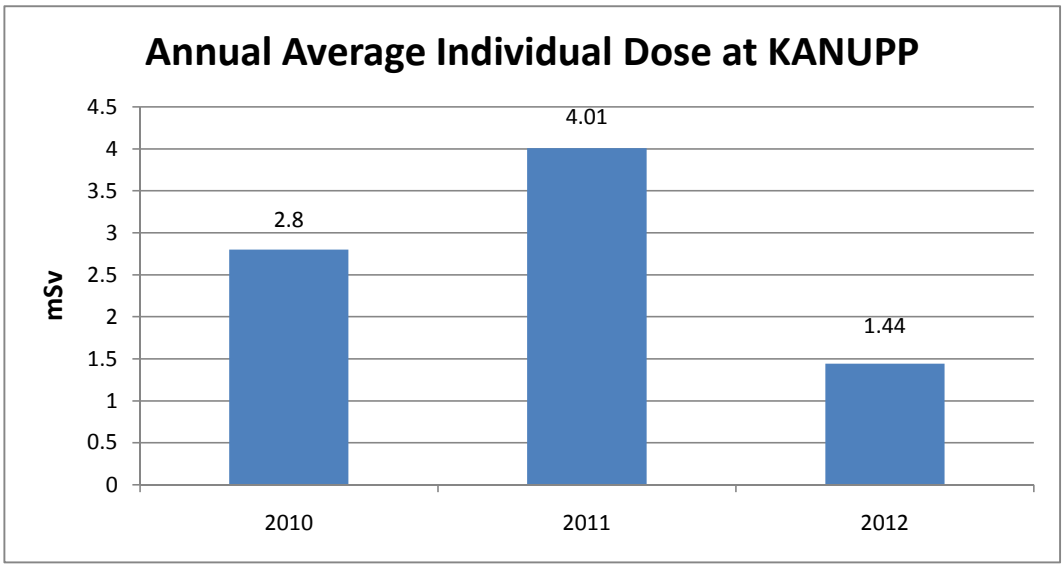
ANNUAL DOSE LIMITS FOR PUBLIC

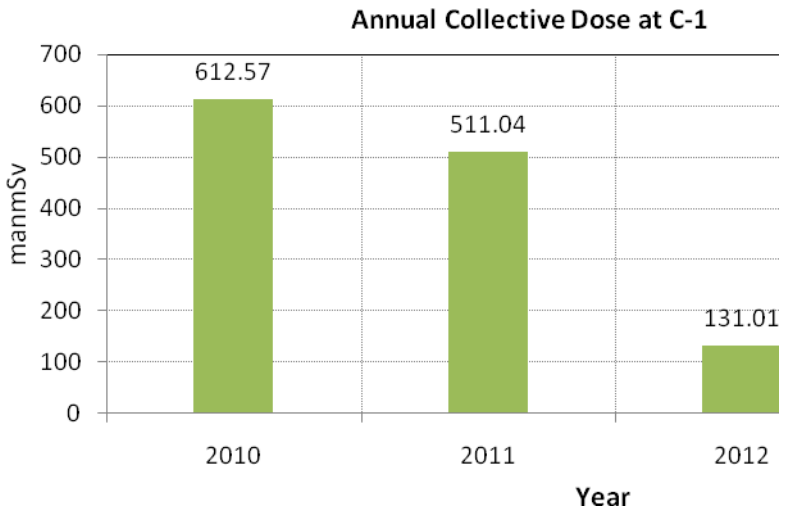
Organ or Tissue	Dose Quantity	Dose Limit (mSv)
Whole body	Effective dose	1*
Lens of the eye	Equivalent dose	15
Skin	Equivalent dose	50

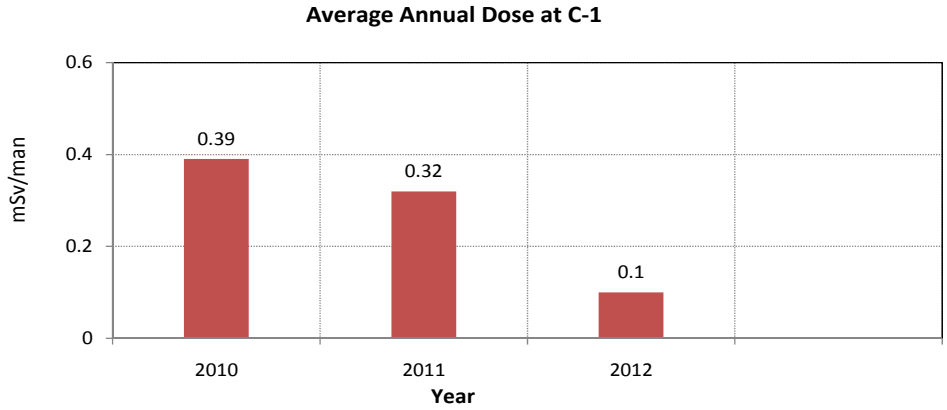
* In special circumstances, an effective dose of up to 5mSv in a single year provided that the average dose over five consecutive years does not exceed 1mSv/year.

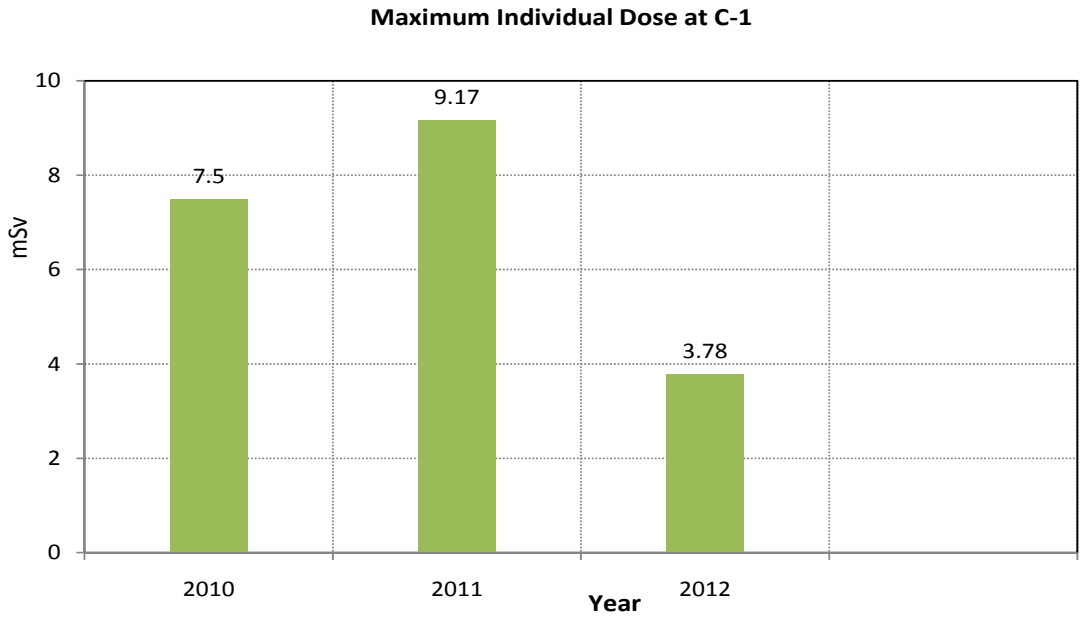
Annexure-IX: Occupational Exposures at Nuclear Installations,



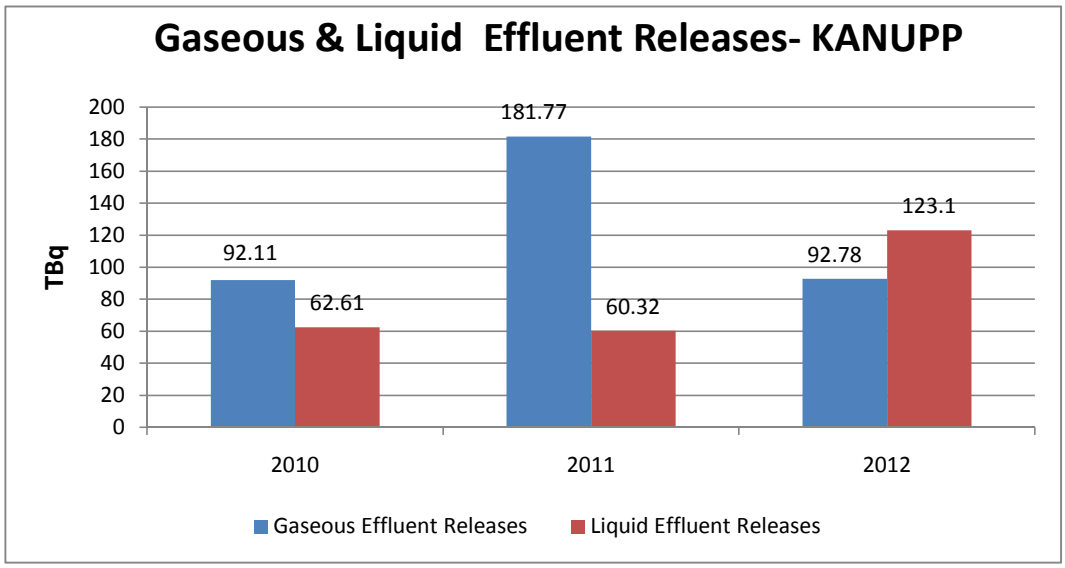


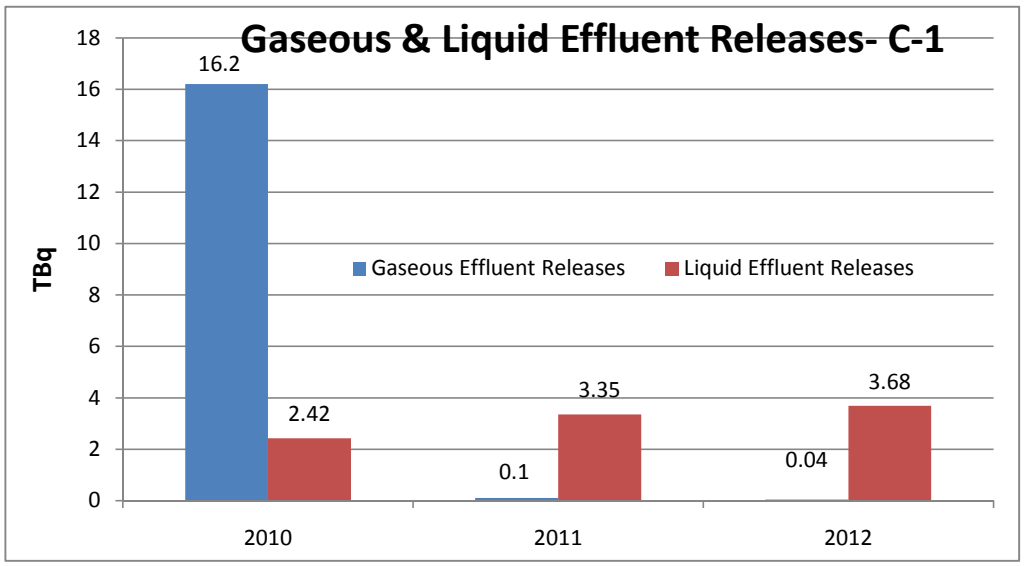

Annual Collective Dose at C-1
700
600
500
400
300
200
100
0
manmSv
612.57
511.04
131.01
2010
2011
2012
Year


Average Annual Dose at C-1
0.6
0.4
0.2
0
mSv/man
0.39
0.32
0.1
2010
2011
2012
Year

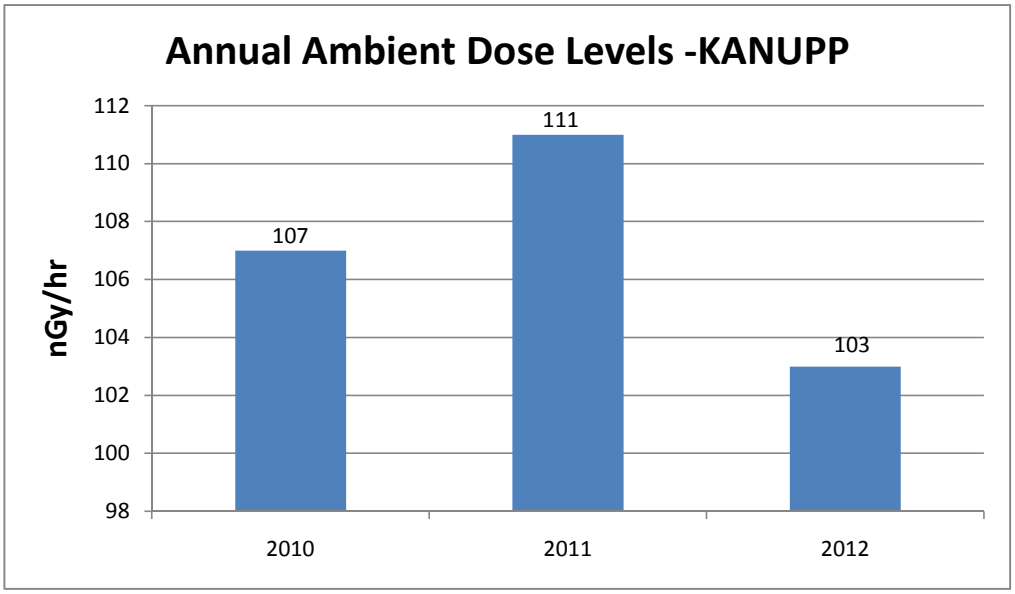

Maximum Individual Dose at C-1
10
8
6
4
2
0
mSv
7.5
9.17
3.78
2010
2011
2012
Year

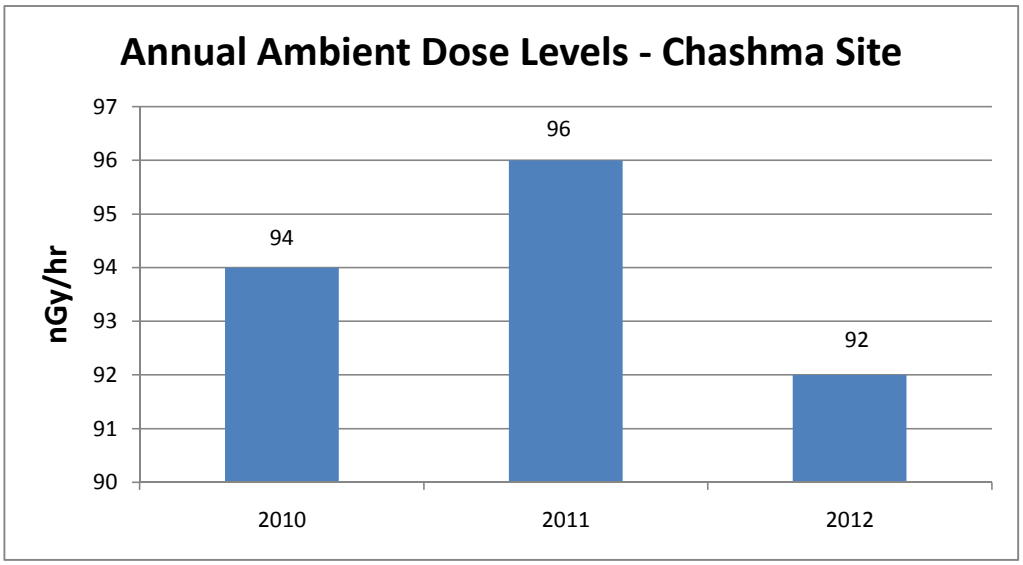
Annexure-X: Effluent Releases from KANUPP and C-1, 2010–12





Annexure-XI: Annual Average Ambient Dose Levels Around Nuclear Installations, 2010-12





Annexure–XII: Frequency of Various Drills/Exercises and Emergency Exercises Performed at KANUPP, C-1 and C-2

No.	Type of Drill/Exercise at KANUPP	Frequency
1	Emergency assembly drill	Yearly
2	Radiological Survey and environmental sampling activities drill	Quarterly
3	Assembly area Air sampling drill	8 weeks
4	Emergency class announcement drill	8 weeks
5	Notification of emergency to KANUPP emergency response organization (KERO) drill	Half yearly
6	Healthiness of VHF communication sets and response of relevant personnel at emergency facilities drill	8 weeks
7	Assembly emergency response team (ERT) drill	Yearly
8	Decontamination of contaminated injured persons drill	Quarterly
No.	**Type of Drill/Exercise at C-1 and C-2**	**Frequency**
1	Communication drill	Quarterly
2	Off-site projected dose assessment drill	Bi-Annual
3	Search and rescue operation drill	Bi-Annual
4	Medical treatment and personnel decontamination drill	Bi-Annual
5	Fire fighting drill	Annual (with on-site PEE/IEE)
6	On-site Emergency Exercise	Year next to year of IEE (2011/2014/2017/2020/2023/2026)
7	Off-site Emergency Exercise	Year next to year of On-site PEE (2012/2015/2018/2021/2024/2027)
8	Integrated emergency exercise	Once in every three years (2010/2013/2016/2019/2022/2025)
9	Environmental Radiation monitoring drill	Bi-Annual
10	Emergency class assessment drill	Quarterly
11	Post accident sampling and analyses drill	Bi-Annual

1. Emergency Exercises Performed at KANUPP

Sr. No.	Date of Exercise	Type of Exercise
1.	June 2010	Off-site Radiological Emergency drill
2.	December 2010	Site Emergency Exercise
3.	December 2011	Site Emergency Exercise
4.	December 2012	Annual Radiological Emergency Exercise (Integrated)
5.	June 2013	Site Emergency Exercise

2. Emergency Exercises Performed at CNPGS (C-1 and C-2)

Sr. No.	Date of Exercise	Type of Exercise
1.	November 2010	C-2 First Fuel Load Emergency Exercise
2.	November 2010	6th Integrated Emergency Exercise (C-1&C-2)
3.	December 2010	Makeup of the 6th Integrated Emergency Exercise
4.	January 2012	C-1/C-2 Joint Partial Emergency Exercise
5.	December 2012	CNPGS 1st Partial Off Site Exercise (Tabletop)

3. IAEA ConvEx Exercises

Sr. No.	Date of Exercise	Type of Exercise
1.	March 2010	Convex 2a
2.	September 2010	Convex 1a
3.	December 2010	Convex 2b
4.	March 2011	Convex 2b
5.	December 2011	Convex-2a
6.	July 2012	Convex 2b
7.	August 2012	Convex 1b
8.	September 2012	Convex-2a
9.	June 2013	Convex 2b

Annexure–XIII: Progress on Implementation of IAEA Nuclear Safety Action Plan

Pakistan actively participated in the development of the IAEA Nuclear Safety Action Plan and endorsed the finalized Action Plan during the IAEA Board of Governors Meeting and subsequently during the IAEA General Conference in September, 2011. A brief overview of the progress made by Pakistan in fulfillment of the IAEA Nuclear Safety Action Plan is presented below:

Safety assessments in the light of the accident at TEPCO's Fukushima Dai-ichi Nuclear Power Station

PNRA issued a directive to NPPs in August 2011 to conduct Self Assessments in the following areas:

i. Re-assessment of natural hazards.
ii. Availability of infrastructure necessary for plant safety such as AC power supply sources, heat sinks etc.
iii. Consideration of the station black-out condition (loss of all AC power) for longer duration.
iv. Re-evaluation of the design features provided at nuclear power plants for controlling and removing hydrogen such as hydrogen recombining system, hydrogen mixing system.
v. Re-evaluation of the Emergency Operating Procedures (EOPs) and Severe Accident Management Guidelines (SAMGs).
vi. Re-evaluation of the off-site Emergency Preparedness Plan (EPP) including Emergency Plan Implementing Procedures (EPIPs).
vii. Re-evaluation of the training program in the light of the Fukushima Dai-ichi accident with particular emphasis on the limitations of simulator.

A comprehensive plan "Fukushima Response Action Plan" (FRAP) was chalked out at PAEC for re-visiting design of nuclear power plants to re-assess safety margins in line with IAEA Nuclear Safety Action guidelines. PAEC Corporate office, reporting to Chairman PAEC , has been made responsible for periodical monitoring of the progress on measures being taken with regard to Fukushima Response Action Plans (FRAP) submitted by all three operating NPPs.

The implementation of FRAP is currently in progress. Progress on FRAP is being reviewed on a half yearly basis. Details of activities performed in response to Fukushima Dai-ichi accident are presented in Section 2.2.

International Peer Reviews

Pakistan is committed to improve the Peer Review process so that meaningful enhancement of nuclear safety at NPPs is achieved.

Self Assessment is a regular feature at PNRA and PAEC. PNRA has invited an IRRS Mission which has been accepted by IAEA. IRRS Mission is planned for April 2014. Self Assessment is presently being conducted in preparation of IRRS Mission using the IAEA updated SAT tool. A Pre-IRRS Mission was held at PNRA in March 2013 to finalize the scope and logistics for the mission.

Independent reviews and assessments are also performed by international expert organizations at Nuclear Power Plants periodically. C-2 is among a few plants which requested and hosted a WANO Pre-Start-up Peer Review during its commissioning phase in July 2010. Installation Verification Program was regarded as a strength, whereas several 'Area for Improvement' (AFIs) were pointed out. These were related to enhancement of preparedness of Human Resource in Operations and Maintenance Divisions, timely preparation of maintenance procedures, strengthening of self-assessment and human performance program etc. C-2 operating organization has started work on the AFIs. This included balancing of manpower between C-1 and C-2, implementation of self assessment program, request for a Technical Support Mission on Human Performance Improvement Program, preparation of ~ 400 maintenance procedures, procurement of five year spares etc.

A WANO Peer Review Mission was conducted at C-1 in April 2012. Following improvements are being implemented as outcome of WANO Peer Review which was conducted at C-1 in April 2012:

- Development and implementation of maintenance personnel training and re-training program.
- Establishment of Operational Decision Making process.
- Establishment of Equipment Performance Monitoring Program.
- Strengthening of Internal Operating Experience Program.
- Establishment of Self Assessment Program.
- Establishment of Integrated Improvement Plan.
- Establishment of Radioactive Waste Reduction Program.
- Development of Centralized Chemical Management Program.

A WANO Special Follow-up Review mission was conducted at KANUPP in April 2013. Following major improvements have been made as a result:

i. Distraction conditions in the MCR have been minimized.
ii. Procurement process for essential spare parts has been expedited.
iii. Plant performance indicator of emergency AC showing improvement.
iv. Changes of multiple to single access control helped in reduction of personal contamination control.

Following WANO Technical Support Missions were conducted for operating nuclear power plants during the reporting period:

I. Organizations for multiunit site. (Chashma)
II. Human performance program. (Chashma)
III. Use of Human performance tools. (Tokyo, Japan)
IV. Key Elements of System Health Monitoring Program. (Chashma)

Following WANO Technical Support Missions (TSM) were conducted during the reporting period at Karachi, Pakistan and Japan:

a. Supervisor Performance.
b. Reliability Centered Maintenance (RCM) and achieving high quality of maintenance in NPPs.
c. Single point vulnerability (SPV) and preventive maintenance optimization.
d. Proper use of error prevention tools in operations crews.

Emergency preparedness and response

PNRA directed the licensee to re-evaluate and strengthen emergency preparedness and response arrangements in the light of the Fukushima Dai-ichi accident considering unavailability of necessary infrastructure (bridges, roads, communication means, etc.) due to severe natural disasters and demonstrate implementation of emergency plans specially the evacuation aspects by involving the public. PNRA also required licensee to re-evaluate Emergency Planning Zones (EPZs). The licensee has submitted action plans for the re-assessment of emergency preparedness and response arrangements. The process for finalization of National Radiological Emergency Plan (NREP) has also been expedited after the Fukushima Dai-ichi accident.

The “Fukushima Response Action Plan” (FRAP) developed by the NPPs, has identified several areas for improvement in Emergency Preparedness and response. EPZs have been revised for all three operating NPPs. Provision of additional access routes to the site has been assessed at C-1/C-2. Personnel de-contamination facility in local hospital has been upgraded at Chashma.

At KANUPP, several improvements in Emergency preparedness and response have been made. Alternate Emergency Control Center (AECC) has been upgraded for use as command point in severe accident conditions. Availability of on-line Critical Parameter Display System (CPDS) in AECC has been ensured. Alternate communication means will be made available at plant and AECC. Quantity of Potassium Iodide (KI) tablets is being increased for population up to 16 Km of the plant.

National regulatory bodies

The monitoring of the regulatory performance of the PNRA is based on 12 strategic performance indicators. (Please refer to Annexure–XIII of Pakistan’s Fifth National Report for a list of Performance Indicators). As part of its self assessment program, PNRA has conducted an internal audit of activities of all its directorates to identify areas for improvement in order to enhance regulatory effectiveness. The conclusions drawn from the audit were implemented.

PNRA has reviewed its organizational capabilities and regulatory oversight processes in the light of Fukushima Dai-ichi accident. Review of organizational capability and regulatory oversight processes did not identify any immediate need for changes. However, review of the PNRA Management system revealed some areas for improvement and need for some additional documents.

PNRA revisited regulatory requirements for the safety of nuclear power plants to incorporate lessons learnt from Fukushima Dai-ichi accident. As a result, a number of recommendations

have been made which are under review process for revision of the regulations. Seven modifications have been proposed in PNRA regulations.

PNRA has invited IRRS Mission which is scheduled in April 2014.

Operating organizations

The safety of the plant is continuously assessed and verified during all phases of the plant life. This includes self assessments, reviews of plant safety performance by plant safety committee, quality assurance division, engineering department, health physics division and relevant operation and maintenance departments. Independent reviews and assessments by the PAEC corporate safety body and international reviews such as WANO peer review, OSART mission, etc. are conducted for reassurance of safety.

Although, Internal Peer Review (IPR) of the Operational Safety of NPPs at the corporate level was initiated in 2009, the scope was expanded after Fukushima Dai-ichi accident to include Design Safety and Emergency Preparedness & Response (EPR). A team of the specialists from diverse disciplines conducted Internal Peer Reviews of all three operating NPPs and recommended various actions and measures to assure nuclear safety. The Review Team also utilized 'IAEA Safety Action Plan' and 'ENSREG Stress Test specifications' as guidelines for the review of Fukushima Response Action Plan.

Internal Peer Review (IPR) of KANUPP was conducted in October 2011 by a team of 15 experienced professionals. The actions in Fukushima Response Action Plan of KANUPP (FRAP-K1) were found as progressing satisfactorily. Combined progress review of C-1 and C-2 on Fukushima Response Plan (FRAP-C12) was conducted in January, 2012 by a team of 7 specialists. There has been satisfactory progress on the actions identified. Review meetings are being conducted quarterly by Corporate Office to assess the progress on FRAP-K1 and FRAP-C12.

WANO Peer Review Mission was held in April 2012 at C-1, while a WANO Special Follow-up Review mission was conducted at KANUPP in April 2013.

IAEA Safety Standards

The PNRA regulatory framework is mainly based on the IAEA Safety Standards.

PNRA participates in the proceedings of various IAEA committees for the development of safety standards, such as the Nuclear Safety Standards Committee (NUSSC), Transport Safety Standards Committee (TRANSSC), Waste Safety Standards Committee (WASSC), Radiation Safety Standards Committee (RASSC), and the Committee on Safety Standards (CSS).

International legal framework

Pakistan is party to the Convention on early notification of a nuclear accident and the Convention on assistance in the case of a nuclear accident or radiological emergency along with the Convention on Nuclear Safety.

Pakistan has registered its National Assistance Capabilities (NACs) in IAEA Response and Assistance Network (RANET). Being the NCA designated under Early Notification and

Assistance Conventions, PNRA, with the consent of GoP, offered assistance to Japan, through IAEA, in areas of radiation monitoring, source search and recovery, environmental measurements and assessment and advice on emergency response.

Three PNRA Officers participated as experts in a workshop at the RANET Capacity Building Center at Fukushima from May 27-31, 2013, which involved a field exercise in Fukushima Prefecture. The Centre forms part of the IAEA's work to further strengthen international emergency preparedness and response, as guided by the *IAEA Action Plan on Nuclear Safety.*

PNRA has bilateral agreements between the National Nuclear Safety Administration (NNSA) of China and its technical support organizations regarding technical support in nuclear safety and capability development of regulatory staff. A similar agreement also exists between VUJE of Slovakia and PNRA.

Following major tasks have been performed with Canadian and Chinese under project “Ensure Long Term Safety of KANUPP (LTSK)-Phase II”

i) Steam Generator Sludge Lancing, Canada Energy Inc (former AECL).

ii) Turbine Generator Overhaul by M/S Harbin, China.

iii) Fuel Channel Condition Assessment by Canada Energy Inc (former AECL).

iv) Purchase of Impact Software for DRLs from Canada.

Capacity Building

PNRA has reviewed its organizational capabilities and regulatory oversight processes in the light of Fukushima Dai-ichi accident. Review of organizational capability and regulatory oversight processes did not identify any immediate need for changes.

PAEC is continually enhancing the capacity and quality of its key training institutes, such as Pakistan Institute of Engineering and Applied Sciences (PIEAS), Karachi Institute of Nuclear Power Engineering (KINPOE), and CHASNUPP Center for Nuclear Training (CHASCENT) as a matter of course. To meet the objective of expansion of the country’s Nuclear Power Generation Program, additional demand of trained/skilled human resource will be partially met from CHASCENT.

To impart maintenance and technical training to plant personnel, a full fledge Maintenance Training Building is being constructed with all major facilities. It is planned to purchase mock ups of plant’s equipment to provide better understanding to workers for improving their working skills.

At present, two training programs namely PGTP (Post Graduate training Program) and PDTP (Post diploma training program) are offered at CHASCENT. By strengthening training facilities and enhanced capacity, CHASCENT has almost doubled the recruitment for PGTP and PDTP batches. All the labs at CHASCENT are upgraded with state of the art equipment for imparting training to plant personnel.

Lessons learnt from Fukushima Dai-ichi are compiled and made part of the training program for personnel at the training organizations of both PNRA and PAEC.

Protection of people and the environment from ionizing radiation

After the Fukushima Dai-ichi accident, Pakistan started air sampling at various stations throughout the country. Results of the sampling analysis showed no anthropogenic radio nuclides and no change in background radiation level. An air analysis study was also performed by NERSP after the Fukushima Dai-ichi accident and the report is submitted to UNSCEAR.

To further ensure public protection, PNRA in coordination with Pakistan Customs restricted import of edible goods from Japan without radiation free certificate issued either by PNRA or Japan.

At NPPs, a number of improvements related to on-site and off-site emergency preparedness have been made as part of the FRAP implementation plan, e.g. Potassium Iodide (KI) tablets are being increased for population up to 16 Km of the plant at KANUPP. Personnel de-contamination facility in local hospital has also been upgraded at Chashma.

Under the National Environmental Radioactivity Surveillance Program (NERSP), three laboratories have been established at Islamabad, Karachi and Chashma. Gamma Spectrometry System (GSS) and Liquid Scintillation Analyzer (LSA) have been installed in the laboratory at Karachi and are now operational. GSS and LSA have also been installed at PNRA HQs Islamabad and Chashma to analyze low volume air samples.

Communication and information dissemination

PNRA is continuously working on improving the communication interface with the public. In this regard, limited scope public awareness program has been started with the involvement of educational institutes and universities throughout the country. PAEC has also identified certain actions for improving the communication interface with the public around nuclear installations during possible emergencies as part of the FRAP implementation plan.

After the Fukushima Dai-ichi accident, the NRECC was activated immediately and was receiving frequent updates from IAEA and websites of Japanese national and other related organizations. The information received was continually reviewed and daily/weekly summary of updates were uploaded at PNRA website.

PNRA briefed the representatives of Prime Minister Secretariat, NDMA, EPA, NGOs and other concerned Government departments about potential consequences of Fukushima Dai-ichi accident on Pakistan. PNRA also briefed media, as and when contacted.

Research and development

PNRA initiated research and development activities in view of enhancing regulatory capability with the involvement of national universities and also under IAEA Technical Cooperation Program and Coordinated Research Projects.

Accident Analyses of C-1 and C-2 were revisited after Fukushima Dai-ichi disaster based on insights from the Fukushima Dai-ichi accident and international operating experience.

Moreover, the activities related to the Development of Regulatory Probabilistic Safety Assessment (PSA) Model for C-1 progressed very smoothly. During the year, two coordination meetings and two review meeting were held under the project PAK/9/035. IAEA expert reviewed the task accomplished and identified the future tasks for the development of the model. Third review meeting was conducted in April 2013 to review the tasks completed and to discuss remaining activities. Furthermore, two officers from PNRA also participated in the meeting conducted by IAEA to review the lower power and shutdown PSA model developed by CHASNUPP NPP.

Research and development activities are being conducted at internationally reputable academic and research institutions of PAEC like PINSTECH and PIEAS in the nuclear and radiation safety related fields. After Fukushima Dai-ichi accident, research and development activities are more focused to various disciplines for enhancing safety at nuclear installations, with special emphasis on equipment qualification, severe accident analysis, and combustible gas control and filtered venting of containment. At the corporate level PAEC has conducted a number of studies related to extreme natural hazards (Tsunami, external and internal flooding, dam break, cyclones, high wind loadings and their combined effects). Capacity building for performing Probabilistic Seismic Hazard Analysis (PSHA) for nuclear installations is also in the process.

Annexure–XIV: List of Abbreviations

5NR	Fifth National Report
6NR	Sixth National Report
AAC	Alternate A.C
ABCC	Automatic Boiler Crash Cool Down
AC	Alternating Current
ACA	Apparent Cause Analysis
ACIURI	Advisory Committee for Improving Utility - Regulatory Interface
AdSec	Advisory committee on Nuclear Security
AECC	Alternate Emergency Control Center
AECL	Atomic Energy of Canada Limited
AFIs	Areas For Improvement
AGS	Annulus Gas System
AISC	American Institute of Steel Construction
ALARA	As Low As Reasonably Achievable
AMP	Ageing Management Program
ASTM	American Society for Testing and Materials
AOP	Abnormal Operating Procedures
AOT	Allowable Outage Time
APO	Assistant Plant Operator
ARP	Alarm Response Procedure
ASME	American Society of Mechanical Engineers
ATWS	Anticipated Transient without SCRAM
BDB	Beyond Design Basis
BDBA	Beyond Design Basis Accidents
BFW	Boiler Feed Water
C & I	Control and Instrumentation
C-1	Chashma Nuclear Power Plant Unit 1
C-2	Chashma Nuclear Power Plant Unit 2
C-3	Chashma Nuclear Power Plant Unit 3
C-4	Chashma Nuclear Power Plant Unit 4
CAA	Civil Aviation Authority
CANDU	Canada Deuterium Uranium
CAP	Corrective Action Program
CBI	Bypass inoperable safety system indication system
CDA	Capital Development Authority
CE	CANDU Energy
CDF	Core Damage Frequency
CERO	CHASNUPP Emergency Response Organization
CFVS	Containment Filtered Ventilation system
CHASCENT	CHASNUPP Centre for Nuclear Training
CHASNUPP	Chashma Nuclear Power Plant
CJLC	Chashma Jhelum Link Canal
CNPGS	Chashma Nuclear Power Generating Station

CNPO	China Nuclear Power Operation Technology Corporation
CNS	Convention on Nuclear Safety
COG	CANDU Operators Group
COMTEX	Communication Test Exercises
ConvEx	Convention Exercise
CPC	Plant Computer System
CPDS	Critical Parameter Display System
CPI	Chemistry Performance Indicator
CRP	Coordinated Research Project
CSA	Canadian Standards Association
CSRC	Corporate Safety Review Committee
CSS	Commission on Safety Standards
CPU	Central Processing Unit
DB	Design Basis
DBA	Design Basis Accidents
DBE	Design Basis Event
DC	Direct Current
D G	Director-General
DFO	Diesel Fuel Oil
DID	Defence-in-Depth
DMW	De-mineralized Water System
DNPS	Directorate of Nuclear Power Safety
DNS	Directorate of Nuclear Safety, (PAEC)
DOS	Directorate General of Safety, (PAEC)
DQA	Directorate of Quality Assurance
DNPER	Directorate of Nuclear Power Engineering, Reactor
DSW	Dousing Spray Water system
DTS	Directorate of Technical Support
EC	European Commission
ECC	Emergency Control Center
ECCS	Emergency Core Cooling System
EDG	Emergency Diesel Generator
EFW	Emergency Feed Water
EIA	Environmental Impact Assessment
EM	Environmental Monitoring
ENAC	Emergency Notification and Assistance Convention
ENR	Event Notification Report
ENSREG	European Nuclear Safety Regulators Group
EOPs	Emergency Operating Procedures
EPA	Environmental Protection Agency
EPREV	Emergency Preparedness Review Mission
EPZ	Emergency Planning Zone
EPIP	Emergency Plan Implementing Procedure
EPP	Emergency Preparedness Plan

ERO	Emergency Response Organization
EQ	Equipment Qualification
ERT	Emergency Response Team
EST	Emergency Sump Transfer
EWI	Emergency Water Injection system
FCIA	Fuel Chanel Integrity Assessment
FIJW	Forced Emergency Injection Water system
FLO- MEST	Front Line Officer- Mobile Expert Support Team
FLP	Fuel Load Permit
FRAP	Fukushima Response Action Plan
FRI	Fuel Reliability Indicator
FSA	Focused Self Assessment
FSAR	Final Safety Analysis Report
FSTS	Full Scope Training Simulator
FY	Fiscal Year
GB	Great Britain
GIK	Ghulam Ishaq Khan Institute of Engineering
GIS	Gas Insulated Switchgear
GSS	Gamma Spectrometry System
H_2	Hydrogen
HDTR	High Density Tray Racking
HE	Human Error
HELB	High Energy Line Break
HEP	Human Error Probabilities
HFE	Human Factor Engineering
HMC	Heavy Mechanical Complex
HMI	Human Machine Interface
HPD	Health Physics Division
HRA	Human Reliability Analysis
HRD	Directorate of Human Resource Development
HSI	Human System Interface
IAEA	International Atomic Energy Agency
ICAP	Integrated Corrective Action Plan
ICD	Directorate of International Coordination
I&E	Inspection and Enforcement
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronic Engineers
IG	Imperial Gallon
IJW	Emergency Injection Water system
IMS	Integrated management system
INES	International Nuclear and Radiological Event Scale
INEX	International Nuclear Emergency Exercise
INPO	Institute of Nuclear Power Operations

INSC	Instrument for Nuclear Safety Cooperation
IOEP	Internal Operating Experience Program
IPR	Internal Peer Review
IPP	Independent Power Producers
IPSART	International PSA Review Team
IPTC	In-Plant Training Center
IRRS	Integrated Regulatory Review Services
IRRSAT	International Regulatory Review Self Assessment Tool
IRS	Incident Reporting System
ISC	Irradiation Surveillance Capsules
ISD	Directorate of Information Services
ISI	In-service inspection
ISO	International Organization for Standardization
JNRC	Jordan Nuclear Regulatory Commission
KANUPP	Karachi Nuclear Power Plant
KESC	Karachi Electric Supply Corporation
KFSAR	KANUPP Final Safety Analysis Report
KI	Potassium Iodide
KINPOE	Karachi Institute of Nuclear Power Engineering
KINS	Korea Institute of Nuclear Safety
KM	Knowledge Management
KOFREP	KANUPP off-site radiological emergency plan
KONREP	KANUPP On-site radiological emergency plan
KW	Kilo Watt
LAN	Local Area Network
LBB	Leak before Break
LCO	Limiting Condition for Operation
LLW	Low Level Waste
LOCA	Loss of Coolant Accident
LOOP	Loss of Off-site Power
LPMS	Loose Part Monitoring System
LPSW	Loss of Process Salt Water System
LSA	Liquid Scintillation Analyzer
LTSK	Long Term Safe Operation of KANUPP
LUMS	Lahore University of Management Sciences
MCR	Main Control Room
MELCOR	Computer code to model the progression of accidents in nuclear reactors
MET	Meteorological
MOU	Memorandum of Understanding
MS	Management System
MRML	Mobile Radiological Monitoring Laboratory
MSL	Mean Sea Level
NAC	National Assistance Capabilities

NAEC	Nigerian Atomic Energy Commission
NCA	National Competent Authority
NCA(A)	National Competent Authority (NCA) for an emergency Abroad
NCA(D)	National Competent Authority (NCA) for an emergency Domestic
NCNDT	National Centre for Non-Destructive Testing
NDCL	National Dosimetry and Protection Level Calibration Laboratory
NDMA	National Disaster Management Authority
NDT	Non Destructive Testing
NEPRA	National Electric Power Regulatory Authority
NERS	Network of Regulators of countries with Small Nuclear Programs
NEMS	Nuclear Emergency Management System
NERSP	National Environmental Radioactivity Surveillance Program
NEWS	Nuclear Events Web Based System
NGA	Next Generation Attenuation
NIAB	Nuclear Institute for Agriculture and Biology
NSAP	Nuclear Security Action Plan
NNSA	National Nuclear Safety Administration
NUST	National University of Science and Technology
NNR	National Nuclear Regulator
NOC	No Objection Certificate
NORM	Naturally Occurring Radioactive Materials
NPP	Nuclear Power Plants
NRECC	National Radiation Emergency Coordination Centre
NREP	National Radiological Emergency Plan
NSAP	Nuclear Security Action Plan
NSC	Nuclear Safety Centre
NSD	Directorate of Nuclear Safety (PNRA)
NSLD	Nuclear Safety and Licensing Division
NTDS	National Transmission and Dispatch Company
NUML	National University of Modern Languages
NUSCC	Nuclear Safety Standards Committee
NWP	National Warning Point
OBE	Operating Basis Earthquake
OE	Operating Experience
OECD	Organization for Economic Cooperation and Development
OEF	Operational Experience Feedback
OGRA	Oil and Gas Regulatory Authority
OIC	Organization of Islamic Conference
OIRs	Operation Inspection Reports
OPEX	Operational Experience
OPP	Operating Policies and Procedures
OQAP	Overall Quality Assurance Program
OSAG	Operational Safety Analysis Group
OSART	Operational Safety Review Team

OSRC	Operational Safety Review Committee
PAEC	Pakistan Atomic Energy Commission
PARs	Passive Autocatalytic Recombiners
PARR-I	Pakistan Research Reactor – I
PARR-II	Pakistan Research Reactor – II
PCR	Plant Conditions Reports
PDMA	Provincial Disaster Management Authority
PDT	Post Diploma Training
PDTP	Post Diploma Training Program
PEPA	Pakistan Environmental Protection Agency
PEPCO	Pakistan Electric Power Company
PGA	Peak Ground Acceleration
PGTP	Post Graduate Training Program
PIE	Postulated Initiating Events
PIEAS	Pakistan Institute of Engineering and Applied Sciences
PIM	Pakistan Institute of Management
PINSTECH	Pakistan Institute of Nuclear Science and Technology
PIRs	Periodic Inspection Reports
PLC	Programmable Logic Control
PM	Preventative Maintenance
PMI	Pakistan Manpower Institute
PMD	Pakistan Meteorological Department
PORV	Pressure operated relief valves
PMRV	Pressurized Motorized Throttle valve
PNRA	Pakistan Nuclear Regulatory Authority
PPD	Directorate of Policies and Procedures
PP&EM	Directorate of Physical Protection and Emergency Management
PPIL	Physical Protection Interior Labs
PPRA	Public Procurement Regulatory Authority
PROSPER	Peer Review of Operational Safety Performance Experience
PSA	Probabilistic Safety Assessment
PSAR	Preliminary Safety Analysis Report
PSDP	Public Sector Development Program
PSF	Performance Shaping Factors
PSHA	Probabilistic Seismic Hazard Analysis
PSI	Pre-Service Inspection
PSQCA	Pakistan Standards and Quality Control Authority
PSR	Periodic Safety Review
PTA	Pakistan Telecommunication Authority
PWI	Pakistan Welding Institute
PWR	Pressurized Water Reactor
QA	Quality Assurance
QA&AD	Quality Assurance and Assessment Division
QAD	Quality Assurance Division

QAP	Quality Assurance Program
QAM	Quality Assurance Manual
QAU	Quaid-e-Azam University
QNPC	Qinshan Nuclear Power Company
RAD	Directorate of Regulatory Affairs
RANET	Response and Assistance Network
RAIS	Regulatory Authority Information System
RAS	Regional Asia
RASIM	Radiation Safety Management System
RASSC	Radiation Safety Standards Committee
RCA	Root Cause Analysis
RCA	Radiation Controlled Area
RCC-M	Design and Construction Rules for Mechanical Components of PWR Nuclear Island (French Code)
RCF	Regional Cooperation Forum
RCO	Radiation Control Officer
RCP	Reactor Coolant Pump
RFO	Refueling Outages
RFW	Reserve Feed Water System
RLO	Relicensing Outage
RMWO	Radioactive Waste Management Officer
RNSD	Regional Nuclear Safety Directorate
RPV	Reactor Pressure Vessel
RSD	Directorate of Radiation Safety
RSIL	Research Society of International Law
RT	Radiographic Testing
RX	Reactor Building
RWP	Radiation Work Permit
SAC	Safety Analysis Centre
SAF	Auxiliary Feed Water System
SAMGs	Severe Accident Management Guidelines
SAP	Self Assessment Program
SAR	Safety Analysis Report
SARIS	Self-Assessment of Regulatory Infrastructure for Safety
SARRP	Safety Analysis Report Review Program
SAT	Self Assessment Tool
SBLOCA	Small Break Loss of Coolant Accident
SBO	Station Blackout
SCATF	Surveillance Capsule Assembly Testing Facility
SCG	Depressurize Containment System
SCW	Component Cooling Water System
SDV	Screening Distance Value
SED	Site Emergency Director
SEOP	Symptom based Emergency Operating Procedures

SER	Site Evaluation Report
SFP	Spent Fuel Pool
SG	Steam Generator
SIS	Safety Injection System
SIT	Structural Integrity Test
SLD	Safety and Licensing Division
SNERDI	Shanghai Nuclear Engineering Research and Design Institute
SNRS	School of Nuclear and Radiation Safety
SOER	Significant Operating Experience Reports
SOP	Standard Operating Procedures
SPD	Strategic Plans Division
SPDS	Safety Parameter Display System
SPI	Safety Performance Indicators
SRC	Reactor Coolant System
SS	Shift Supervisor
SSC	Structures Systems and Components
SSE	Safe Shutdown Earthquake
SSW	Standby Salt Water System
STI	Secretariat Training Institute
TC	Technical Cooperation
TAEK	Turkey Atomic Energy Commission
TEPCO	Tokyo Electric Power Company
TEWS	Tsunami Early Warning System
TLD	Thermo Luminescent Dosimeter
TNA	Training Need Assessment
TRANSCC	Transport Safety Standards Committee
TSC	Technical Support Centre
TSO	Technical Support Organization
UHS	Ultimate Heat Sink
UPS	Un-interrupted Power Supply
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USNRC	United States Nuclear Regulatory Commission
UT	Ultrasonic Testing
VCW	Vault Cooling Water
VSS	Vehicle Service Station
VUJE	Nuclear Power Plant Research Institute, Slovak Republic
WANO	World Association of Nuclear Operators
WAPDA	Water and Power Development Authority
WASCC	Waste Safety Standards Committee
WSD	Directorate of Transport and Waste Safety
WUH	Ultimate Heat Sink System