Collaboration in Nuclear Science and Technology: Prospects and Challenges for Pakistan's Regulator

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Abstract

A nuclear regulator cannot be complacent due to the peculiar nature of its job. The regulator continuously strives to be the best and a role model for others. However, this persistent striving for excellence requires several factors. Among these factors, the most important is the collaboration with its peers and other organizations at the international level, in the sharing of knowledge, information, feedback, experience, and capacity building. Pakistan, being the pioneer member of the International Atomic Energy Agency (IAEA), has a long history of cooperation with the international community. Pakistan Nuclear Regulatory Authority (PNRA) was established in 2001 as the national nuclear regulatory authority, in compliance with the Convention on Nuclear Safety (CNS) - through the promulgation of PNRA Ordinance, i.e., Ordinance III of 2001. It was assigned the responsibility to regulate all nuclear installations, radiation facilities, and associated activities in Pakistan for the protection of workers, the general public, and the environment. PNRA, like other international Regulatory Bodies (RBs) in the nuclear domain, has developed mechanisms for international collaboration to bring its performance and processes at par with the international standards. PNRA regularly

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participates in global nuclear forums and bilateral as well as multilateral arrangements, assigns experts to participate in international activities, and also presents itself for peer review. Despite these efforts, Pakistan faces certain challenges related to international cooperation. Alongside, PNRA also faces several complications while achieving its mission and vision. These primarily include limited access to codes and standards for ensuring nuclear safety, technology denials, and international emphasis on Pakistan's defense initiatives, which sometimes limits the visibility of its efforts and achievements in the peaceful applications of nuclear technology. Against this backdrop, this paper offers two sets of proposals to overcome these challenges, both at the regulatory and policy level.

Keywords: Global Nuclear Collaboration, International Cooperation, Pakistan Nuclear Regulatory Authority, Inclusive Partnership, Multilateralism.

Introduction

Over the years, the global nuclear sector has undergone significant changes, placing greater importance on international cooperation to enhance nuclear safety and security and promote the peaceful application of the nuclear field. Among other key players in this field, Nuclear Regulators hold a crucial responsibility of ensuring nuclear safety and security while encouraging collaboration with their counterparts in other nations. However, at the same time, the need for a common platform to discuss mutually affecting issues such as nuclear safety, security, or preparing against a nuclear accident or radiological emergency, is undeniable.

At the global level, the IAEA serves as a collaborative platform for Member States, facilitating cooperation in the nuclear sector. Its mission is to promote the safe, secure, and peaceful utilization of nuclear technologies. Whether sharing best practices or providing support during nuclear

accidents or radiological emergencies, the IAEA remains actively engaged with its Member States. For Pakistan, a country with a growing nuclear energy program and a pioneer member of the IAEA, international cooperation is a necessary instrument for promoting activities at the international fora. Nevertheless, engaging in global collaboration presents both opportunities and challenges for Pakistan.

As one of the first countries to implement "Atoms for Peace,"[1] Pakistan's nuclear program was initiated in the 1960s and has gradually evolved from operating a single research reactor to developing several nuclear power reactors, and from limited applications to its broader use in medicine, industry, and agriculture. Today, nuclear technology is widely utilized in various sectors of Pakistan. While Pakistan has achieved significant milestones in nuclear technology, its journey has been marked by significant challenges, such as the need for updated infrastructural build-up, qualified and trained manpower.

Nevertheless, Pakistan's national nuclear regulator, the PNRA, is committed to ensuring that nuclear safety remains a top priority while utilizing nuclear technology for civilian purposes. In the contemporary interconnected world, PNRA has realized the importance of global collaboration among nuclear regulatory authorities. It understands that a collective approach is essential to addressing shared risks and leveraging shared opportunities. To achieve this, PNRA has established a comprehensive institutional mechanism related to international cooperation. From establishing a dedicated wing to fulfilling the country's obligations concerning different nuclear-related conventions, entering into cooperation agreements with other countries' regulatory bodies, providing its experts to IAEA-run training activities, and presenting itself for peer reviews, PNRA is actively collaborating with the international community.

[1] Mark Fitzpatrick, *Overcoming Pakistan's Nuclear Dangers* (London: Routledge, 2014), 13, https://sanipanhwar.com/uploads/books/2024-08-28_10-43-30_65dcbce3ca07380a9463fc32326df5ac.pdf

In this backdrop, the paper aims to analyze how PNRA is cooperating with the international community at bilateral and multilateral fronts, with particular emphasis on exploring its institutional mechanism for international cooperation. It also explores the prospects and challenges for Pakistan related to global collaboration. The significance of the study lies in analyzing the current state of the PNRA mechanism for international cooperation and seeks to provide actionable recommendations for policymakers, regulators, and other stakeholders to navigate the complex landscape of global nuclear governance. By fostering a deeper understanding of the benefits and challenges associated with international collaboration, the paper aims to contribute to the discourse on peaceful nuclear applications.

The paper is divided into three sections. Section one describes the importance of global collaboration from a regulatory perspective by highlighting the role of the IAEA in facilitating its Member States in different partnerships. Section two discusses PNRA's institutional mechanism in detail to explore potential avenues for international cooperation. This section also elaborates on different actions PNRA has taken to enhance its international visibility, thereby highlighting Pakistan's responsible behavior internationally. The last section presents international cooperation-related challenges faced by PNRA and suggests ways to overcome these challenges in the future.

Significance of International Cooperation for Nuclear Regulators

The international nuclear landscape has undergone considerable transformation over the years, with nuclear technology emerging as a critical component in energy production and its widespread application in medicine, agriculture, and industry. Climate concerns and attaining net-zero targets are pushing countries to consider nuclear as a sustainable and secure energy source.[2] However, at the same time, this shift has been accompanied

[2] Jan Horst Keppler, "Nuclear Energy in the Global Energy Landscape: Advancing Sustainability and Ensuring Energy Security," *Oxford Energy Forum*, no. 139 (February 2024): 8, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2024/02/OEF-139-.pdf

by growing concerns about the transboundary nature of nuclear accidents, emphasizing the need to expand and deepen international collaboration.[3] The devastating consequences of nuclear accidents/incidents such as the 1986 Chernobyl accident and the 2011 Fukushima accident have underscored the importance of establishing stringent regulatory frameworks and promoting effective collaboration among nuclear regulatory authorities worldwide.[4]

At the international level, organizations like the IAEA facilitate the Member States by providing guidance, setting standards, and fostering international partnerships.[5] This facilitation for cooperation is particularly essential for nuclear regulators to ensure the safe use of nuclear technology and address transnational challenges that are affecting all Member States in one way or another. These challenges include climate change, energy security, environmental concerns, technological advancements, and so on. In an email interview conducted on 6 May 2025, Zia Hussain Shah, Director General PNRA,[6] emphasized the importance of global collaboration, particularly under the ambit of the IAEA, and commented that the IAEA pursues international cooperation, specifically regarding nuclear safety, security, and peaceful uses of nuclear applications. While highlighting the Technical Cooperation of the IAEA, Shah explained that the IAEA assists its members in different areas, including nuclear power development, nuclear safety and security, food and agriculture, human health and nutrition, water resource management, climate change adaptation and mitigation, with a particular focus on developing countries. In response to a

[3] Pablo Fernández-Arias, Georgios Lampropoulos, Álvaro Antón Sancho, and Diego Vergara, "Progress, Challenges, and Sustainable Perspectives in Nuclear Energy Strategies," *Applied Sciences* 14, no. 24 (December 2024): 11864, https://doi.org/10.3390/app142411864

[4] Mycle Schneider, Antony Froggatt, Steve Thomas, "Nuclear Power in a Post-Fukushima World", The World Nuclear Industry Status Report 2010–2011, (Washington: World Watch Institute, 2011), https://www.worldnuclearreport.org/IMG/pdf/2011MSC-WorldNuclearReport-V3.pdf

[5] IAEA, Governmental, Legal and Regulatory Framework for Safety, General Safety Requirements No. GSR Part 1 (Rev. 1), (Vienna, 2016), https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1713web-70795870.pdf

[6] Email interview with Zia Hussain Shah, Director General, Pakistan Nuclear Regulatory Authority (PNRA), May 6, 2025. Shah previously served in the Department of Nuclear Safety at the International Atomic Energy Agency (IAEA), 2016–2024.

question on the regulatory body, Shah elaborated that the IAEA has established different forums for strengthening and enhancing regulators' competence. To be specific, international cooperation enhances the effectiveness of regulatory bodies in many ways, highlighted in the subsequent section:

i. Mutual Learning and Sharing Best Practices

Collaboration allows regulators to learn from each other's experiences, adopt proven methods, and enhance regulatory frameworks. Multilateral forums provide their Member States with a platform where they can share their experiences and learn from each other. The most relevant case in reference, amongst others, is the Review Meeting platform of the Convention on Nuclear Safety (CNS), which takes place once every three years under Article 21(3) of the Convention.[7] Review Meetings offer a platform for evaluating the National Reports, facilitating discussions and assessments of all CNS Contracting Parties (CPs), by which CPs learn from each other's good practices. By identifying common issues being faced by all parties, CPs can also adopt a common approach to solve those problems. In addition, the Regulatory Cooperation Forum (RCF), established by the IAEA, focuses on collaboration among its members (Providers and Recipients) for enhancing the capacity of individual regulators to address complex issues effectively.[8] Some other notable multilateral forums for mutual learning and sharing of good practices include the Commission on Safety Standards (CSS), Advisory Group on Nuclear Security (AdSec), Global Nuclear Safety and Security Network (GNSSN), Technical Support Organization Forum (TSOF), Nuclear Safety Standard Committee (NUSSC), Transport Safety Standards Committee (TRANSSC), Waste Safety Standards Committee (WASSC), Radiation Safety Standards

[7] International Atomic Energy Agency (IAEA), *Convention on Nuclear Safety (CNS): Introduction to the CNS and Its Associated Rules of Procedure and Guidelines, Technical Booklet*, CNS Booklet 2024 (Vienna: IAEA, 2024), https://www.iaea.org/sites/default/files/24/08/cns_technical_booklet_august_2024_final.pdf

[8] International Atomic Energy Agency (IAEA), "Regulatory Cooperation Forum (RCF)," IAEA, https://gnssn.iaea.org/regnet/embarking/rcf/Pages/default.aspx

Committee (RASSC), Nuclear Security Guidance Committee (NSGC), and Emergency Preparedness and Response Standards Committee (EPReSC).

ii. Setting Global Safety and Security Standards by Harmonizing Regulatory Practices

In addition, the above-mentioned forums also provide a kick-start for establishing safety fundamentals, requirements, and guidelines of future documentation in particular technical areas related to Nuclear Power Plants (NPPs). Cooperation among regulatory bodies facilitates the development of consistent and internationally accepted safety standards with the aim of minimizing risks and ensuring the safety of the public and the environment. Although member states devise their independent regulations, there is a need for a harmonized approach related to regulatory practices that facilitates cooperation and trade across the countries by minimizing regulatory barriers.

iii. Facilitating Multilateralism against Transnational Nuclear Accidents / Radiological Emergencies

Availing nuclear technology is a national prerogative, but its impact, in case of unsafe handling, can go beyond national boundaries. On the premise that radiation does not respect boundaries, collaboration among countries is essential to share information, coordinate, and assist in the case of a nuclear accident or radiological emergency. There are two conventions,[9] i.e., the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (CACNARE) and the Convention on Early Notification of a Nuclear Accident (CENNA), to facilitate swift actions among its member states. These conventions require the designation of a national competent authority to deal with notifications and requests for assistance in case of a nuclear accident or radiological emergency. The actions can be either

[9] IAEA, *Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency*, INFCIRC/336 (Vienna: IAEA, 1987), https://www.iaea.org/sites/default/files/infcirc336.pdf; and IAEA, *Convention on Early Notification of a Nuclear Accident*, INFCIRC/335 (Vienna: IAEA, 1986), https://www.iaea.org/sites/default/files/infcirc335.pdf

related to the notification of an emergency or to responding during a nuclear accident / radiological emergency. The referred emergency-related conventions were devised out of a consensus built up by IAEA member states after the 1986 Chernobyl accident, where they agreed to establish a framework for cooperation. This framework for cooperation is based on the rationale of facilitating assistance in case of nuclear accidents or radiological emergencies. Once there is increased cooperation among member states, there will be more facilitation to prepare against transnational accidents/emergencies. Thus, collaboration and cooperation are the key to devising a common approach for emergency preparedness and response.

iv. Building Capacity through Collaborative Ventures

Cooperation among regulators can stimulate capacity building by enhancing expertise and improving each other's regulatory infrastructure. In this regard, the role of the IAEA is crucial as it provides a common platform for its Member States to discuss their training needs and infrastructure build-up requirements. The Technical Cooperation (TC) Program, a flagship of the IAEA, assists Member States in addressing their nuclear knowledge development and management / infrastructure-related issues. The IAEA also entertains member states' requests related to strengthening training needs by arranging training courses, fellowships, scientific visits, and workshops under different regional and inter-regional projects. In addition, the IAEA has also designated Collaborating Centers (CCs) in some Member States as institutions supporting the IAEA's programmatic activities. Besides other activities, CCs also support IAEA training activities, including research training courses, or the development of training or other educational materials. Such collaborative ventures are significant for assisting member states in preparing their workforce to better deal with regulatory challenges.

v. Promoting Trust and Transparency

Besides the IAEA, countries also cooperate bilaterally in areas of nuclear regulatory interest to learn and support each other. In this way, international

collaboration also contributes to building trust and transparency among nations, thereby dispelling suspicions. Countries' active engagement in international regulatory networks exhibits their commitment to global norms. It also enhances their credibility while fostering mutual respect.

To sum up, there is a need to recognize the fact that no nation can tackle global challenges alone; thus, international cooperation is not only a need but also a compulsion in this interconnected globalized world. By fostering international partnerships for enhancing technical capabilities and ensuring safe and secure use of nuclear technology, regulatory bodies can create a safer and more sustainable future for all.

Whether it is the mitigation of leaked radioactivity after nuclear accidents or radiological emergencies, or the management of nuclear waste, one aspect is omnipresent: global issues require global cooperation. For this, countries need to have effective coordination and communication among themselves. Specifically, nuclear regulators need to balance national interests with international cooperation goals, which can be achieved through the harmonization of regulatory standards and practices across countries. In addition, considering regional and global needs, cooperation among nations is particularly required in emerging areas like Small Modular Reactors (SMRs), digitalization, advanced modalities, and so on. It is worth mentioning that hindrances to international cooperation can impact the effectiveness of nuclear regulatory bodies. The sharing of information related to regulatory business plays a significant role in strengthening the capacity building and infrastructure of regulatory bodies and, in turn, contributes to the establishment of trust and transparency among regulators, a prerequisite for effective global cooperation.

Besides enhancing mutual learning, sharing best practices among the regulators and continual improvement in regulatory processes and activities, review meetings under conventions and peer review mechanisms adopted by the IAEA are also important in overcoming challenges associated with trust, transparency, and confidentiality. However, resource

disparities, either in terms of expertise or infrastructure, make it difficult for states to collaborate with each other. Developing countries require funding to build their competence and strengthen their infrastructure, due to which collaboration becomes difficult.

Institutional Mechanism for International Cooperation: Regulatory Perspective

Being the pioneer member of the IAEA,[10] Pakistan has a long history of international cooperation with the IAEA and its Member States for developing its nuclear energy capabilities and regulatory mechanisms. Pakistan's nuclear regulatory regime evolved gradually and strengthened through participation in capacity-building programs conducted by the IAEA and other Member States.

i. Pakistan's Nuclear Regulatory Journey

The concept of nuclear regulation in Pakistan is as old as the advent of nuclear technology in Pakistan since 1965, when the first research reactor, PARR-I, was commissioned.[11] It was further improved with the commissioning of the first NPP in 1971, in Karachi. Although at that time, a nuclear safety and licensing division was established in the Pakistan Atomic Energy Commission (PAEC) to act as a regulatory body till it was upgraded to the Directorate of Nuclear Safety and Radiation Protection (DNSRP) after the promulgation of the Pakistan Nuclear Safety and Radiation Protection Ordinance 1984.[12] This directorate had regulatory wings; however, with the expansion of the nuclear power program and with the increasing use of nuclear technology in the non-power sector, the need to have a regulatory setup independent from a promotional body was

[10] Ghazala Yasmin Jalil, *Deepening IAEA-Pakistan Partnership for Peaceful Nuclear Cooperation*, March 3, 2025, https://issi.org.pk/wp-content/uploads/2025/03/IB_Ghazala_March_03_2025.pdf
[11] Feroz Hassan Khan, "Eating Grass: The Making of the Pakistani Bomb", (California: Stanford University Press, 2013), p. 57.
[12] Mazzammal Hussain, Rizwan Ali Khan, and Bushra Nasim, "Regulatory Framework for Occupational Exposure Management in Pakistan," paper presented at the ISOE Symposium 2009, Vienna, Austria, October 2009, https://www.isoe-network.net/publications/pub-proceedings/symposia/international-symposia/vienna-austria-october-2009/papers-5/session-4-occupational-exposure-in-npps-1/1304-nasim2009-pdf/file.html

realized. This independence was sought gradually as DNSRP led to the creation of the Pakistan Nuclear Regulatory Board in 1994.[13] The quasi-independence was established in 2001 with the establishment of PNRA as a legally and administratively independent nuclear regulatory body with the mandate to regulate the use of nuclear energy, radioactive sources, and ionizing radiation.

ii. Functions of Nuclear Regulator

Since its establishment, PNRA has been mandated to formulate and implement safety regulations. PNRA ensures effective regulatory oversight nationwide. PNRA's core functions include establishing the regulatory framework, reviewing and assessing, granting authorizations, issuing licenses, performing inspections, and enforcing regulations for all nuclear and radiation facilities as well as activities in Pakistan.

In addition, PNRA is leading the national efforts to ensure that emergency preparedness and response mechanisms are implemented by its licensees. At PNRA headquarters, the National Institute of Safety and Security (NISAS) plays a vital role in the competency development of not only the regulatory workforce but also of other related entities. Following the IAEA's recognition of PNRA training capabilities, NISAS has also been designated as an IAEA Collaborating Center for Nuclear Safety and Security.

iii. Institutional Arrangements for International Cooperation

PNRA recognizes the importance of bilateral and multilateral cooperation for the improvement of its contribution to enhancing global nuclear safety and security. Upon the twentieth anniversary of its inception, PNRA issued a Twenty-Year Report highlighting significant achievements made by the

[13] *Creation of Pakistan Nuclear Regulatory Board*, Prime Minister's Secretariat Notification, Islamabad, October 30, 1994, https://www.vertic.org/media/National%20Legislation/Pakistan/PK_No_F8_52_94_PAEC_F_Creation_Nuclear_Board.pdf

regulator during this period.[14] Much of the information related to international accomplishments is taken from that report. It is important to highlight that PNRA has adopted a very systematic approach to increase its visibility at the global level. The contours of this systematic approach are discussed below.

iv. Establishment of a dedicated International Cooperation Office

Over the years, PNRA has made commendable efforts to project and promote Pakistan's nuclear safety and security record at the international level. It has established a dedicated department, the Directorate of International Cooperation (ICD), to promote and enhance its regulatory visibility internationally. As one of the oldest directorates, ICD is coordinating with international organizations, including the IAEA, for international affairs and capacity building of PNRA officials. It also ensures implementation of obligations of international conventions, resolutions, safety and security committees, forums, networks, etc., on behalf of the Government of Pakistan. It is also responsible for developing, coordinating, and implementing Memoranda of Understanding (MoUs) / agreements with international organizations.

v. Implementing Pakistan's International Obligations

The Government of Pakistan has signed several international conventions and has designated PNRA as the national point of contact. PNRA is implementing country obligations related to a few conventions to which Pakistan is a party. These include Conventions on Nuclear Safety (CNS), Conventions on Early Notification of a Nuclear Accident (CENNA), Conventions on Assistance in the Case of a Nuclear Accident or Radiological Emergency (CACNARE), and Conventions on Physical Protection of Nuclear Materials (CPPNM) and its amendment. Either compilation of country report for submission in review meeting of CNS or participating/hosting IAEA emergency exercises under the emergency-

[14] Pakistan Nuclear Regulatory Authority, "20 Years OF PNRA, Pakistan Nuclear Regulatory Authority (2001 – 2020)" (Islamabad: PNRA, 2021), https://www.pnra.org/upload/pnrarpt/PNRA%20Report%202020.pdf

related conventions, PNRA is implementing national obligations in true letter and spirit.

Besides obligatory responsibilities, PNRA is also ensuring the non-obligatory requirements arising from Pakistan's subscription related to the safety of research reactors and the safety and security of radioactive sources.

vi. Participation in Multilateral Forums

PNRA is actively participating in multilateral forums, particularly those of the IAEA, to foster cooperation and address shared challenges. Aiming to develop technical standards and guidance documents, PNRA officials are members of various IAEA Safety Standard Committees, including Nuclear Safety Standards Committee (NUSSC), Transport Safety Standards Committee (TRANSSC), Waste Safety Standards Committee (WASSC), Radiation Safety Standards Committee (RASSC), Emergency Preparedness and Response Standards Committee (EPReSC), Nuclear Security Guidance Committee (NSGC), and Commission on Safety Standards (CSS). It also participates in the Response and Assistance Network (RANET), Global Nuclear Safety and Security Network (GNSSN), Regulatory Cooperation Forum (RCF), Radiation Safety Information Management System (RASIMS), International Generic Ageing Lessons Learned (IGALL), United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), Technical Support Organization Forum (TSOF), National Nuclear Security Support Centre (NSSC), and the International Nuclear Security Education Network (INSEN), and so on. Pakistan has the honor of hosting the first-ever meeting of NSSC outside Vienna, Austria.[15] In addition, PNRA has also hosted CANDU Senior Regulator's Meetings twice in 2005 and 2022.

IAEA has also established various non-binding reporting mechanisms for member states to learn from each other's experience by reporting on

[15] **"**Ambassador Jenkins Travels to Pakistan for the IAEA International Network for Nuclear Security Meeting", March 17, 2016: http://www.nss2016.org/news/2016/3/18/xewb29qm3pdj8sqxblr2v4djvu0td

relevant issues. PNRA also contributes to such forums as the International Nuclear and Radiological Event Scale (INES), Incident Reporting System (IRS), Incident Reporting System for Research Reactors (IRSRR), International Physical Protection Advisory Services (IPPAS), Good Practices Database, Denials of Shipment of Radioactive Material (DoS), and Incident and Trafficking Database (ITDB).[16]

vii. Provision of Expert Manpower

PNRA, as reflected below in Figure 1, regularly provides its experts' services to the IAEA for the conduct of IAEA peer review missions, consultancies for the development of IAEA documents and training material, and resource persons for training courses and workshops held at the IAEA and its Member States.[17] Further statistics about the provision of experts are available in PNRA annual reports. [18]

viii. Execution of TC Projects

PNRA also participates in various Technical Cooperation projects of the IAEA, which have reinforced the regulatory infrastructures. It also participates in various IAEA Coordinated Research Projects (CRPs) to strengthen its organizational capabilities.

[16] Pakistan Ministry of Foreign Affairs, *Pakistan Nuclear Security Regime*, booklet presented at the IAEA International Conference on Nuclear Security, May 2024, https://www.iaea.org/sites/default/files/24/05/cn-321_pakistan.pdf

[17] Rahila Hammad, *Managing Nuclear Safety Knowledge – PNRA Experience*, https://gnssn.iaea.org/main/Activity%20Documents1/Technical%20Meeting%20on%20Managing%20Nuclear%20Safety%20Knowledge%20%E2%80%93%20Approaches%20and%20National%20Experiences/Presentations/Day%202/PAKISTAN.%20Rahila%20Hammad.pdf

[18] Pakistan Nuclear Regulatory Authority, "Reports," Pakistan Nuclear Regulatory Authority, https://www.pnra.org/report.html

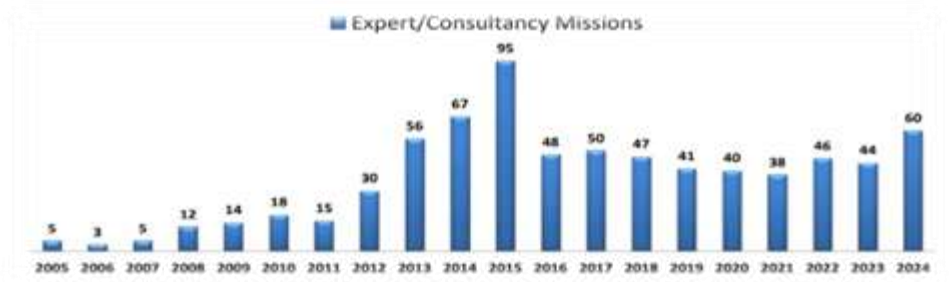

Figure 1: Expert Mission from PNRA: 2002-2024

Source: The author has consulted various annual reports of the PNRA to create a consolidated graph.

ix. Honoring Bilateral Commitments

Besides collaboration at multilateral forums, as shown below in Figure 2, PNRA has established bilateral cooperation agreements with three relevant organizations in China. These organizations include the National Nuclear Safety Administration (NNSA), Nuclear Safety and Radiation Protection Centre (NSC), and China Nuclear Power Operations Technology Corporation Ltd. (CNPO).[19] In addition, PNRA has also signed an MoU with the Nigerian Nuclear Regulatory Authority (NNRA) and the Nuclear Regulatory Authority (NRA) of the Republic of Ghana for capacity building of their regulatory staff.[20]

[19] Dr. Hamid Saeed Raza, Noreen Iftakhar, Faiza Batool, "Pakistan-China Cooperation: A [Nuclear] Regulator Perspective", *Science Diplomacy Perspective*, COMSTECH, March 2022. p: 62. https://www.comstech.org/wp-content/uploads/2022/03/Compiled-Special-Issue-10-3-2022.pdf

[20] Noreen Iftakhar, "Emerging Nuclear Countries and International Cooperation: What Can Pakistan Offer?" *Journal of Security and Strategic Analyses* 9, no. 2 (2023), https://jssa.thesvi.org/index.php/ojs/article/view/261

Figure 2: Bilateral Agreements of PNRA
Source: The author has reviewed various annual reports of the PNRA to create a consolidated graph.

x. International Benchmarking through Peer Reviews and Advisory Services

PNRA has developed mechanisms for internal oversight and regularly conducts such monitoring and assessment activities at the internal level periodically as a self-check to measure its performance and processes. However, it can also request relevant international organizations, such as the IAEA, for an independent review. The IAEA also offers its Member States peer review and advisory services on nuclear safety and security.[21]

PNRA has also set provisions for independent external review in its organizational management system to oversee the consistency of its

[21] International Atomic Energy Agency (IAEA), *Supporting Member States: IAEA Peer Reviews and Advisory Services*, *Nuclear Safety and Security Program of IAEA*, https://www.iaea.org/sites/default/files/20/07/supporting-member-states-iaea-peer-reviews-and-advisory-services.pdf

regulatory framework, processes, and practices in agreement with international standards and best practices. As highlighted below in Figure 3, PNRA has invited several IAEA peer review & advisory missions to demonstrate openness and transparency, which are critical for any nuclear regulator to grow positively.[22] The outcome of these missions helped PNRA in enhancing its regulatory oversight and capacity building related to nuclear safety and radiation protection. Furthermore, after the successful conduct of the internal International Physical Protection Advisory Service (IPPAS), Pakistan is planning to host IAEA IPPAS in 2026, as announced by the Head of Pakistan's delegation during the International Conference on Nuclear Security (ICONS): Shaping the Future, which was held in Vienna from 20-24 May 2024.[23]

Figure 3: International Appraisals and Peer Review Missions to Pakistan
Source: The author has consulted various annual reports of the PNRA to create a consolidated graph.

[22] Pakistan Nuclear Regulatory Authority (PNRA), *20 Years of PNRA, Pakistan Nuclear Regulatory Authority* (Islamabad: PNRA, 2021), https://www.pnra.org/upload/pnrarpt/PNRA%20Report%202020.pdf; also see *Convention on Nuclear Safety: National Report for Joint Eighth and Ninth Review Meeting*, Islamic Republic of Pakistan, 2023, 6, https://www.pnra.org/upload/pnrarpt/NR%20for%208th%20and%20%209th%20RM.pdf; also see *Education and Training Appraisal in Radiation Protection and the Safety of Radiation Sources: Preparatory Mission Pakistan, 10–15 November 2013* (Vienna: IAEA), https://www-ns.iaea.org/downloads/rw/training/eduta/prep-eduta_2013-pakistan.pdf

[23] National Statement, International Conference on Nuclear Security: Shaping the Future (Vienna, 20-24 May 2024), https://www.iaea.org/sites/default/files/24/05/cn-321_pakistan.pdf

To understand the dynamics of PNRA and international cooperation, an in-person interview with Faizan Mansoor, currently leading the PNRA, was conducted on 6 May 2025.[24] Mansoor explained that "being a contact point for international conventions related to nuclear safety, physical protection, nuclear accident and radiological emergency, PNRA in collaboration with other national organizations, is fulfilling Pakistan's commitment in true letter and spirit."[25] He was of the view that "a comprehensive inter-agency process is being established and practiced maximizing global footprints of PNRA." [26] Explaining his personal experience of interacting with other regulatory bodies, he maintained that "expertise of PNRA officials either in the areas of nuclear safety, security, radiation protection, emergency preparedness, are well reputed at IAEA level and now PNRA officials, from resource person of training courses to the experts of review missions, are participating in different programs of IAEA." Regarding areas of cooperation that PNRA can offer to other countries, Mansoor believes that "having proficiency in all regulatory core functions, PNRA is willing to share its expertise in the development of regulatory framework, review and assessment, authorization and licensing, inspection and enforcement."[27] Mansoor stated that excellence in regulatory affairs requires constant learning and equipping with advanced technologies; however, resource constraints sometimes create difficulties. While acknowledging the role of the IAEA in supporting its Member States, Mansoor applauded the IAEA in strengthening the regulatory competence of PNRA.

To sum up, PNRA has a well-established mechanism at the organizational level for international cooperation. This global collaboration has helped Pakistan to contribute to shaping international nuclear safety and security-related norms and policies. The PNRA is playing a proactive role in addressing common challenges for the peaceful use of nuclear applications.

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[24] Faizan Mansoor, Chairman of the Pakistan Nuclear Regulatory Authority (PNRA), interview by the authors, Islamabad, May 6, 2025
[25] Mansoor, interview, May 6, 2025
[26] Mansoor, interview.
[27] Mansoor, interview.

However, realizing these benefits requires overcoming significant challenges, which are discussed in the following section.

PNRA and International Cooperation: Challenges and Future Prospects

The retrospective analysis of the institutional mechanism adopted by PNRA for enhancing its global presence exhibits that since its inception, PNRA has been aware of the importance and usefulness of international cooperation. It remains committed to ensuring the peaceful use of nuclear and radiation technology in the country through the highest standards of safety, security, and regulatory oversight. The supporting role of international and experienced regulatory bodies is vital for the capacity building and organizational improvement of a growing organization like PNRA. Therefore, PNRA worked on obtaining maximum support from the IAEA and with the nuclear regulators of other countries through bilateral relations. Hence, PNRA is using all possible international avenues for competence building, knowledge sharing, and strengthening its regulatory oversight.

Nevertheless, there are certain challenges related to international cooperation faced by PNRA, which are more embedded due to restrictions imposed on the other side of its nuclear coin. Even with restrictions and limited access, PNRA has attained the required knowledge and skill to perform regulatory functions in the true spirit. PNRA's experts are recognized by the IAEA, and based on the training provided by the IAEA in the initial years of PNRA, the organization is now contributing to enhancing nuclear safety globally by transferring knowledge and sharing experience. However, this knowledge and skill require continuous update, and hence, PNRA is facing a challenge to be at par with technological advancements. Based on the discussions with the teams involved in the organizational conduct related to global collaboration, the following challenges are worth pondering:

i. Limited Access to Codes and Standards for Ensuring Nuclear Safety

PNRA has a mandate for ensuring the safe and secure application of nuclear technology. This assurance is guaranteed through different core processes, such as review and assessment. PNRA carried out the review and assessment of the licensees' submissions against PNRA regulations and other agreed industrial codes and standards. These industrial codes and standards are developed by internationally accepted/recognized organizations/bodies[28] provide acceptance criteria for the implementation of regulatory requirements. With the advancements in technology, these codes are also updated. Therefore, it is essential for regulators to not only understand the criteria and technical requirements related to the design, construction, operation, and maintenance of nuclear installations but also have expertise to perform an audit analysis of the results presented by the licensee in the safety analysis report. Unfortunately, PNRA has limited access to some industrial codes and standards. This limited access is due to high cost and licensing restrictions by the developer. This barrier can be reduced by collaboration and partnerships between standard-setting organizations and regulatory bodies through the IAEA, for open access to these critically significant industrial codes and standards necessary for ensuring nuclear safety.

ii. Technology Denials

Ensuring radiation protection and maintaining emergency preparedness is one of the primary tasks of PNRA. To achieve this, PNRA needs to have updated and state-of-the-art radiation monitoring equipment, safety analysis software, and emergency preparedness tools. Nevertheless, PNRA faces challenges in the procurement of these essential technologies. These technologies' denials and restrictions are usually imposed by supplier states. There should be recognition of the fact that ensuring safety is a shared responsibility of all nations, and this responsibility should never be

[28] Pakistan Nuclear Regulatory Authority (PNRA), *Convention on Nuclear Safety: National Report for Joint Eighth and Ninth Review Meeting* (Islamabad: PNRA, 2023), 13–14, https://www.pnra.org/upload/pnrarpt/NR%20for%208th%20and%20%209th%20RM.pdf

compromised by any other factors. Hence, there should be non-discriminatory access to safety-related technologies. Supplier countries should also re-evaluate that, regardless of geopolitics, access to the equipment and technology is essential to ensure protection of the public and the environment.

iii. Underrepresentation of Pakistan's Peaceful Nuclear Initiatives in the International Discourse

PNRA has a noble cause of ensuring nuclear safety and radiation protection related to the peaceful application of nuclear and radiation technology. Regardless of this clearly defined mandate and the administrative, technical, and financial autonomy of PNRA, its international cooperation is often hindered by the global emphasis on its national defense imperatives, which have, at times, limited the visibility of its efforts and achievements in the peaceful applications of nuclear technology. Consequently, Pakistan faces restricted technological access under the pretext of political sensitivities and trust deficit. Owing to this misperception, nuclear safety tools and equipment are often caught in broader export restrictions despite PNRA's strong commitment to international safety norms. As a result, PNRA's achievements and contributions to nuclear safety are underreported or underacknowledged in global forums due to broader political narratives.

This study proposes two sets of proposals for the regulatory and policy levels to overcome these challenges. PNRA should focus on the following areas:

i. Diversify and expand its bilateral cooperation with IAEA, other regulatory bodies, and with countries outside technology denial cartels by building technical partnerships. Broadening international partnerships will benefit PNRA in enhancing its international credibility and gaining greater acceptance in multilateral platforms.
ii. Leverage IAEA Technical Cooperation Programs and advocate free and equitable access to nuclear safety codes and standards as cooperation agenda.

iii. Continue active participation in IAEA's capacity-building and safety enhancement projects, as well as hosting regional IAEA workshops or training programs in its Collaborating Center (NISAS). In this way, PNRA can exhibit its leadership and expertise in the nuclear regulatory domain.

iv. Sensitize the international community to assess the regulatory credentials of PNRA based on its performance, not through a political lens.

v. Engage researchers and think-tanks, for focused published academic literature to overcome perception issues as a cooperation barrier. Since its legal and regulatory framework is openly available, PNRA should pursue targeted science diplomacy to maximize its national outreach and strengthen its international profile.

At the policy level, these challenges can be overcome by adopting two approaches:

i. ***More Inclusive Partnerships:*** A more globalized world means a more interdependent community. Ensuring nuclear and radiation safety is the prime job of the nuclear regulator. Since leaked radiation does not respect geographical jurisdiction, so shared threat needs a shared response. All countries should be part of international arrangements without any attribution of size, economy, or political concerns. Thus, there is a need to have inclusive partnerships. No country should be barred from joining any forum on the pretext of differing national interests. Neither regional biases nor preferential treatment should be exercised in international partnerships. Excluding countries for promoting certain geopolitical and geo-strategic interests should not be the desirable agenda of any international partnership.

ii. ***Advocating Multilateralism:*** Multilateralism[29] has three distinguished principles: equality without discrimination, dispute settlement, and durability; henceforth, multilateralism, being a "uniquely inclusive vehicle," can serve as a coordination mechanism during "heightened geopolitical tension and big power rivalry."[30] While unilateral initiatives are good in achieving short-term results but their impact does not last.[31] International cooperation is more effective under multilateral forums like the IAEA, which serves the purpose of providing a multilateral forum. With its near-universal membership, the IAEA provides a central forum for its Member States to address areas that require international cooperation. Addressing emerging global threats, developing harmonizing regulatory standards, providing training and capacity-building programs, discussing technological differences, and building understanding on different legal and liability issues, a multilateral forum like the IAEA plays a significant role in establishing regular dialogue and clear communication channels by identifying shared goals and interests to facilitate cooperation.

Conclusion

To sum up, cooperation among countries is necessary to ensure nuclear and radiation safety, security, and the peaceful use of technology. All nuclear regulatory bodies have the common objective of protecting the people and environment by ensuring and upholding safety and security standards. International cooperation enhances the effectiveness of nuclear regulatory bodies by mutual learning and sharing best practices and by setting global

[29] United Nations, "The Multilateral System," United Nations, https://www.un.org/en/global-issues/multilateral-system

[30] Ulrika Modéer and Tsegaye Lemma, The value of strong multilateral cooperation in a fractured world, UNDP: April 20, 2023.https://www.undp.org/blog/value-strong-multilateral-cooperation-fractured-world

[31] Noreen Iftikhar, "International Nuclear Law: A Case Study of Pakistan," *Strategic Studies* 38, no. 4 (2018): 75, 85, https://issi.org.pk/wp-content/uploads/2019/01/5-SS_Noreen_Iftakhar_No-4_2018.pdf

safety standards to harmonize regulatory practices. While facilitating a multilateral approach against transnational nuclear accidents or radiological emergencies, international cooperation is also essential for building the capacity of all countries through collaborative ventures, hence promoting trust and transparency.

With its commendable record, Pakistan's civilian nuclear program is managed by PAEC, while PNRA ensures the safe and secure use of nuclear technology. Though Pakistan started its regulatory journey in the 1960s, its independent regulatory setup has been fully functional since 2001. Within the short span of twenty-four years, PNRA has made commendable efforts to establish a robust regulatory framework, comprehensive processes for review and assessment, mechanisms for licensing and authorizations, emergency response mechanisms, and inspection and enforcement protocols. PNRA has made a noticeable presence at both the national and international levels. Its collaboration with the IAEA and participation in conventions in the areas related to nuclear safety, nuclear accidents and radiological emergencies, and physical protection, as well as effective contribution in different committees and forums at the international level, reflect Pakistan's commitment to international nuclear governance.

Pakistan's policymakers and diplomats should keep advocating the rights and needs of developing countries for robust scientific knowledge, expertise, and infrastructure to pursue socioeconomic development. PNRA should keep navigating the complex international system by exploring frameworks and agreements to engage in international cooperation. It should leverage the IAEA Technical Cooperation Program for capacity-building activities. It needs to establish more partnerships with other regulatory bodies, particularly those RBs that are new in this field. PNRA can establish bilateral agreements with regulatory bodies to facilitate cooperation and knowledge sharing, particularly in areas of its specialized expertise, like nuclear safety, radiation protection, review and assessment, regulatory framework, inspection and enforcement, licensing and authorization, physical protection, and regulatory body human resource

development. While advocating for more inclusive partnerships through multilateral forums, PNRA should keep its active engagement in international forums to enhance Pakistan's credibility as a responsible nuclear state. By addressing obstacles in global collaboration and leveraging opportunities, PNRA should keep pursuing international cooperation for strengthening global efforts aiming to further strengthen nuclear safety, radiation protection, and nuclear security in the country.