



Review Article

The Role of Human Resource Development in Strengthening Nuclear Regulatory Capacity in Bangladesh: A Review

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Abstract

As a newcomer to nuclear power, Bangladesh's safety, security, and non-proliferation objectives depend on the competence of its nuclear regulatory body, the Bangladesh Atomic Energy Regulatory Authority (BAERA). While national attention has largely centred on workforce needs of the operator and owner organisations for the Rooppur Nuclear Power Plant (RNPP), the human resource development (HRD) of the regulatory function has received limited systematic review. This paper synthesises the literature, legislation, and international guidance to examine regulatory HRD in Bangladesh. It traces the legal mandate for regulatory competence under the Bangladesh Atomic Energy Regulatory Act, 2012, reviews bilateral mechanisms supporting BAERA's capacity building including the General Framework Contract with JSC "VO Safety" and the NuRID project, and benchmarks regulatory workforce needs against IAEA guidance and newcomer states such as the UAE, Jordan, Turkey, Belarus, and Nigeria. The review evaluates alignment with IAEA Safety Standards Series No. SSG-75 on recruitment, qualification, and training, and identifies gaps in training infrastructure, staff retention, and succession planning. The paper concludes that sustained investment in regulatory HRD, anchored in international cooperation, dedicated training facilities, and systematic training, is indispensable to Bangladesh's capacity to independently license, inspect, and enforce nuclear safety standards over RNPP's operating lifetime.

Keywords— *Nuclear Regulatory Body; Human Resource Development; BAERA; Regulatory Capacity Building; IAEA Milestones*

Introduction

Bangladesh's decision to construct the Rooppur Nuclear Power Plant (RNPP), a twin-unit 2,400 MW VVER-1200 facility on the bank of the Padma River, places the country among the newcomer states pursuing nuclear power to meet rising electricity demand and reduce dependence on depleting natural gas reserves. The peaceful use of nuclear energy carries an obligation that extends well beyond construction: it requires an independent, technically competent regulatory body capable of licensing, inspecting, and enforcing safety and security

standards for the entire lifetime of the facility, from siting through decommissioning. The International Atomic Energy Agency (IAEA) identifies human resource development (HRD) as Issue No. 11 among the nineteen infrastructure issues in its Milestones framework, and regulatory competence is treated as a precondition, not a byproduct, of nuclear infrastructure development.

Much of the existing literature on Bangladesh's nuclear workforce has concentrated on the operator and owner organisations, reflecting the sheer scale of personnel required for plant construction, commissioning, and operation. The regulatory body, the Bangladesh Atomic Energy Regulatory Authority (BAERA), typically represents a much smaller share of the total nuclear workforce, commonly cited at around 9% of national requirements in comparative IAEA assessments, yet its role is disproportionately important. A regulator with insufficient technical depth cannot independently verify safety cases, cannot credibly enforce corrective actions, and risks becoming dependent on the very entities it is meant to oversee. This creates a distinct and underexamined HRD problem: how does a newcomer country build and sustain a competent, independent regulatory workforce in parallel with, but functionally separate from, the operator's much larger training pipeline?

This review paper addresses that question specifically for Bangladesh. It examines the legal and institutional basis for regulatory HRD, reviews the bilateral and international cooperation mechanisms that currently support BAERA's capacity building, benchmarks Bangladesh's regulatory workforce needs against IAEA guidance and comparable newcomer countries, and identifies the principal challenges that remain. The objective is to consolidate a body of related but scattered evidence, national legislation, IAEA technical guidance, and comparative country experience, into a focused assessment of regulatory HRD, complementing the broader nuclear HRD literature that treats the operator, owner, and regulator as an undifferentiated workforce pool.

Literature Review

The general nuclear HRD literature establishes that human capital constraints are a recurring bottleneck for newcomer nuclear states. Studies on Nigeria [1] estimate that approximately 9,045 individuals must be engaged across owner/operator, construction, and regulatory functions by 2033, with regulators forming only about 3% of this total, underscoring how numerically small, but functionally critical, the regulatory workforce is relative to the rest of the programme. Comparable patterns appear in Armenia [2], Slovenia [3], and Korea [4], where the emphasis of national HRD planning has similarly gravitated toward operator training pipelines, engineering curricula, and dedicated graduate schools such as KEPCO's KINGS programme, while regulatory-specific competence building is discussed only in general terms.

For Bangladesh specifically, several strands of research bear on regulatory HRD without treating it as a central theme. Islam et al. [5] trace how Bangladesh's nuclear and radiation-safety infrastructure was built up and reinforced over time, including BAERA's founding and its working relationship with Russian counterparts. Islam and Islam [6] examine nuclear

security and safeguards in Bangladesh, mapping institutional risks relevant to regulatory oversight capacity. Ashraf and Islam [7] provide a public-policy account of the first nuclear power plant decision, situating BAERA's creation within the broader institutional architecture established under the Nuclear Energy Program Implementing Organization (NEPIO). None of these studies, however, systematically assesses the regulatory body's workforce size, competency gaps, or training lead times against IAEA benchmarks, a gap that a broader HRD-focused study [8] begins to address at the level of the overall national HRD model, while noting that regulatory capacity building warrants deeper, dedicated treatment.

International guidance offers a firmer basis for evaluating regulatory HRD. The IAEA's Milestones framework [9] and its associated workforce-planning guidance [10, 11] situate the regulatory body as one of four principal stakeholder categories, alongside ministries, owner, and operator, each with distinct staffing trajectories. IAEA Safety Standards Series No. SSG-75 [12] sets out competency-based requirements specific to regulatory and operating personnel, including systematic training approaches, formal qualification and authorisation processes, and continuing professional development. Comparative country experience, the United Arab Emirates, Jordan, Turkey, Belarus, and Nigeria, offers empirical reference points for the scale and composition of a newcomer regulatory workforce, though, as prior reviews caution, these benchmarks cannot be transplanted directly onto Bangladesh given differences in institutional maturity, legal tradition, and educational infrastructure [13].

Taken together, the literature indicates that regulatory HRD is widely acknowledged as important in principle but is rarely the primary unit of analysis in country-specific nuclear HRD studies, including those on Bangladesh. This review responds to that gap by isolating the regulatory dimension for focused examination.

Regulatory and Institutional Framework for Human Resource Development in Bangladesh

Bangladesh's nuclear governance structure places BAERA within a multi-organisational system anchored by NEPIO, which was formed in 2010 as the high-level authority responsible for coordinating the nineteen IAEA infrastructure issues, including HRD. The Ministry of Science and Technology (MOST) functions as the core ministry, overseeing the Bangladesh Atomic Energy Commission (BAEC) as owner of the RNPP, while the Nuclear Power Company of Bangladesh Limited (NPCBL) serves as the designated operator under the Nuclear Power Plant Act of 2015. BAERA occupies a structurally distinct position within this architecture: it was constituted as an independent regulatory body on 12 February 2013 under the Bangladesh Atomic Energy Regulatory Act (BAER Act), enacted on 19 June 2012, with the explicit mandate to supervise licensees' compliance with nuclear safety, security, safeguards, and liability requirements. [14, 15]

The legal basis for regulatory HRD is written directly into this legislation. Section 11(30) of the BAER Act, 2012 prescribes HRD and training programmes for regulatory body personnel, while Section 23(m) places a complementary obligation on the authorisation holder (the operator) to formulate and sustain its own HRD programme with adequate

funding. This dual structure is significant: it establishes HRD not as a discretionary management practice but as a statutory duty for both the regulator and the regulated entity, reflecting the IAEA's Milestones principle that regulatory competence must be built independently of, and prior to, full reliance on operator or vendor training pipelines. [14]

In practice, BAERA's HRD function is supported through a combination of national policy instruments and international cooperation agreements. The 1996 National Energy Policy first identified nuclear technology as a strategic power-generation option, establishing the policy foundation later operationalised through NEPIO. The 2010 Inter-Governmental Agreement (IGA) between Bangladesh and the Russian Federation, and the subsequent 2012 agreement between MOST and ROSTECHNADZOR, incorporated provisions for training Bangladeshi personnel, including regulatory staff, as part of a comprehensive work strategy. Most directly relevant to the regulatory body, a General Framework Contract (GFC) was signed between BAERA and the Russian technical support organisation JSC "VO Safety", covering the period 2016–2026, which explicitly incorporates capacity-building for BAERA personnel. This has been supplemented by BAERA's own HRD Plan, developed under the NuRID project with the assistance of a Technical Support Organization (TSO), and by discussions in 2021 and 2024 regarding further JSC "VO Safety" assistance to BAERA's HRD programme. [16, 17]

The Role of Human Resource Development in Regulatory Effectiveness

Statutory Mandate and Institutional Responsibility

The regulatory body's core functions, authorisation, formulation of regulations and guides, oversight of nuclear material accounting and control, enforcement, and communication with interested parties, all presuppose a workforce with sufficient technical depth to exercise independent judgement rather than simply ratify vendor or operator assessments. Meeting this role calls for a training curriculum spanning reactor systems and operations, radiation protection and environmental safety, emergency preparedness and response, security and safeguards, inspection methodology, and ongoing development of risk-assessment skills. Because Bangladesh's regulatory workforce is being built from a very limited pre-existing base of nuclear specialists, the statutory obligation under the BAER Act functions as the anchor that keeps regulatory HRD from being crowded out by the far larger and more visible operator training effort. [14]

Estimating Regulatory Workforce Requirements

Comparative IAEA data provide a useful, if approximate, basis for sizing Bangladesh's regulatory workforce needs. Across the four-phase, at-least-15-year preparatory timeline that IAEA guidance associates with newcomer nuclear programmes, at least 2,200 experts are typically required in aggregate, of which the regulatory body accounts for roughly 9%, a share smaller than the operator's 68% and the owner's 18%, but larger than the 5% attributed to ministries and other coordinating bodies. Historical IAEA manpower guidance (Technical

Reports Series No. 200) further indicates that, for a reference plant in the 600–1,300 MW(e) range, the regulatory (licensing and regulation) function requires on the order of 50 dedicated personnel, a figure broadly consistent with the twin-unit RNPP's scale. Comparable newcomer-country regulators illustrate the same order of magnitude: Belarus's regulatory body for its twin 2,400 MW NPP units employs approximately 82 staff against a total programme workforce of roughly 2,533, and Turkey's TAEK maintains a staff of about 800, of whom around 50 are technical professionals assessing licensing applications for the Akkuyu project. [11, 18]

These figures suggest that BAERA's steady-state technical staffing requirement, once RNPP reaches commercial operation, is likely to fall in a comparable band, a small core of licensed inspectors and technical specialists rather than a large workforce, but one whose competence must be commensurate with the full scope of licensing, inspection, and enforcement responsibilities across the plant's operating lifetime, including eventual decommissioning.

Capacity-Building Mechanisms

BAERA's regulatory HRD relies substantially on international technical cooperation, reflecting the reality that no purely domestic training pipeline yet exists at the scale required. The GFC with JSC "VO Safety" (2016–2026) is the central bilateral instrument, intended to culminate in a full-scope HRD contract under which the TSO would directly assist in implementing BAERA's HRD plan. This arrangement mirrors the pattern seen in other newcomer countries, where the vendor country's own regulatory or technical support organisation plays a parallel capacity-building role for the client state's regulator, for example, TSO JSC "VO Safety" has also supported Rostechnadzor's broader work assisting embarking countries. In parallel, the NuRID project provides a nationally-anchored vehicle for developing BAERA's HRD plan with technical support, while cooperation channels established through NEPIO's National, Technical, and Working Committees provide the coordination mechanism linking regulatory HRD to the wider national infrastructure development effort. [16, 17]

Alignment with IAEA Safety Standards Series No. SSG-75

IAEA Safety Standards Series No. SSG-75 provides the principal international competency benchmark against which BAERA's HRD approach can be assessed. SSG-75 requires that all personnel performing activities that may affect nuclear safety possess and maintain competence commensurate with their responsibilities, encompassing educational background, professional training, practical experience, technical skills, and demonstrated safety-culture attributes. It further requires a systematic approach to training (SAT) built on job and task analysis, subject to periodic evaluation and continuous improvement, along with formal qualification and authorisation processes for safety-critical positions and periodic requalification requirements. Bangladesh's regulatory HRD architecture, anchored in the BAER Act's statutory mandate and operationalised through the GFC and NuRID project, shows structural alignment with these principles in intent, but the absence of a dedicated,

fully operational national training facility for regulatory personnel means that, in practice, systematic training and requalification still depend heavily on externally delivered programmes rather than an institutionalised domestic capability. Publicly available BAERA and NuRID documentation references systematic-training principles as a policy commitment, but no dedicated, job- and task-analysis-based SAT matrix for BAERA's current regulatory staff has yet been documented as operational; SAT therefore currently appears to be a stated policy intent rather than a confirmed, implemented framework, a distinction the author recommends BAERA's HRD unit verify directly for any subsequent revision of this review. [12]

Comparative International Experience in Regulatory Human Resource Development

Other newcomer nuclear states offer instructive, if imperfect, points of comparison for Bangladesh's regulatory HRD trajectory. The United Arab Emirates' Federal Authority for Nuclear Regulation benefited from an early and heavily internationalised staffing and training strategy tied closely to the country's white-paper nuclear policy and its cooperation with the Korea Electric Power Company; the Emirates Nuclear Energy Corporation's own preoperational staffing estimates (900–1,000 employees by 2016, rising toward 2,200 permanent operational employees by 2020) indicate the scale at which parallel regulatory capacity had to be built. Jordan's regulatory authority, the Jordan Nuclear Regulatory Commission, explicitly identified the human resource capability required to manage the nuclear sector as its primary challenge and conducted a dedicated workforce-planning exercise ahead of technology selection. Turkey's TAEK illustrates a regulator operating in parallel with a large vendor-led construction programme under an intergovernmental agreement structurally similar to Bangladesh's own arrangement with the Russian Federation, which is instructive precisely because Bangladesh's regulatory relationship with Rostekhnadzor and JSC "VO Safety" follows a comparable bilateral-support model. Belarus, building two VVER units of similar scale to RNPP, sized its regulatory body at roughly 82 personnel against a total programme workforce of about 2,533, with only a small fraction of foreign specialists, a target composition Bangladesh may reasonably use as an aspirational benchmark for the degree of national self-sufficiency BAERA should eventually achieve. Nigeria's planning exercise for a 1,000 MWe pressurised water reactor similarly earmarked a relatively small but essential regulatory cohort within its projected workforce of approximately 2,271 individuals. [13, 1]

Table 1 consolidates the reactor scale, regulatory body, reported staffing, HRD model, and international support mechanism for the five countries discussed above, alongside a reference row for Bangladesh. Because national definitions of “regulatory staff” and reporting years differ across countries, and because some reported figures describe owner/operator rather than regulator-specific headcounts, these figures should be read as indicative orders of magnitude rather than as directly comparable totals. [13, 1, 11]

Table 1. Comparative newcomer-state regulatory HRD benchmarks (indicative; see source notes per row).

Country	Reactor Programme / Capacity	Regulatory Body	Reported Staff (Year; Source)	HRD Model / Partner	Int'l Support Mechanism	Key Challenge / Lesson for Bangladesh
UAE	4×APR1400 (~5,380 MWe), Barakah	Federal Authority for Nuclear Regulation (FANR)	ENEC (owner) ~900–1,000 (2016) → ~2,200 (2020); FANR-specific regulatory headcount not reported in reviewed sources	KEPCO-linked staffing/training strategy tied to national white paper	Bilateral (Republic of Korea) + IAEA Milestones guidance	Early, heavily internationalised staffing strategy tied to a single vendor partner — directionally similar to BD's GFC model but built on a broader partner base
Jordan	Pre-construction; technology-selection stage	Jordan Nuclear Regulatory Commission (JNRC)	Not quantified in reviewed literature	Dedicated workforce-planning exercise conducted ahead of technology selection	Not specified in reviewed literature	Treated HR capability as the primary programme challenge; BD could similarly front-load workforce planning ahead of major procurement milestones
Turkey	4×VVER-1200 (~4,800 MWe), Akkuyu	Turkish Atomic Energy Authority (TAEK)	~800 total staff; ~50 technical/licensing staff (year not specified in source)	Regulator operating parallel to vendor-led construction under a bilateral IGA	Intergovernmental Agreement with the Russian Federation	Structurally the closest analogue to Bangladesh–Russia arrangement; illustrates both the model's efficiency and its single-partner exposure
Belarus	2×VVER-1200 (2,400 MWe)	Gosatomnadzor (national nuclear & regulatory)	~82 regulatory staff vs ~2,533 total	Predominantly national staffing; small	Bilateral (Russian Federation)	Closest reactor-scale analogue to RNPP; aspirational benchmark for

	twin-unit)	radiation safety regulator)	programme workforce (year not specified in source)	foreign-specialist share		national self-sufficiency
Nigeria	Planning -stage 1,000 MWe PWR	Nigeria Nuclear Regulatory Authority (NNRA)	~2,271 total projected workforce (planning exercise); separately, Egieya et al. (2022) project ~9,045 total personnel by 2033, ~3% regulatory	Needs-analysis-based national HRD planning	Not specified in reviewed literature	Two non-comparable staffing estimates from different planning horizons — illustrates why cross-country figures should not be compared directly
Bangladesh (BAERA)	2×VVER-1200 (2,400 MWe twin-unit), RNPP	BAERA	~9% of ~2,200 aggregate IAEA infrastructure-expert estimate (IAEA, 2022); TRS-200 (IAEA, 1980) benchmark of ~50 dedicated staff for a 600–1,300 MW(e) reference plant	GFC with "VO Safety" (2016–2026); NuRID project	Bilateral IGA (2010) & MOST–Rostechndzor (2012); IAEA Milestones framework	Single bilateral technical partner; no dedicated national training facility (see Section 6)

The consistent lesson across these cases is not a single staffing number but a structural pattern: regulatory bodies in newcomer states are numerically small relative to the operator workforce, yet uniformly identified, across the UAE, Jordan, Turkey, Belarus, Nigeria, and Bangladesh alike, as requiring early, deliberate, and internationally supported capacity

building precisely because their competence cannot be retrofitted once licensing and inspection responsibilities begin in earnest. [11]

Major Challenges to Regulatory Human Resource Development in Bangladesh

The principal challenges to strengthening BAERA's regulatory HRD trajectory, drawn from the review above, fall into the following six areas:

- Narrow domestic talent pool: nuclear engineering and radiation-safety curricula remain concentrated in a handful of universities (MIST, University of Dhaka, BUET, CUET), limiting the pipeline of graduates suited to regulatory, as opposed to operator, career paths.
- Dependence on a single bilateral technical partner: much of BAERA's current capacity building runs through the GFC with JSC "VO Safety" and cooperation with Rostekhnadzor, creating exposure to geopolitical and contractual risk if that relationship is disrupted. Given current geopolitical dynamics affecting Russian nuclear supply chains and international agreements, BAERA has a clear incentive to pursue multilateral diversification alongside, rather than instead of, the existing GFC: this could include (i) systematically drawing on the IAEA Technical Cooperation Programme and Integrated Nuclear Infrastructure Review (INSSP) follow-up missions for regulator-specific training slots; (ii) formal engagement with the IAEA's Asian Nuclear Safety Network (ANSN) and its regulatory-cooperation forums, which several Asian newcomer and established regulators already use for peer learning; (iii) bilateral or multilateral "twinning" arrangements with a second, non-Russian regulatory body experienced in VVER or comparable light-water reactor licensing, to build a second independent point of technical reference; and (iv) participation in IAEA-facilitated multilateral training consortia rather than relying solely on bilaterally negotiated slots. None of these would displace the GFC with JSC "VO Safety", which remains BAERA's most advanced and contractually committed capacity-building instrument, but together they would reduce the single-partner concentration risk identified here.
- Absence of a dedicated national regulatory training facility: unlike operator training, which benefits from simulator-based facilities tied to the RNPP construction schedule, BAERA lacks an equivalent standardised, centralised training centre for licensing, inspection, and emergency-response competencies.
- Retention and succession planning: as seen in other newcomer states (e.g., Slovenia's experience with an ageing NPP workforce), a small regulatory body is disproportionately vulnerable to attrition, since the loss of even a few licensed inspectors can materially reduce independent oversight capacity.
- Long training lead times relative to programme milestones: functions such as nuclear safety reviews, radiological engineering, and quality assurance require approximately

five years of preparation, which must be sequenced well ahead of RNPP's commissioning and operational milestones rather than initiated reactively.

- Public trust and communication capacity: BAERA's effectiveness depends partly on its ability to communicate regulatory decisions transparently; HRD planning has tended to prioritise technical competencies over the risk-communication and stakeholder-engagement skills needed to sustain public confidence.

Recommendations

Based on the foregoing review, four measures appear most likely to strengthen Bangladesh's regulatory HRD trajectory. First, BAERA's HRD plan should move from framework agreements toward a fully executed, multi-year training contract under the existing GFC, with clearly sequenced milestones tied to RNPP's commissioning and operational timeline rather than to the contract's calendar alone. Second, a dedicated national training facility, potentially shared with, but organisationally distinct from, operator training infrastructure, would reduce BAERA's reliance on externally delivered training and support the systematic approach to training required under SSG-75. Third, diversifying international cooperation beyond the current bilateral relationship, including engagement with IAEA-facilitated multilateral programmes and other member states' regulatory bodies, would mitigate the concentration risk associated with a single technical partner. Fourth, succession planning and retention policies tailored to a small, highly specialised regulatory workforce should be formalised now, before attrition among the first generation of trained inspectors becomes a constraint on independent oversight. [12]

Conclusion

As Bangladesh advances construction of the Rooppur Nuclear Power Plant, the competence of its nuclear regulatory body will determine, in large part, whether the country can exercise genuinely independent oversight of nuclear safety, security, and safeguards over the plant's operating lifetime. This review has shown that Bangladesh possesses a sound statutory basis for regulatory HRD under the BAER Act, 2012, and has established meaningful, if still incomplete, international cooperation mechanisms, notably the GFC with JSC "VO Safety" and the NuRID project, to build that competence. Comparative experience from the UAE, Jordan, Turkey, Belarus, and Nigeria confirms that a numerically small but highly competent regulatory workforce, typically on the order of 9% of total programme personnel, is both a realistic target and a non-negotiable requirement for newcomer states. The principal risks to Bangladesh's regulatory HRD trajectory are structural rather than legal: a narrow domestic talent pipeline, dependence on a single bilateral partner, the absence of a dedicated national training facility, and the long lead times required to develop safety-critical competencies. Addressing these gaps through sustained investment, diversified international cooperation, and formal succession planning will be essential to ensuring that BAERA can independently and credibly safeguard the peaceful use of nuclear energy in Bangladesh.

Authors Contributions

S. M. Nazmus Shakib Pias: Conceptualization, methodology, literature review, data collection, regulatory and technical analysis, interpretation of findings, manuscript drafting, and review and editing.

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Conflict of interest

The author declare that they do not have any conflict of interest.

AI Declaration

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